**INCH-POUND**

**MIL-STD-705D**
**22 November 2016**
**SUPERSEDING**
**MIL-STD-705C**
**24 April 1989**

# DEPARTMENT OF DEFENSE
# TEST METHOD STANDARD

## MOBILE ELECTRIC POWER SYSTEMS

**AMSC N/A** **FSC 6115**

**DISTRIBUTION STATEMENT A**. Approved for public release; distribution is unlimited.

# FOREWORD

1. This Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. This Standard explains, establishes and standardizes specific methods for measurements associated with the evaluation of mobile electric power systems. The intended use of this standard is to determine compliance with characteristics represented by procurement documents. In no case is failure criteria established within this document. The specific methods are included herein.

3. Due to the complexity of the specified requirements needed in procurement documents covering mobile electric power systems, referencing the applicable specific method should greatly simplify the preparation of specifications and help to expedite the purchase and acceptance of the subject equipment. The procurement document requirements paragraph, included as the final paragraph of each Method 300 and above, lists the data required in the procurement documents.

4. This revision combines MIL-HDBK-705 with this Standard. All Methods except those listed in 6.3 were revised. These revisions include corrections, updates to include new test equipment, test instruments, and test procedures.

5. Address all comments, suggestions, or questions on this document to Communications Electronics Research Development Engineering Center (CERDEC) Product Realization Directorate (PRD), 10108 Gridley Road, Fort Belvoir, Virginia 22060. Since contact information can change, verify the currency of this address information using the ASSIST Online database at http://quicksearch.dla.mil.

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# 1. SCOPE

1.1 Coverage. This Standard covers eight series of specific methods for testing and determining the characteristics of Mobile Electric Power Systems (MEPSs). This Standard establishes methods of test for determining characteristics desired by the Military Departments to ensure that the MEPS complies with Military requirements. This Standard establishes uniform methods for the Military services, uniform test equipment and facilities, and uniform procedures for setting up and conducting the various tests. These methods provide for conservation of manpower, materials, equipment, and facilities. This Standard does not establish limiting values for the results of the tests nor does it specify the test required for any specific MEPS.

1.2 Numbering system. The following system defines the assigned method numbers.

1.2.1 Methods numbered in the 100 series. These methods describe basic instruments and measurements and their theory.

1.2.2 Methods numbered in the 200 series. These methods describe basic instrumentation procedures and applications.

1.2.3 Method numbers in the 300 through 800 series. The method numbers in the 300 through 800 series have no significance; they are the original method numbers or the numbers of new methods.

1.2.4 Figure numbering within methods. The beginning digits of any figure number are the same as the method number that figure pertains to. A hyphen is used to separate the first and second portions of the figure number. The digits used in the second portion of the figure number establish the order of figures within each method. For example, the first figure number for Method 205.1 is Figure 205.1-1; the second figure number is Figure 205.1-2.

1.2.5 Decimal system. The decimal system is used to list similar or associated methods in numerical sequence and to provide means for readily identifying main and subparagraphs for purpose of reference.

1.2.6 Revisions to methods identification. Lower case alphabetic characters are suffixed to the method numbers to identify revisions to methods.

1.3 Method of reference. Reference the Methods of test contained in this Standard, when applicable, in the individual procurement documents by specifying this Standard and the method number. These procurement documents will give specific requirements for test and limiting values.

# 2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this Standard. This section does not include documents cited in other sections of this Standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this Standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATIONS

| | | |
|---|---|---|
| MIL-DTL-917 | – | Electric Power Equipment, Basic Requirements for |

DEPARTMENT OF DEFENSE STANDARDS

| | | |
|---|---|---|
| MIL-STD-209 | – | Interface Standard for Lifting and Tiedown Provisions |
| MIL-STD-810 | – | Environmental Engineering Considerations and Laboratory Tests |
| MIL-STD-882 | – | System Safety |
| MIL-STD-1472 | – | Human Engineering |
| MIL-STD-1474 | – | Noise Limits |
| MIL-STD-40051-2 | – | Preparation of Digital Technical Information for Page-Based Technical Manuals (TMs) |

DEPARTMENT OF DEFENSE HANDBOOKS

| | | |
|---|---|---|
| MIL-HDBK-705 | – | Generator Sets, Electrical, Measurement and Instrumentation Methods |

(Copies of these documents are available at http://quicksearch.dla.mil.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

| | | |
|---|---|---|
| TM 9-6140-200-13 | – | Technical Manual Operator and Field Maintenance for Automotive Lead-Acid Storage Batteries |

DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

| | | |
|---|---|---|
| TB 9-6140-252-13 | – | Recharging Procedures for Automotive Valve Regulated Lead-Acid Batteries |

(Copies of these documents are available at https://www.logsa.army.mil.)

Surface Deployment and Distribution Command Transportation Engineering Agency (SDDCTEA)

| | | |
|---|---|---|
| Pamphlet 55-20 | – | Tiedown Handbook for Truck Movements |

(Copies of this document are available at https://www.tea.army.mil/pubs/pubs_order.htm.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)/AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS (ASHRAE)

| | | |
|---|---|---|
| ANSI/ASHRAE 41.6 | – | Standard Method for Humidity Measurement |

(ANSI and ASHRAE publish this Standard jointly. Copies are available from http://ansi.org or https://www.ashrae.org.)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)/
NATIONAL CONFERENCE OF STANDARD LABORATORIES (NCSL)

| | | |
|---|---|---|
| ANSI/NCSL Z540.2 | – | U.S. Guide to the Expression of Uncertainty in Measurement |
| ANSI/NCSL Z540.3 | – | Requirements for the Calibration of Measuring and Test Equipment |

(ANSI and NCSL publish these Standards jointly. Copies are available from http://ansi.org or http://www.ncsli.org.)

ASSOCIATION OF AMERICAN RAILROADS (AAR)

Rules Governing the Loading of Department of Defense Material on Open Top Cars

(Copies are available from https://www.aar.org.)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

| | | |
|---|---|---|
| IEEE C2 | – | National Electric Safety Code |

(Copies are available from http://www.ieee.org.)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 10012 – Measurement Management Systems – Requirements for Measurement Processes and Measuring Equipment.

(Copies are available from http://www.iso.org.)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)/ INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

ISO/IEC 17025 – General Requirements for the Competence of Testing and Calibration Laboratories

(ISO and IEC publish this Standard jointly. Copies are available from http://www.iso.org.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J537 – Storage Batteries

(Copies are available from http://standards.sae.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

## 3. DEFINITIONS

3.1 Terms. This section defines the general terminology as it is used in this Standard. In certain cases the terminology used may be somewhat different from its use in the general engineering community. No attempt has been made to be complete; therefore the glossary is limited to such terms as are found in this Standard and that are important to the application of this Standard. Terminology unique to a particular method is defined, as appropriate, in that method.

a. **Alternate fuel**. An alternate fuel is a fuel that provides acceptable operational performance versus the primary fuel, but may be a restricted item of supply in tactical areas or has environmental limitations. Alternate fuel performance shall not degrade below the minimum specification requirements. No degradation in reliability or durability is allowed.

b. **Alternating Current (AC)**. Alternating current occurs when charge carriers in a conductor or semiconductor periodically reverse their direction of movement.

c. **Altitude**. Altitude is a distance measurement, usually in the vertical or "up" direction, between a reference datum and a point or object.

d. **Ambient air temperature**. The ambient air temperature is the temperature at the conditions that characterize the air that surrounds the materiel.

e. **Ammeter**. An ammeter is a current measuring device.

f. **Battery**. A battery is a container consisting of two or more cells, in which chemical energy is converted into electricity and used as a source of power.

g. **Current**. Current is the measurement of the amount of electrical charge transferred per unit time.

h. **Current transformer**. A current transformer is a device which produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments used for measurement of AC.

i. **Direct Current (DC)**. Direct current is the unidirectional flow or movement of electric charge carriers (which are usually electrons). The intensity of the current can vary with time, but the general direction of movement stays the same at all times.

j. **Distribution system**. A distribution system is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers.

k. **Emergency fuel**. An emergency fuel is a fuel used only when the primary or alternate fuel is not available. The use of an emergency fuel shall not materially degrade the design operating life of the power system. Severe performance degradation is permissible when an emergency fuel is used.

l. **Force**. Force is a quantitative description of the interaction between two physical bodies, such as an object and its environment.

m. **Frequency**. Frequency is the number of complete cycles per second in alternating current direction. The standard unit of frequency is the Hertz, abbreviated Hz. If a current completes one cycle per second, then the frequency is 1 Hz; 60 cycles per second equals 60 Hz.

n. **Frequency meter**. A frequency meter is an instrument for measuring the frequency of periodic processes (oscillations). The frequency of mechanical vibrations is usually measured by means of mechanical vibration frequency meters and by electrical meters equipped with transducers to convert the mechanical vibrations into electrical oscillations.

o. **Generator**. A generator is a device that converts mechanical energy to electrical energy for use in an external circuit.

p. **Generator set**. A generator set typically consists of an engine and a generator that are mounted together as a single unit. The primary function of the set is for the electrical generator to convert mechanical energy from the engine into electrical energy.

q. **Harmonic analyzer**. A harmonic analyzer is a precise electronic voltmeter combined with a tunable band-pass filter with provisions for determining the magnitude or the relative value of voltages of different superimposed frequencies applied to its terminals.

r. **Humidity**. Humidity is the amount of water vapor in the air.

s. **Kelvin Bridge**. The Kelvin Bridge is a method to obtain resistance. This method utilizes that characteristic of generator windings whereby a change of resistance is proportional to a change of temperature.

t. **Load instrumentation**. Load instrumentation are instruments used in combination to measure load conditions.

u. **Maintenance-free battery**. A maintenance free battery is a rechargeable battery requiring only cleaning and regular functional testing.

v. **Manometer**. A manometer is a liquid filled device used to measure pressure. It consists of two chambers partially filled with a liquid and connected so that the liquid is free to flow from one to the other. A pressure applied to the liquid in one chamber is communicated to the other chamber only through the liquid.

w. **Megohmmeter**. A megohmmeter is a special type of ohmmeter used to measure high resistance.

x. **Microgrid**. A Microgrid is a small-scale power grid with multiple sources that can operate independently. See definition for tactical Microgrid.

y. **Mobile Electric Power Distribution System (MEPDS)**. MEPDSs are equipment including protective devices, boxes and cabling necessary to distribute power from MEPGS to the load (user equipment that requires power).

z. **Mobile Electric Power Generating Source (MEPGS)**. MEPGSs are mobile, electric power generating sources, 1.5 Megawatt (MW) and smaller which are skid-mounted, wheel-mounted, or man-portable that are complete equipment assemblages or a part of an assemblage, and that are capable of independently producing electric power. Examples are engine driven generating sets, hybrids, fuel cells, photovoltaic systems, wind generation, and thermoelectric devices.

aa. **Mobile Electric Power System (MEPS)**. MEPSs consist of Mobile Electric Power Generating Sources, Mobile Electric Power Distribution Systems, Mobile Electric Power Storage Systems, and Mobile Electrical Power Management Systems. A MEPS is also called a power system.

bb. **Mobile Electrical Power Management System (MEPMS)**. MEPMSs are power management systems that control power generation systems and loads to efficiently reduce the energy usage and logistics support on the battlefield. Examples are Microgrid or hybrid controllers.

cc. **Mobile Electrical Power Storage System (MEPSS)**. MEPDSs are storage devices capable of accepting and providing energy greater than 500 Watts, e.g. rechargeable battery or capacitor.

dd. **Multiplier**. A multiplier is an electronic measuring instrument consisting of a wire wound resistor that provides a high resistance in order to drop excess voltage allowing a voltmeter to read a potential difference that is greater than the measuring capability of the device.

ee. **Ohmmeter**. An ohmmeter is an instrument that measures resistance.

ff. **Oscillogram**. An oscillogram is a graphical representation of a wave.

gg. **Oscillograph**. An oscillograph is an instrument for measuring alternating or varying electric current in terms of current and voltage.

hh. **Oscilloscope**. An oscilloscope is a type of electronic test instrument that allows observation of constantly varying signal voltages, usually as a two-dimensional plot of one or more signals as a function of time.

ii. **Overload**. An overload is a situation where an electrical machine or system is subjected to a greater load than it was designed to handle.

jj. **Overvoltage**. An overvoltage is a situation where excess voltage relative to the normal operating voltage is applied to a system or machine.

kk. **Phase angle**. The phase angle is the phase difference between the voltage applied to the impedance and the current driven through it.

ll. **Phase angle meter**. The phase angle meter is a device which employs pulse measurement of the difference in time between zero and crossover of the compared voltages to measure the phase angle.

mm. **Phase rotation**. Phase rotation is the order of the phase voltages at the output terminals of a three-phase generator.

nn. **Phase rotation indicator**. A phase rotation indicator is a device which indicates the order of the phase voltages at the output terminals of a three-phase generator.

oo. **Potential transformer**. A potential transformer is a device which produces a reduced voltage accurately proportional to the voltage in the circuit.

pp. **Power**. Power is the rate at which electric energy is transferred by an electric circuit. The SI unit of power is the watt, one joule per second.

qq. **Power factor**. Power factor is the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number between -1 and 1.

rr. **Power factor meter**. A power factor meter is a device used to measure the power factor.

ss. **Power system**. A power system is a Mobile Electric Power System (MEPS).

tt. **Pressure**. Pressure is the exertion of force upon a surface by an object, fluid, etc., in contact with it.

uu. **Primary fuel**. A primary fuel permits full design performance.

vv. **Rated load**. As defined in the procurement document, rated load of the power system is rated kilowatt at rated power factor, rated frequency and rated voltage.

ww. **Resistance**. Resistance is the opposition to current flow.

xx. **Selector switch**. A selector switch consists of a mechanical or electrical or electronic device for making or breaking or changing the connections in a circuit.

yy. **Short circuit**. A short circuit is a connection between two points of different potential in an electric circuit, bypassing the load and establishing a path of low resistance through which an excessive current can flow.

zz. **Shunt**. A shunt is a device which allows electric current to pass around another point in the circuit by creating a low resistance path.

aaa. **Single-phase system**. A single-phase system distributes AC electric power using a system in which all voltages of the supply vary in unison.

bbb. **Sound**. Sound is a vibration that propagates as a typically audible mechanical wave of pressure and displacement through a medium such as air or water.

ccc. **Sound level meter**. A sound level meter is an instrument for reading, in terms of a standard reference sound level, the sound level at its microphone. The instrument consists essentially of a microphone, electronic amplifying and filtering equipment, octave band analyzer, and an indicating meter calibrator.

ddd. **Speed**. Speed is the rate of change of position with respect to time.

eee. **Speed counter**. A speed counter is an instrument used to measure speed. One of the ways to measure speed during a test is to count revolutions for a measured time interval.

fff. **Tachometer**. A tachometer is an instrument that measures the rotational speed of a shaft or disk, as in a motor or other machine.

ggg. **Tactical Microgrid**. A tactical Microgrid is a warfighter-operated and maintained, mobile, flexible group of interconnected sources and loads with a power generation capacity less than 1.5 MW that acts as a single controllable entity, which can be organized as a system, intended to be self-contained, readily deployable, may utilize power storage and limited alternative energy resources, and is capable of interfacing with other grids.

hhh. **Temperature**. Temperature is the degree or intensity of heat present in a substance or object.

iii. **Test method.** A test method is the criteria and procedures used to formulate a test.

jjj. **Thermocouple**. A thermocouple is a thermoelectric device used for measuring temperature. A thermocouple consists of two metals in contact with each other at two junctions. The voltage developed between the two junctions is in proportion to the temperature difference.

kkk. **Thermometer**. A thermometer is a device that measures temperature or a temperature gradient using a variety of different principles. A thermometer has two important elements: the temperature sensor (e.g. the bulb on a glass thermometer) in which some physical change occurs with temperature, plus some means of converting this physical change into a numerical value (e.g. the visible scale that is marked on a glass thermometer).

lll. **Three-phase system**. A three-phase system distributes AC electric power using a system in which all currents of the supply reach their peak sequentially.

mmm. **Time**. Time is a measure of the durations of events.

nnn. **Transient**. A transient is a momentary variation in current, voltage, or frequency.

ooo. **Transient waveform recorder**. A transient waveform recorder is an analog-to-digital converter with memory used to measure momentary variation in voltage or frequency.

ppp. **Voltage**. Voltage is the electromotive force or the electrical potential difference between two points in a circuit expressed in volts.

qqq. **Voltmeter**. A voltmeter is an instrument used for measuring the electrical potential difference between two points in an electric circuit.

rrr. **Watt**. A watt is the unit of measurement for power.

sss. **Wattmeter**. A wattmeter is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit.

ttt. **Waveform**. A waveform is the shape and form of signal such as a wave moving in a physical medium or an abstract representation. In the case of power systems, the waveforms are usually of voltage or frequency.

uuu. **Waveform recorder**. A waveform recorder is an analog-to-digital converter with memory to measure waveforms of voltage and frequency.

vvv. **Weight**. Weight is a body's relative mass or the quantity of matter contained by it, giving rise to a downward force.

www. **Wheatstone Bridge**. The Wheatstone Bridge is an electrical circuit used to measure an unknown electrical resistance by balancing three legs of a bridge circuit, one leg of which includes the unknown component.

3.2 Acronyms.

| | |
|---|---|
| AMSC | Acquisition Management Systems Control |
| ANSI | American National Standards Institute |
| ASHRAE | American Society of Heating, Refrigerating and Air Conditioning Engineers |
| DOD | Department of Defense |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronics Engineers |
| ISO | International Organization for Standardization |
| MEPDS | Mobile Electric Power Distribution Systems |
| MEPGS | Mobile Electric Power Generating Sources |
| MEPS | Mobile Electric Power Systems |
| MEPMS | Mobile Electrical Power Management Systems |
| MEPSS | Mobile Electrical Power Storage Systems |

| | |
|---|---|
| NCSL | National Conference of Standard Laboratories |
| NEC | National Electric Code |
| NIST | National Institute of Standards and Technology |

3.3 Abbreviations.

| | |
|---|---|
| A | Amperes |
| A/D | Analog-to-digital |
| AC | Alternating Current |
| AGM | Absorbed Glass Mat |
| Ah | Ampere-hour |
| C | Celsius |
| CCA | Cold Cranking Amps |
| DC | Direct Current |
| F | Fahrenheit |
| GAA | Grease, Automotive and Artillery |
| Hz | Hertz |
| KVAR | Kilovolt-amperes reactive |
| kW | Kilowatt |
| MTA | Munson Test Area |
| NBC | Nuclear Biological Chemical |
| SI | International System of Units |
| SPL | Sound Pressure Level |
| V | Volt |
| VAR | Volt-amperes reactive |
| VRLA | Valve Regulated Lead-Acid |
| W | Watt |

# 4. GENERAL REQUIREMENTS

4.1 Physical standards, conventions and calibration traceability. Primary and secondary standards, conventions, and values for calculations, computations, conversions, and calibration of instruments shall be those recognized by the International Electrotechnical Commission (IEC), International Organization for Standardization (ISO), and the United States National Institute of Standards and Technology (NIST). The IEC and ISO are both located in Geneva, Switzerland. In the U.S.A., obtain information regarding all these standards and conventions from NIST, Gaithersburg, MD 20899.

Requirements for the calibration of measuring and test equipment shall be in accordance with ISO 10012 and American National Standards Institute/National Conference of Standard Laboratories (ANSI/NCSL) Z540.2, Z540.3, and shall be considered competent when accredited to ISO/IEC 17025. The results of a calibration or measurement shall be traceable through a controlled, unbroken chain of competent calibrations and associated uncertainties to and through the NIST to the SI units of measurement.

All test instruments shall be calibrated per ANSI/NCSL Z540.3 at maximum intervals of 6 months to ensure their accuracy. If the test instrument manufacturer's recommended calibration interval is less than 6 months, that interval shall be used for that instrument. If upon calibration the test instrument requires adjustment to be within specification, then the calibration interval for that instrument shall be reestablished in accordance with ANSI/NCSL Z540.3. Test instruments shall be calibrated within 30 days prior to the start of any new test program.

4.2 Accuracy of test instruments. Indicating laboratory-type electrical instruments referred to in this Standard shall have accuracy of at least 0.5 percent of full scale, unless otherwise specified herein or in the procurement document. Instruments will be selected and connected to indicate in the accurate portion of their range.

Some instruments have leads which are calibrated for use with particular instruments. These instruments shall always be used with the leads provided or the calibrations will be useless. The calibrated leads shall not be used for any purpose other than that for which the leads were calibrated.

For testing, three significant digits are required for all electrical measurements unless additional digits are needed for clarity or definition for the applicable test.

4.3 Test instrumentation. Instrumentation shall not be powered from the power system under test.

4.4 Digitized testing and evaluating systems. Digitized testing systems may be used alone or in conjunction with other types of test instrumentation as long as all data required in each Method is obtained. Digital evaluation of test data can be used as long as all data is evaluated correctly.

4.4.1 Testing and evaluating system approval. For all DOD standard family power system contracts, PM E2S2 shall approve the testing and evaluating system prior to the beginning of testing.

4.4.1.1 Approved testing and evaluating system changes. For all DOD standard family power system contracts, PM E2S2 shall re-approve the testing and evaluating system if changed in anyway.

4.5 Comprehensive risk assessment. Testers shall perform a comprehensive risk assessment to determine power system safety characteristics and any hazards prior to conducting any test listed in this Standard.

4.6 Failure requirements. No failure requirements are provided in this Standard. Failure requirements shall be listed in the procurement document.

## 5. DETAILED REQUIREMENTS

5.1 Test methods. The individual test methods immediately follow section 6 of this document.

5.2 Test method guidelines. Unless otherwise specified, all testing shall be in accordance with the general laboratory test method guidelines of MIL-STD-810.

5.3 Tailoring. The methods documented herein may be tailored to meet the requirements of the tester to verify the power system's characteristics and compliance with user needs. If so, the procurement agency/Project Manager (or designated representative) shall approve the tailoring. The tester will document any tailoring in the final report.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This Standard explains, establishes and standardizes specific methods for measurements associated with the evaluation of mobile electric power systems. Use this standard to determine compliance with characteristics represented by procurement documents.

6.2 MIL-HDBK-705. Methods 101.1 through 222.1 of MIL-HDBK-705 were revised and incorporated into this Standard. The revisions to these Methods will continue from MIL-HDBK-705. For instance, Method 105.1 is at revision b in MIL-HDBK-705. Once revised, METHOD 105.1 is at revision c in this Standard.

6.2.1 MIL-HDBK-705 indexing. The incorporation of the methods maintains the indexing of MIL-HDBK-705. For instance, Method 101.1 of MIL-HDBK-705 is now METHOD 101.1 of this Standard. Appendix A on load banks in MIL HDBK-705 was revised and incorporated into this Standard as METHOD 118.1 and METHOD 118.1, APPENDIX A.

6.2.2 Methods incorporaed from MIL-HDBK-705.

| Method Number | Title |
|---|---|
| 101.1c | Measurement of Potential |
| 102.1c | Measurement of Current |
| 103.1c | Measurement of Power |
| 104.1c | Measurement of Frequency |
| 105.1c | Measurement of Resistance |
| 106.1c | Measurements of Transients and Waveform |
| 107.1c | Measurement of Power Factor |
| 108.1c | Measurement of Time |
| 109.1c | Measurement of Speed |
| 110.1c | Measurement of Temperature |

| | |
|---|---|
| 111.1c | Measurement of Weight and Force |
| 112.1c | Measurement of Pressure |
| 114.1c | Temperature Control (Hot Room) |
| 114.2b | Temperature Control (Cold Room) |
| 114.3b | Temperature Control (Altitude Chambers) |
| 115.1b | Measurement of Sound Level |
| 116.1c | Determination of Phase Rotation |
| 117.1c | Determination of Phase Relationship |
| 118.1 | Load Banks |
| 201.1c | Electrical Instruments: Care, Inspection, Use, and Required Accuracy |
| 202.1c | Thermal Instrumentation |
| 203.1c | Data Sheets and Record Entries |
| 205.1c | General Instructions for Connecting Testing Instruments |
| 220.1c | Engine Pressure Measurements |
| 220.2c | Pressure and Temperature Corrections to (Spark and Compression Ignition) Engine Data |
| 221.1b | Temperature Corrections to Resistance Measurements |
| 222.1b | Battery Servicing and Condition Assurance Prior to "Cold Starting" Tests |

6.3 Unchanged methods. Some methods were not changed and still reference MIL-HDBK-705. Of these Methods, the applicable figures were updated to an editable format; however, the contents of the figures and the figure numbers did not change. The unchanged methods are as follows:

| Method Number | Title |
|---|---|
| 414.1c | Rotating Exciter Saturation Curve Test |
| 415.0b | Summation of Losses Test |
| 416.1b | Brush Potential Test |
| 423.1b | Zero-Sequence Reactance Test |
| 424.1b | Quadrature-Axis Synchronous Reactance Test |
| 430.1a | Direct-Axis Transient Open-Circuit Time Constant Test |
| 506.1b | Underspeed Protective Device Test |
| 509.1b | Circulating Current Test |

| | |
|---|---|
| 510.1d | Rheostat Range Test |
| 516.1a | Controls, Direction of Rotation |
| 521.1a | Paralleling Aid Device Test |
| 610.1b | Voltage and Frequency Droop Test |
| 611.1b | Inherent Voltage Droop Test |
| 614.1b | Voltage and Frequency Regulation Test (for Generator Sets) |
| 615.1b | Inherent Voltage Regulation Test |
| 621.1b | Unbalanced Load Heating Test |
| 652.1b | Shaft Current Test |
| 680.1c | Temperature Rise Test (Generator Only) |
| 680.2b | Temperature Rise Test (Alternate Loading Method) |
| 702.1c | Standby Operation Test (Extreme Cold) |
| 711.6b | Immersion Test |
| 740.1c | Vibration Test |
| 740.7a | Forklift Handling Test |
| 760.2c | Winterization Test |
| 770.1c | Rectifier Test |
| 771.1a | Load Bank Test |

6.4 New Methods.

| Method Numbers | Title |
|---|---|
| 608.3 | Voltage and Frequency Drift Test |
| 619.3 | Voltage Undershoot for Low Power Factor Loads Test (RMS Method) |
| 619.4 | Voltage Undershoot and Overshoot for Rated Load Test (RMS Method) |
| 670.2 | Fuel Consumption Test (Load Profile) |
| 695.2 | Wet Stacking Test |
| 772.1 | Ice Glaze and Wind Test |
| 773.1 | Solar Radiation Test |
| 774.1 | Road Test |
| 801.1 | Alternate/Emergency Fuel Test |
| 802.1 | Safety and Health Test |
| 803.1 | Human Factors Engineering Test |

6.5 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of this Standard.

6.6 Subject term (key word) listing.

Digitized
Frequency regulation
Fuel consumption
Generator set
Microgrid
Reliability
Saturation curve
Short circuit
Stability
Torsiographic
Transient reactance
Voltage regulation
Waveform

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to previous issue due to extent of the changes.

METHOD 101.1c

MEASUREMENT OF POTENTIAL

101.1.1 General. Potential is the measurement of the energy within an electric field, or an electric circuit, at a given point. The terms "voltage", "electromotive force", and "potential" are considered synonymous herein.

101.1.2 Indicating voltmeters.

101.1.2.1 DC voltage. Voltmeters measure DC voltage. Connect the voltmeter in accordance with manufacturers' recommendations.

Voltmeter ranges can be further extended, even beyond 50,000 volts, by conjunctive use with externally-attached multiplying devices. Such devices, commonly referred to as "series resistance multipliers" and "series multipliers", are precision-made, wire-wound resisters. They are carefully manufactured and calibrated to be electrically stable within specific tolerances over ranges of temperature and periods of time.

Do not connect voltmeters, especially millivoltmeters, into circuits having voltages higher than the rating of the instrument. To measure voltages higher than the rating of a relatively low resistance instrument, use a "series resistance multiplier" with it. In this case, solve for the correct voltage using the following equation:

$$E = \frac{V_r(R_v + R_m)}{R_v}$$

Where:

$E$ is the voltage to be measured.

$V_r$ is the reading of the voltmeter.

$R_v$ is the resistance of the voltmeter. (This may be found on the voltmeter dial or on the voltmeter cover.)

$R_m$ is the resistance of the series multiplier. (This value is usually stated on the exterior of the series multiplier housing.) This formula, solved for $R_m$, can be used for selecting a series multiplier to be used if the approximate value of $E$ is known.

DC voltmeters may be subject to high-inductive-voltage surges; therefore, disconnect the DC voltmeters from a field circuit before the field switch is opened or closed. Because of high alternating voltages developed by transformer action in the field windings during starting, also disconnect DC voltmeters from synchronous motors or synchronous condenser fields before the machines are started from the AC line.

101.1.2.2 AC voltage. Voltmeters measure AC voltage. Do not use voltmeters outside their rated frequency range.

101.1.3 Recording voltmeters. Use recording voltmeters to measure transients or time-varying voltages.

101.1.4 Potential transformers. Use potential transformers for two purposes: to isolate the testing instruments from the line voltage, and to act as multiplying devices for the instruments.

To obtain satisfactory accuracy when using a potential transformer use at manufacturer's rated conditions of voltage, frequency, and volt-ampere burden.

# METHOD 102.1c

## MEASUREMENT OF CURRENT

102.1.1 General. Current is the measure of the amount of electrical charge transferred per unit time. Obtain current from the following formula:

$$I = \frac{E}{R}$$

Where:

$I$ is the current in amperes.

$E$ is the potential reading in volts.

$R$ is the resistance in ohms.

102.1.2 Indicating ammeters. When any ammeter is used in a circuit having cyclic or varying current levels, such as exciter fields, recognize that the accuracy of the instrument is compromised by these fluctuations, often by an amount that renders the instrument useless for the intended measurement. Filtering devices are available for minimizing the effects of these fluctuations.

102.1.2.1 Direct current (DC). For the measurement of direct current, ammeters are used.

For measuring current beyond the capacity of the instrument at hand, shunts can be used to extend the range of the meters. Shunts are precision four-terminal resistors used to measure current by measuring the voltage drop between the voltage terminals with the current introduced at the current terminals. Shunts are normally calibrated for a specific millivolt drop at a specific known current.

102.1.2.2 Alternating current (AC). For the measurement of root mean squared (RMS) alternating currents, ammeters are used. By combining these ammeters with appropriate current transformers, any AC current measurements having practical significance can be made.

102.1.2.3 Current transformers. Current transformers are used for two purposes: to isolate the instrument from the line voltage, and to act as a multiplying device for the instruments.

If desired, use three current transformers with three ammeters (or one ammeter and a suitable transfer switch) to measure the three line currents on three-phase, three-wire circuits.

**CAUTION: Allowing Direct Current to flow in either winding may cause the transformer core to become magnetized and impair the accuracy of the instrument. If magnetization is suspected or if the calibration is not evident, submit the transformer to a proper calibration facility for certification.**

**WARNING:**

**Dangerously high voltages may be induced in the secondary winding (primary or secondary), causing possible injury to the operator and breakdown of the winding insulation. In order to obtain maximum safety for operators and apparatus, ground one secondary terminal. Ground the metal case or core, if accessible. Do not change connections with voltage on. Connect the primary of the transformer in the line and the secondary to the instruments, and not vice versa; and do not open the secondary of the transformer with the current flowing in the primary. A shorting switch across the secondary will be provided normally as a part of the current transformer. Open this switch only when taking meter readings.**

# METHOD 103.1c

## MEASUREMENT OF POWER

103.1.1 General. Power is the rate at which electric energy is transferred by an electric circuit. Horsepower is the equivalent of the amount of work performed in a given time. One horsepower is the rate of work performed equivalent to raising 33,000 pounds 1 foot in 1 minute.

Mechanical power is most commonly expressed in horsepower. Electrical power ordinarily is expressed in watts. Watt is derived from volt and ampere. Expressed in terms of work performed, one kilowatt (kW) (1,000 watts) is equal to 1.34 horsepower.

103.1.2 DC measurement. Compute DC power by multiplying the voltage and amperage in the circuit using the following formula:

$$W = EI$$

Where:

$W$ is in watts.

$E$ is the voltage.

$I$ is the current.

Ordinarily, do not use wattmeters for measuring power in DC circuits.

103.1.3 AC measurements. Wattmeters for measuring AC power may be designed for use in single-phase or polyphase circuits. Compute power in a single-phase circuit using the following equation:

$$W = EI \cos \theta$$

Where:

$E$ is the line voltage.

$I$ is the line current.

$\cos \theta$ is the power factor (see METHOD 107.1).

Compute power for balanced three-phase circuits using the following equation:

$$W = \sqrt{3} E I \cos\theta$$

Where:

*E* is the line-to-line voltage.

*I* is the line current.

$\cos\theta$ is the power factor.

Wattmeters are generally available with potential circuits rated from 10 to 600 volts, and current circuits rated from 1.5 to 200 amperes. Full scale readings for such instruments range from 15 to 120,000 watts. Some wattmeters are designed for use at low power factors.

Transducers are available to convert real power (watts) to a DC voltage with the DC voltage directly proportional to the power. These transducers may be used during the performance of the tests contained in this Standard providing the accuracy of the system (transducer and voltmeter) meets the instrumentation accuracy requirements in 4.2 and the normal instrumentation calibration requirements in 4.1.

# METHOD 104.1c

## MEASUREMENT OF FREQUENCY

104.1.1 General. Frequency is the number of complete cycles per second in alternating current direction. The standard unit of frequency is the hertz, abbreviated Hz. If a current completes one cycle per second, then the frequency is 1 Hz; 60 cycles per second equals 60 Hz.

The National Institute of Standards and Technology (NIST) maintains the primary standard of frequency in the form of quartz-crystal oscillators maintained under carefully controlled conditions, at constant pressure.

104.1.2 Frequency meters. Frequency meters are used to measure frequency. Recording frequency meters are used to measure the transient change in frequency due to a sudden change in load and the steady state stability under constant conditions. The use of a recording frequency meter is especially convenient for alternating current power systems, and has the important advantage of giving a record of frequency variation.

METHOD 105.1c

MEASUREMENT OF RESISTANCE

105.1.1 General. Resistance is the opposition to current flow. The primary standard of resistance is the ABSOLUTE ohm, which is derived from the fundamental units of length, mass, and time. The National Institute of Standards and Technology (NIST) maintains the primary standards of resistance in the form of 1-ohm resistors, which are kept at constant temperature when in use.

The importance of accuracy in measuring resistance cannot be overemphasized. These measurements are used to calculate the efficiency of a generator and to determine the temperature rise of its windings. Both of these are critical factors in design. These measurements also are used to determine the correctness of the internal connections of the generator, and, at times, to ascertain whether a sample test generator is the same as the production model.

The leads of the winding to be measured shall be clean. Clean the terminal lugs with emery cloth to make sure that all foreign matter, paint, varnish, or oxide coating is removed and only bright, bare metal remains exposed for contact with the test leads. Firmly secure the test leads to assure positive contact with the terminal lugs. Use care to compensate for lead resistance to the test instrument if such resistance is of a significant value compared to the resistance being measured (105.1.3.2).

105.1.2 Classes of resistance measurements. Resistance measurements are divided into three general classes. These are: LOW resistances, covering a range below 1 ohm; MEDIUM resistance, covering a range between l and 100,000 ohms; and HIGH resistances, covering a range above 50,000 ohms. These will be discussed in detail in the following paragraphs.

**CAUTION: Circuits whose resistance is to be measured often are highly inductive, and damage to the detector may result unless the operator exercises the following precautions: Close the battery or supply switch first, wait a few seconds for the current to build up, and then close the detector switch. After obtaining the setting or reading, open the detector switch first, and then open the supply switch.**

105.1.3 Low resistance measurements. Resistances below 1 ohm may be measured by an ohmmeter or by the Double-Bridge method, the Drop-in-Potential method, or the Comparison method.

105.1.3.1 Ohmmeters. Ohmmeters are available with full-scale ratings down to 1 micro ohm.

105.1.3.2 Double-Bridge method. The so-called "Kelvin Double Bridge" is a modification of the "Wheatstone Bridge" and is so arranged that the resistance of the instrument leads and contacts is not included in the measured resistance. It is, therefore, adaptable to the measurement of very small resistances, of which the lead and contact resistance would otherwise form a large and indeterminate part. The double bridge is a null-balance instrument.

These bridges are supplied with special calibrated leads. If other leads are used, they should have a resistance within about 20 percent of the resistance of the regular bridge leads.

105.1.3.3 Drop-in-Potential method. Ohm's Law states the following:

$$R = E/I$$

Where:

$R$ is the resistance.

$E$ is the voltage.

$I$ is the current.

If the voltage across the resistance and the amperage through it are known the resistance may be calculated. Thus, to measure a resistance by the drop-in-potential method, connect the unknown resistance in series with an ammeter and a source of constant direct current. Connect a voltmeter across the resistance. Then, calculate the resistance by dividing the voltmeter reading by the ammeter reading (FIGURE 105.1-1).

The current used should be great enough to give good instrument readings without heating the unknown resistance, which would change its value. If the current used is unsteady, take simultaneous instrument readings by two observers. A series of such readings, when averaged, will give reasonably accurate results although the individual readings are in error.

The ratio of the voltmeter resistance to the unknown resistance affects the accuracy of the measurement because the voltmeter current flows through the ammeter. The fractional error is equal to the reciprocal of this ratio (the unknown resistance divided by the voltmeter resistance). If the ratio is 1,000 or less, correct the ammeter reading accordingly.

For very precise work, replace the voltmeter with a potentiometer, and replace the ammeter with a potentiometer and calibrated shunt.

105.1.3.4 Comparison method. The comparison method of measuring resistance is an adaptation of the drop-in-potential method described above. However, the results are independent of the current measurement.

In this method, connect the unknown resistance in series with a known resistance and a source of direct current (FIGURE 105.1-2). Measure the voltage across both resistances and calculate the unknown resistance by the following formula:

$$X = \frac{RE_x}{E_R}$$

Where:

*X* is the unknown resistance.

$E_x$ is the voltage across *X*.

$E_R$ is the voltage across *R*.

*R* is the known resistance.

**NOTE:** Maximum accuracy is obtained when *R* and *X* are equal.

The current source should be steady and the voltmeter should have a resistance 100 or more times the resistance of either *R* or *X*.

This method is especially applicable to a wide variety of measurements in which the actual value of each of a series of resistances is relatively unimportant, but in which all of the elements should be equal, such as the windings of a DC generator, or the field coils of an alternator. In this case, connect the elements to be measured in series and measure the drop across each one. If the resistance of one element is used as a standard, the calculations are the same as previously described.

105.1.4 Medium resistance measurements. Resistances which fall between approximately 1 ohm and 100,000 ohms are measured by either an ohmmeter or with the Wheatstone Bridge method.

105.1.4.1 Ohmmeter. Ohmmeters are available with full-scale ratings from 1 ohm to 100,000 ohms.

105.1.4.2 Wheatstone Bridge method. The Wheatstone Bridge is a null-balance type instrument designed to measure an unknown electrical resistance. The value of an unknown resistance is determined within a network comprised of three known resistances.

**CAUTION: To prevent damage to connected instrumentation, approximate the value of the resistance before selecting the applicable range. Also, consider a system's ability to store energy capacitively and the potentially damaging high voltage transients that can occur in highly inductive circuits.**

105.1.5 High resistance measurements. Resistances of 50,000 ohms and more may be measured by an ohmmeter or by the DC voltmeter or megger method (see 105.1.5.3).

105.1.5.1 Ohmmeter. Ohmmeters are available with full-scale ratings up to 110 megohms.

105.1.5.2 DC voltmeter method. A DC voltmeter with a resistance of approximately 100 ohms per volt, and a source of constant potential, usually about 500 volts, are used in this method.

Connect the voltmeter directly across the source and note the reading. Insert the unknown resistance in series with the voltmeter and source and again note the reading.

Calculate the unknown resistance from the following formula:

$$X = R_v \frac{(E - V_r)}{V_r}$$

Where:

$X$ is the unknown resistance.

$E$ is the supply voltage.

$V_r$ is the voltmeter reading in series with $X$.

$R_v$ is the voltmeter resistance.

Use this method only when the supply voltage is steady. When the voltage is unsteady, take simultaneous readings of $E$ and $V_r$ with two voltmeters. In this case, $R_v$ is the resistance of the voltmeter in series with $X$.

| **WARNING:** |
| --- |
| **Dangerously high voltages may be induced, causing possible injury to the operator. Exercise caution when using this Method due to the high voltage supply.** |

105.1.5.3 Megger method. A "megger", or insulation resistance tester, is a self-contained direct-reading instrument, consisting of a permanent magnetic generator, battery, or electronic power supply, standard resistances; and a differential-current milliammeter.

The electromotive force (emf) of the generator is impressed upon the unknown resistance and the standard resistance, in parallel. The megger compares the two currents in the differential-type instrument so that the instrument reading depends only upon the value of the unknown resistance and is independent of the applied emf.

A slip-clutch is used to obtain constant speed on the hand-driven type instruments in order to avoid the erratic efforts which would otherwise appear as a result of the charging currents caused by variable voltage being applied to circuits having appreciable electrostatic capacity, such as the armatures of large generators. While these instruments are being used, the crank must be turned at a speed sufficiently high to keep the clutch from slipping.

Always operate the megger until the indication is steady and constant before a reading is taken.

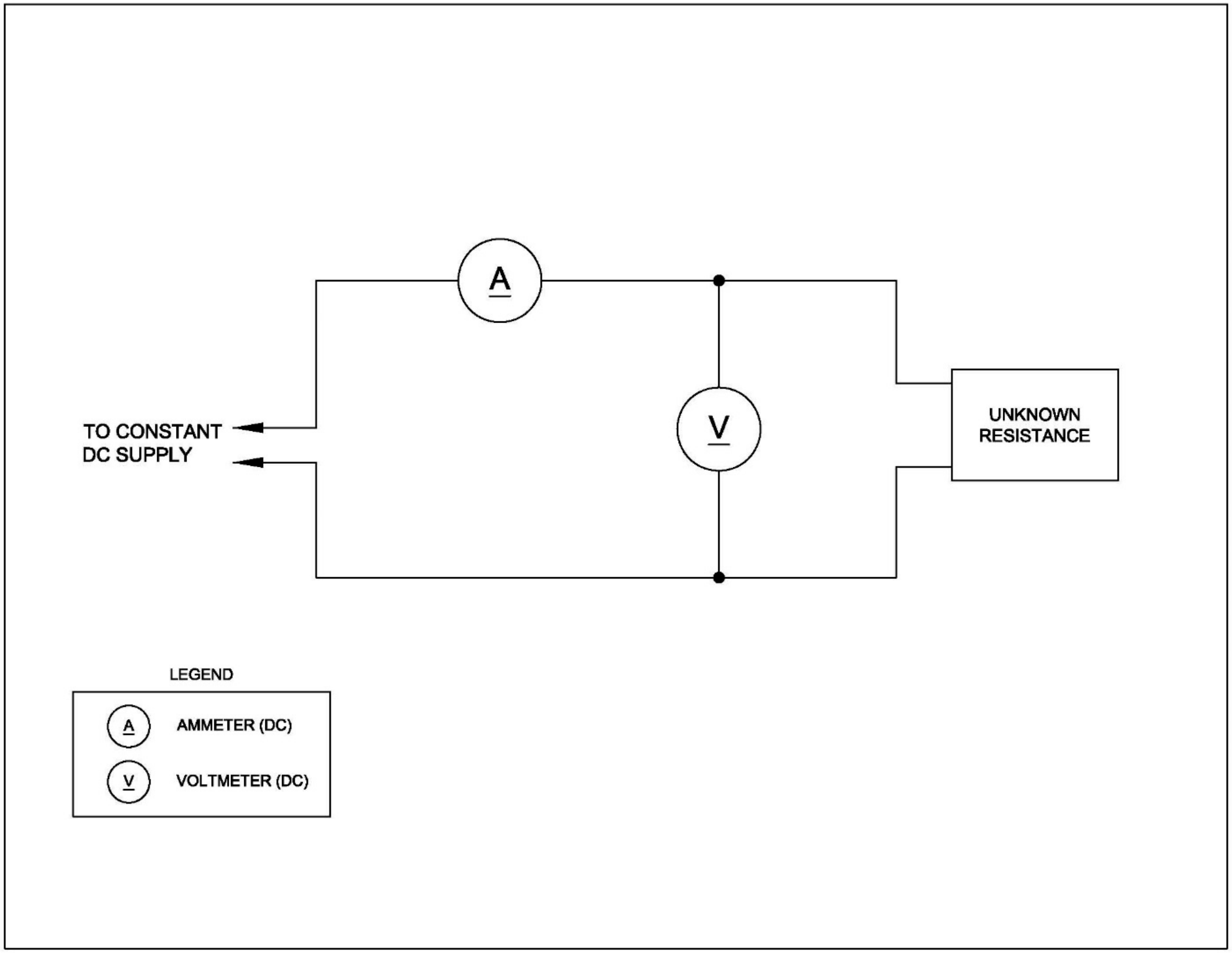



FIGURE 105.1-1 Drop-in-potential test connections.

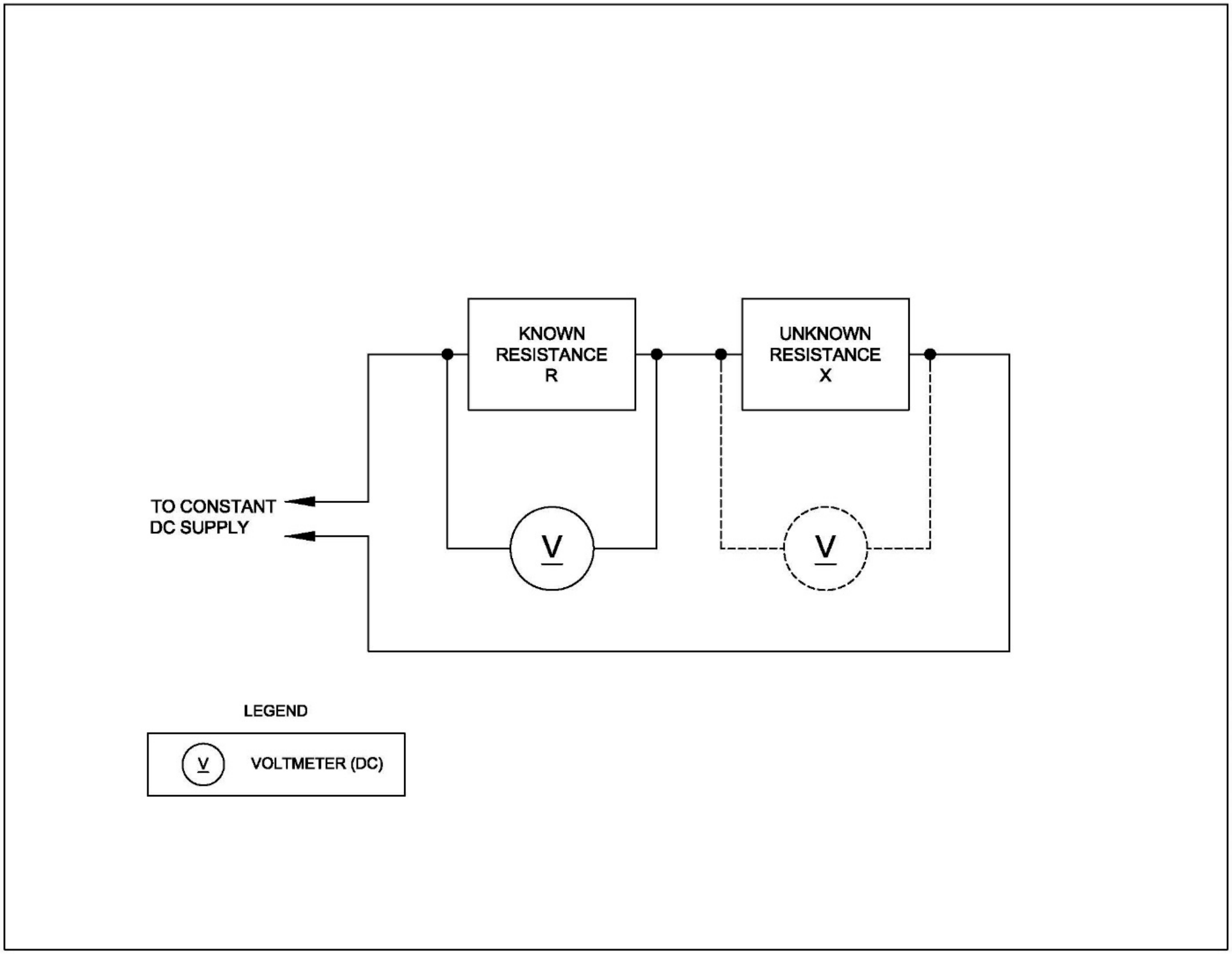



FIGURE 105.1-2 Comparison method test connections.

# METHOD 106.1c

## MEASUREMENTS OF TRANSIENTS AND WAVEFORM

106.1.1 General. A transient is a momentary variation in current, voltage, or frequency. Electrical transients and waveform may be observed by connecting an oscilloscope or an oscillograph to the circuit in question. Waveform cannot be determined by using a harmonic analyzer to measure the magnitude, or relative value, of the component frequencies, and plotting the waveform from these values, since the phase angle differences of the various harmonics would not be known. However, harmonic analyzers may be used to determine a measure of deviation of an unknown wave from a sine wave.

106.1.2 Oscilloscope. Oscilloscopes are extremely versatile instruments which are procurable in single-beam and multi-beam models.

Oscilloscopes use two different kinds of storage: digital and cathode-ray-tube (CRT) type. Digital scopes store data representing waveforms in a digital memory. CRT storage scopes store waveforms within the CRT either on a mesh or special phosphor.

A digital oscilloscope is an instrument that digitizes, stores, and displays a digital representation of analog signals. Sampling is the process of obtaining the value of an input signal at a discrete point in time; quantizing is the transformation of that value into a binary number by the analog-to-digital (A/D) converter. The time base determines how often digitizing occurs. The time base uses a digital clock to time the A/D conversion and to store the data in memory. The rate at which this happens is the digitizing (or sampling) rate. Once the data is stored in the digital memory, it can be recalled for displaying or further waveform processing.

The oscilloscope is used for the observation of waveform and transients; by connecting the signal under observation to the Y, or vertical-axis, input terminals. The internal sweep, which supplies a sawtooth signal, with a magnitude linearly proportional to time, is then applied to the X, or horizontal-axis, input terminals and synchronized to the signal being studied. The resulting screen image shows the waveform of the unknown signal as time progresses.

Observe the following precautions when using an oscilloscope:

**CAUTION: Exercise care when observing line-to-line voltage since the scope may be grounded through the bench power cord. If measurement is above ground potential, isolate scope prior to use. Do not operate the equipment with the case removed due to the internal high voltage hazard.**

(1) Do not keep a small spot or highly intensified line stationary on the screen since such spots or lines will cause the screen to burn or become discolored.

(2) Keep the instrument as far as possible from magnets, power transformers, reactors, or busses carrying current to preclude spurious deflections.

(3) Use a regulated power supply, if extremely large power line voltage fluctuations are present. Also, observe precautions against spurious magnetic fields (see step 2).

(4) Keep the image on the plane portion of the screen. The image will be distorted if it is extended to the edge of the screen due to the curvature of the tube. Moreover, the linearity of the oscilloscope amplifier is seldom satisfactory when the signal is amplified to the value necessary for full screen projection.

106.1.3 Oscillograph.The instantaneous variations of current and voltage in a circuit can be measured by oscillographs. The basic operating principle of an oscillograph may be either: (1) that of a D'Arsonval galvanometer with attached pen with inertia of the pen low enough to permit it to follow low frequency variations; or (2) that of a reflected light beam (inherently has very low inertia) employed in conjunction with electric or magnetic fields to govern the beam's deflection. In addition to tracing waveforms, oscillographs are used for measurements of transient phenomena, such as those that occur in power system characteristic evaluations.

The oscillograph galvanometer may have a light low-inertia coil with attached mirror or, for higher-frequency response, a pair of thin metal ribbons tightly stretched across insulating bridges and tied together by a small mirror at their midpoints, mounted in the field of a permanent magnet. A light beam from the galvanometer mirror traces its response to varying current on a moving photographic film or on a stationary viewing screen by means of an intermediate rotating mirror. Light beam galvanometer elements have been built with natural response frequencies as high as 8 kHz (a more common construction has a resonance frequency of about 3 kHz). If damped at about 0.7 of critical, these elements have a response to signals which is practically free from distortion up to about half their resonant frequency. At resonant frequency, the deflection sensitivity of the elements is decreased to about 70 percent of their DC sensitivity to the damping.

Observe the following precautions when using an oscillograph:

(1) Use well insulated and twisted double conductor type or shielded type leads connected to the circuit to be tested to avoid inductive effects.

(2) Protect the oscillograph against mechanical vibration at all times, but especially during operation.

(3) Condition the oscillograph input signal in accordance with the manufacturer's recommendations to obtain proper indications and to match the galvanometer specifications.

(4) Ensure all circuit connections are tight.

(5) Check the light beam for proper width and focus.

(6) Use the proper amplifier for protection of the galvanometer. Include the maximum resistance in the control circuit prior to application of the signal. The resistance may be reduced to obtain the desired deflection. This affords maximum protection for the galvanometer.

(7) If an automatic delay circuit is not included in the oscillograph, allow sufficient time for the drum holding the photosensitive paper to attain its operating speed before taking the event record.

(8) Dampen the galvanometer(s) in accordance with manufacturer's instructions.

106.1.4 Harmonic analyzer. The harmonic analyzer is essentially a precise electronic voltmeter combined with a tunable band-pass filter with provisions for determining the magnitude or the relative value of voltages of different superimposed frequencies applied to its terminals.

To obtain the harmonics with a harmonic analyzer, connect the signal to the input terminals and the magnitude or relative value of the fundamental and harmonics is determined in accordance with instructions obtained from the manufacturer of the harmonic analyzer.

**CAUTION: Take care to assure the analyzer is ungrounded when used on line-to-line voltages. Be aware that this above ground potential is present and personnel must not touch the analyzer and a grounded conductor at the same time.**

106.1.5 Transient waveform recorder. A waveform recorder is most simply described as an analog-to-digital converter with memory. These waveforms can then be output in various ways. The display output reconstructs the stored digital data via a digital-to-analog (D/A) converter at a repetitive cycle for a flicker-free presentation on a x-y monitor or an oscilloscope. A plot may be obtained from the D/A output for record and analysis. Digital output is also available for interface with external computer input busses. This feature facilitates incorporation of the instrument into extensive automated data collection and analysis systems. Digital oscilloscopes with storage capability are also transient waveform recorders.

Transient waveform recorders have fast analog-to-digital converters. These converters can sample and digitize information at rates to 10 million times per second and can store 4,000 points of data at this acquisition rate. Voltage resolution of 1 part in 1,000 is possible.

# METHOD 107.1c

## MEASUREMENT OF POWER FACTOR

107.1.1 General. Power factor is the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number between -1 and 1. Real power is the capacity of the circuit for performing work in a particular time. In single-phase and balanced three-phase systems it is equal to cos $\theta$, where $\theta$ is the phase angle between the voltage and current in a single-phase circuit, or between the phase voltage and phase current in a balanced three-phase circuit.

Reactive volt-amperes (VARS) are the product of the reactive voltage and current, or the product of the voltage and reactive current in an AC circuit.

107.1.2 Instruments and equipment for power factor measurement. Compute DC wattage by ascertaining the product of the voltage and current in a circuit from the following equation:

$$W = EI$$

Where:

$W$ is the power in watts.

$E$ is the potential in volts.

$I$ is the current in amperes.

When this same mathematical process is applied to an AC circuit, the resulting answer is not necessarily a measure of the power and is either equal to or greater than the actual power. If this product, called "apparent power" (VA, or Volt-Amps), is divided into the actual power ($W=EI \cos\theta$) of a circuit, the result ($\cos\theta$) is defined as the power factor of the system.

Load banks are routinely used to simulate load conditions for electrical power system testing and evaluation. Information on load banks is contained in METHOD 118.1.

When the load is entirely resistive, the power factor will be unity. If any inductance is in the circuit, the value of the power factor will be less than unity and is said to be "lagging" (current "lagging" or not in phase with the voltage). Thus, if the power actually consumed by an inductive load is 300 watts and the product of the voltage and amperage is 500 volt-amperes, the power factor is 300/500, or 0.6 lagging. If capacitance is present in the circuit, the value of the power factor will be more than unity and is said to be "leading" (current leading voltage).

When measuring a three-phase balanced system, that is, one in which the voltages are equal in the three phases and in which the currents are likewise equal, and no current in the neutral conductor, use the formula for power as follows:

$$W = \sqrt{3}EI \cos\ \theta$$

Where:

*E* is line voltage.

*I* is current.

*cos θ* is the power factor.

Instruments are designed to measure the power factor in single-phase circuits, and other instruments are designed to measure the power factor in balanced three-phase circuits. No instruments are designed to measure power factor directly in unbalanced three-phase systems or in systems in which the alternating current wave is greatly different from a sine wave. More rigorous methods of analysis are necessary to determine power factor in these cases. These are beyond the scope of this Standard but are amply discussed in handbooks on electrical metering and instrumentation.

In measuring low values of power factor, take care not to use a meter which is accurate only for high values of power factor. Balanced polyphase systems and sinusoidal voltages and currents are assumed in the following discussions.

107.1.3 Instruments for reactive volt amperes. Determine power factor from the equation:

$$PF = \cos(\tan^{-1}\frac{VAR}{W})$$

Where:

*PF* is the power factor.

*VAR* is the reactive volt-amperes.

*W* is active power.

Reactive volt-amperes may be measured on an ordinary wattmeter, providing either the voltage or current coil is excited by a signal proportional to, and vectorially in quadrature with, its normal wattmeter excitation. The two common methods of providing such excitation are described below.

107.1.3.1 Series reactance method. The potential coil excitation may be shifted 90 degrees by the insertion of a series reactance in the potential coil circuit. This type of instrument is connected in the same manner as a standard wattmeter, and may be used in single-phase circuit as well as in individual phases of a polyphase circuit.

107.1.3.2 Cross-Phase method. In three-phase systems, the active component of current in one line is in quadrature with the voltage between the other two lines, while the reactive component of the same current is in phase with this voltage. Thus, an ordinary wattmeter connected with its current coil in one line and its potential coil between the other two lines indicates VAR directly. Total VAR for the system is the wattmeter reading multiplied by the square root of three.

107.1.4 Phase angle meters. Various other instruments, graduated in terms of either phase angle or power factor, are available for power factor measurements. These instruments may operate on any of a number of principles such as the use of phase angle itself, or the use of a mechanical comparison of the speeds of a watt-hour meter and VAR-hour meter to indicate power factor directly. Connect them in accordance with manufacturer's instructions, depending upon the type to which they belong.

107.1.5 Two-wattmeter method. When active power is being measured by the two-wattmeter method, calculate the power factor from the two readings by applying the following formula:

$$PF = \cos\theta = \frac{W_1 + W_2}{2\sqrt{{W_1}^2 - W_1 W_2 + {W_2}^2}}$$

Where:

*PF* is the power factor.

$W_1$ is the higher wattmeter reading, which may be either positive or negative.

$W_2$ is the lower wattmeter reading, which may be either positive or negative.

# METHOD 108.1c

## MEASUREMENT OF TIME

108.1.1 General. Time is a measure of the durations of events. The standard of time is the second. The second is defined in terms of radiation emitted by caesium atoms.

108.1.2 Time. For testing purposes, time can be determined using the National Institute of Standards and Technology (NIST) website.

108.1.3 Clocks. All clocks must be accurate to within 0.5 seconds per every 24 hours.

108.1.4 Timers. All timers must be accurate to within 0.5 seconds per every 24 hours.

108.1.5 Oscillogram timing traces. Oscillograms (see FIGURE 108.1-1) may require some sort of time scale if measurements are made on them. The provision of such a scale is quite simple with most galvanometer types of oscillographs. A standard frequency from a crystal or tuning fork oscillator may be impressed upon the element, or a commercial power voltage may be used as a timing trace. On an oscillogram, when position is the important quantity rather than time, as in engine indicator diagrams, the timing trace may be supplied by a contactor on the engine crankshaft, or by a magnetic pickup from a slotted iron disk on the crankshaft. Oscilloscopes may have a so-called Z-AXIS control. This control acts to blank out the trace when a signal is applied. Thus, a periodic pulse may be used to dot the trace and consequently show time intervals by the distance between dots. Oscilloscopes without Z-AXIS control can be made to show a dotted trace by interrupting the signal periodically. This latter method is much more difficult to calibrate; avoid whenever possible.

**SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY**

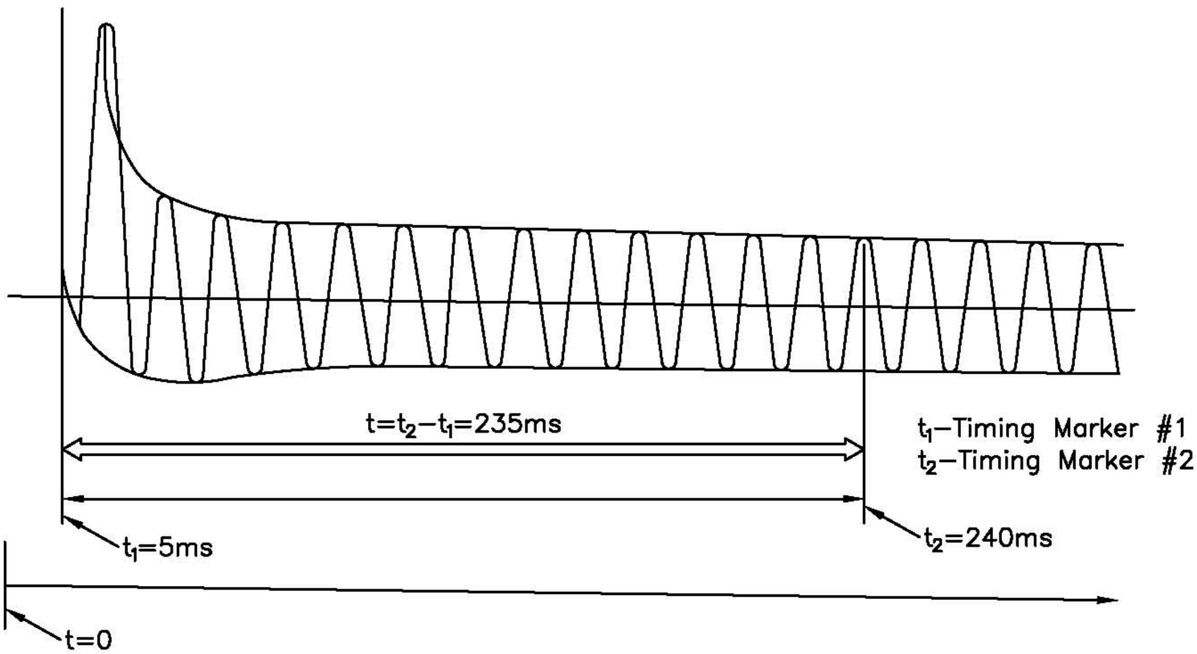



FIGURE 108.1-1 Sample oscillogram with timing traces.

METHOD 109.1c

MEASUREMENT OF SPEED

109.1.1 General. Speed is the magnitude of velocity (the rate of change of position with respect to time). Speed of rotation is derived by counting revolutions and measuring elapsed time. This operation may be performed very accurately by means of a counter and electric clutch, automatically timed by a synchronous clock and a standard frequency source.

Rotational speed may be translated to frequency by the use of an AC generator driven by the rotating element. This then may be measured electrically (see METHOD 104.1).

109.1.2 Speed counters. One of the ways to measure speed during a test is to count revolutions for a measured time interval. This may be done by observing the readings of a counter permanently attached to the machine shaft, or by temporarily attaching a counter to the shaft, through a friction wheel or disk. In either case, the duration of the observation shall be great enough to minimize all the errors due to starting and stopping the stopwatch/timer or counter. In the case of a portable counter, either the counter should be started as the clock hand sweeps through zero, or vice versa. Do not attempt to start both the counter and stopwatch/timer simultaneously.

109.1.3 Direct reading tachometers. Use several methods to indicate speed directly. Among them are the position of centrifugal flyballs, the voltage of a magneto, the pressure of a centrifugal hydraulic pump, photocell sensors, and the eddy-current drag of a rotating magnet on a conducting disk. Each of these devices may be used as a tachometer, and each has its own advantages and disadvantages. Direct reading tachometers are available either for positive connection to the machine under test, or for hand use.

Chronographs or recording tachometers are speed recording instruments in which a graphic record of speed is made. The speed sensing pickup may consist of a mechanically coupled tachometer generator or a magnetic proximity device whose function is to generate a voltage, the magnitude of frequency of which is supplied to the recorder. Some recorders accept electrical signals directly from the AC generator output and record the frequency on the chart as a corresponding speed (revolutions per minute).

109.1.4 Stroboscopes. Stroboscopic methods are especially suitable for determining the speed of machine parts which are not readily accessible, where it is not practicable to use mechanical methods, or where the speed is variable. Stroboscopes are devices for producing periodic light flashes of high intensity and short duration. If a piece of moving machinery is illuminated by such a light source, an observer sees the machine only during the periodic light flashes. If the period is adjusted to coincide with a periodic movement or rotation of the machine, the machine will appear to stand still. Any deviation from synchronism will appear as a slow movement of the machine through its operating cycle. Therefore, if the frequency of the light is held constant, the machine speed may be held constant by keeping it "standing still". Also, if a disk having radial stripes is mounted on the-machine as a target for the stroboscope, and the stroboscope is excited with a constant frequency, the machine speed may be held to any integral multiple or fraction of the stroboscope frequency.

The accuracy of stroboscopes depends on calibration of the dial and since most dials only have cardinal markings, stroboscopes cannot be used for accurately determining speed unless the instrument has an external input connection for an input from an oscillator of known accuracy.

METHOD 110.1b

MEASUREMENT OF TEMPERATURE

110.1.1 General. Temperature is the degree or intensity of heat present in a substance or object. Temperature measurement by electric means is done almost exclusively with direct current. There are three methods used to determine temperatures of various components of a power system, as well as the temperatures of coolants, lubricants, etc. These three methods are: contact, resistance, and embedded detector.

When temperatures are to be obtained by thermocouples, resistance thermometers, or other electric temperature measuring devices, take care to insure that these elements and their indicating instruments are functioning properly. Install the wiring between the detecting elements and the indicating instrument so there are no loose connections. Take a complete set of ambient temperature readings on the power system prior to starting the power system to confirm the functioning of an instrumented power system. Do not operate the power system for 12 hours prior to the readings. Compare the complete set of readings with the temperature of principal metal parts of the machine, as measured with several reliable thermometers. The electric devices should indicate consistent temperatures in close agreement with the thermometers. If appreciable temperature differences exist, check for loose connections, stray fields, and the possibility that the machine has not reached a uniform temperature. If necessary, replace the faulty temperature measuring device.

The temperature rise of certain components and materials during operation of the power system is an important characteristic. Temperature rise is the difference between the temperature of the component or material, and the ambient temperature, at a point in operation of the power system where temperatures have stabilized. Temperature stabilization of a component is reached when three consecutive readings taken at 10-minute intervals are the same or within the limits of variation as specified in the procurement documentation.

110.1.2 Contact method. The contact method consists of determining temperature by placing a thermometer or a thermocouple in direct contact with the component or material whose temperature is to be measured.

When these devices are used in connection with the measurement of surface temperatures, cover them with oil putty, or a felt pad. The covering material is used to protect the temperature device from the air above the surface but should not be so large as to interfere with the natural cooling of the surface by circulation of the ambient air.

A thermocouple consists of two metals in contact with each other. The two metals are of different molecular structure, and electromotive force is produced at the junction of the two metals due to temperature. Use the type of thermocouple that has a sufficient temperature range to perform methods of this Standard. The electromotive force produced at the junction is compared to another thermocouple output that is at a known temperature, usually either 0°C or room ambient as measured by a thermometer.

Thermocouples are fabricated in different shapes and in different combinations of metals to suit individual locations and for different ranges in temperature. These thermocouples are used in connection with various types of thermal potentiometers which indicate temperature in degrees, or in numbers which can be converted to degrees. Complete temperature data acquisition systems are commercially available for handling inputs from a few to several hundred thermocouples.

A block diagram of a typical system is shown in FIGURE 110.1-1.

To determine the temperature rise, convert both the ambient temperature readings and the maximum contact device readings to degrees Celsius if necessary. Then subtract the ambient from the contact readings.

110.1.3 Resistance method. The resistance method determines temperature by the comparison of the resistance of a winding, at the temperature to be determined, with the resistance of the winding at a known temperature. Since a small error in measuring either the hot or cold resistance will make a comparatively large error in determining the temperature rise, use the Wheatstone or Kelvin Bridge method of obtaining resistance (see METHOD 105.1) to assure accuracy. This method utilizes that characteristic of generator windings whereby a change of resistance is proportional to a change of temperature. Follow the steps below to determine the temperature rise by this method.

(1) Obtain the resistance of the winding at a known temperature. Make the cold resistance measurements with the power system at approximately the surrounding ambient temperature; that is, take the measurements after the power system has been inoperative for a sufficient time (approximately 12 hours) to bring the major power system mass temperature, as measured by a thermocouple, to within 3°C of the ambient temperature.

(2) Operate the device being tested prescribed by the method until it reaches the condition at which the temperatures or temperature rise of the winding is to be obtained.

(3) Record the ambient air temperature at this time and if in degrees F, convert to degrees C.

(4) Compute the hot resistance of a DC field winding from the ammeter and voltmeter readings, as follows:

$$R_h = \frac{V_{ef}}{I_{ef}}$$

Where:

$R_h$ is the hot resistance of the field winding.

$V_{ef}$ is the voltage across the field winding.

$I_{ef}$ is the current in the field winding.

(5) The above method may be used on the stationary fields but should not be used on rotating fields. However, the method described in (6) below, is preferred.

(6) Use the Kelvin, Wheatstone Bridge or other means of equivalent accuracy to determine the hot resistance of the generator armature, exciter armature, and the generator field except in the case of rotating windings of less than 1 ohm resistance (see METHOD 105.1).

(7) Use the drop-in-potential method to obtain the hot resistance of rotating windings of less than 1 ohm resistance (see METHOD 105.1).

(8) To determine the hot resistance by either the bridge method or drop-in-potential method, perform the following:

(a) Shutdown the power system.

(b) Make a reading immediately (in less than 30 seconds).

(c) Make additional readings at intervals of 30 seconds or less for at least 3 minutes. If the resistance is increasing at the end of 3 minutes, continue making readings at 30 seconds intervals until the resistance definitely begins to decrease.

(d) Use a precision timer to determine time from shutdown to initial reading and between subsequent readings (see METHOD 108.1).

(e) Plot the resistance readings against time on semi-log paper. Plot time along the divisions of equal size and plot resistance along the logarithmic divisions. Extrapolate (extend) this curve from the first reading back to the time of shutdown. Use the highest resistance on the curve as the hot resistance. Automated data systems may be utilized for numerical calculations and presentation of this data. In lieu of plotting the data, a linear regression (least squares fit) may be used to determine the resistance at shutdown. Calculate the temperature rise for copper windings from the formula:

$$T_r = T_h - T_a = \frac{R_h}{R_c}(234.5 + T_c) - (234.5 + T_a)$$

Where:

$T_r$ is the temperature rise in degrees C.

$T_h$ is the temperature of the winding in degrees C when hot resistance ($R_h$) was measured.

$T_a$ is the ambient temperature in degrees C.

$R_h$ is the hot resistance.

$R_c$ is the cold resistance.

$T_c$ is the temperature of the winding in degrees C when cold resistance ($R_c$) was measured.

110.1.4 Embedded detector method. The embedded detector method of determining temperature employs thermocouples or a resistance temperature detector built into the machine. Usually they are used on power systems rated above 500 kW and then only if other means of temperature measurement are not practicable.

The embedded resistance temperature detector is a resistance of a known value at a specific temperature. To determine a temperature with an embedded resistance detector, make an accurate measurement of the detector resistance (see METHOD 105.1). Calculate the temperature from the formula:

$$T_r = T_h - T_a = \frac{R_h}{R_c}(234.5 + T_c) - (234.5 + T_a)$$

(The above formula applies only to copper windings.)

Where:

$T_r$ is the temperature rise in degrees C.

$T_h$ is the temperature of the detector in degrees C when $R_h$ is measured.

$T_a$ is the ambient temperature in degrees C.

$R_h$ is the hot resistance.

$R_c$ is the known resistance of the detector at $T_c$ degrees C.

$T_c$ is the temperature of the detector in degrees C when the known resistance ($R_c$) was measured.

110.1.5 Converting Fahrenheit to Celsius, and vice versa.

To convert Fahrenheit to Celsius:

$$C = \left(\frac{5}{9}\right)(F - 32)$$

To convert Celsius to Fahrenheit:

$$F = \left(\frac{9}{5}\right)C + 32$$

When converting a temperature rise from degrees Fahrenheit to degrees Celsius, and vice versa:

$$Temperature\ rise\ in\ degrees\ C = \frac{5}{9}\,(Temperature\ rise\ in\ degrees\ F)$$

$$Temperature\ rise\ in\ degrees\ F = \frac{9}{5}\,(Temperature\ rise\ in\ degrees\ C)$$

**NOTE**: The addition or subtraction of 32 degrees is not used for temperature rise conversions because a difference in temperatures, rather than a temperature, is being converted.

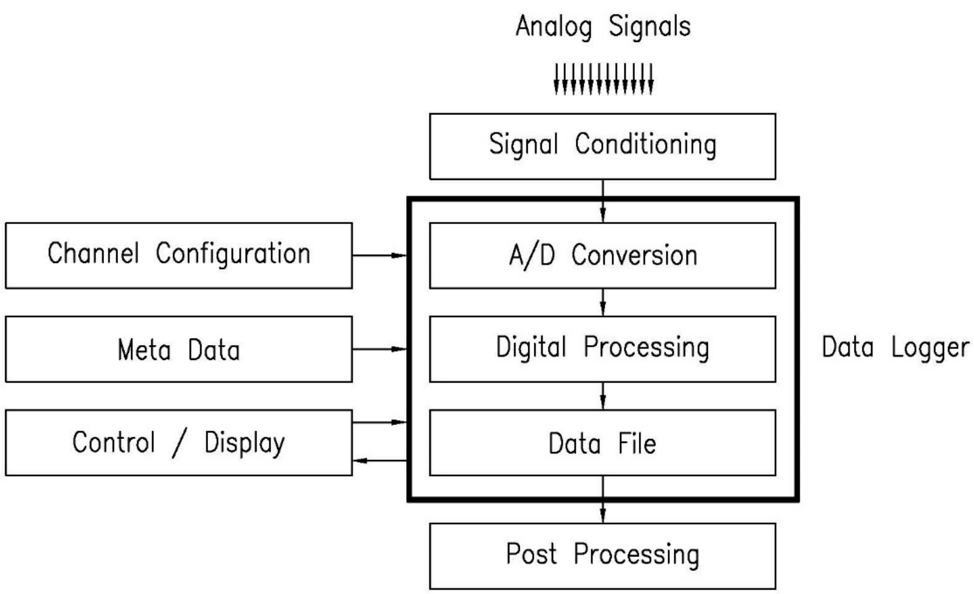



FIGURE 110.1-1 Multiple-sensor automatic data-logging system.

# METHOD 111.1c

## MEASUREMENT OF WEIGHT AND FORCE

111.1.1 General. Weight is a body's relative mass or the quantity of matter contained by it, giving rise to a downward force. Force is a quantitative description of the interaction between two physical bodies, such as an object and its environment. Weights, operating forces, spring tensions, and brake torques are measured on one of the following instruments.

111.1.2 Platform balances. Platform balances are the most accurate means of measuring force that are readily available, and use them in preference to other means whenever practicable. They should be used for all fuel consumption and other weight measurements.

Inspect a platform balance before use to insure that the beam swings freely and to determine if the balance has any zero error. Prove balances every six months to insure that their calibrations remain constant.

**CAUTION: Do not use platform balances where they will be subject to shock or serious vibration, because of the danger of damaging the knife-edge pivots of the instrument.**

Ensure platform balances are level when in use.

111.1.3 Spring balances. Spring balances are much more convenient to use for most force measurements than are platform balances. However, spring balances usually are less accurate. Spring balances may be used in any position, but the zero error should be noted with the balance in the position in which it is to be used.

Spring balances are most useful for measuring such quantities as brush pressure, valve spring pressures, and operating forces of all kinds. In these measurements, use care in order to avoid errors due to friction in the balance. Spring balances are subject to calibration errors due to changes in the spring tension which may occur in normal use. Therefore, check these balances frequently.

111.1.4 Other devices. Load cells utilizing known materials and strain gages, and hydraulic jacks with known piston area and a pressure gage, are acceptable methods of measuring and controlling weight and force.

METHOD 112.1c

MEASUREMENT OF PRESSURE

112.1.1 General. Pressure is the exertion of force upon a surface by an object, fluid, etc., in contact with it. The following instruments are used to measure any of the various fluid pressures encountered in testing power systems.

112.1.2 Deadweight gages. The most accurate pressure-measuring instruments for gage pressures above one atmosphere are deadweight gages. These devices use a small piston loaded with a known deadweight to balance the pressure of oil in a vertical cylinder below the piston. Accurate measurements of the piston area and value of the deadweights are easily obtained so that the instrument can be very accurately calibrated. The only remaining source of error is static friction and this is eliminated by rotating the piston and weights about their vertical axes. These instruments can be used, however, only for constant pressures greater than atmospheric, since they are not direct reading instruments. They are most useful as standards for relatively high pressures, to be used to calibrate other instruments.

112.1.3 Manometers. Liquid manometers always consist of two chambers partially filled with a liquid and connected so that the liquid is free to flow from one to the other. A pressure applied to the liquid in one chamber is communicated to the other chamber only through the liquid. If the pressures in the two chambers are unequal, the liquid will flow from one chamber to the other until the unbalanced pressure is exactly offset by the unbalanced liquid head. If the density of the liquid is known, the pressure can be computed from the measured difference between the liquid levels. The liquid used in manometers may be water, mercury, alcohol, oil, or any other, depending upon the pressures to be measured. Manometers always measure a pressure difference. Therefore, the absolute pressure on one chamber must be known before the absolute pressure on the other chamber can be calculated. For measuring pressure differences such as the drop across an orifice, or in a venturi, the manometer is connected to show the difference directly. Manometers are simple, direct reading, accurate instruments that can be used for a wide range of applications and for pressures both above and below atmospheric. They are impractical for use with pressure differences much greater than one atmosphere, but for anywhere within their useful range their accuracy and simplicity make them the preferred type of instrument for static or slowly changing pressures.

112.1.4 Mechanical gages. Pressure gages making use of bellows and Bourdon tubes to change pressure into a mechanical reading are available for all ranges of pressures encountered in testing power systems. These instruments are convenient to use, direct reading, and durable; however, they must not be subject to pressures greater than their ratings nor to high temperature gases because their condition may destroy the calibration. Because of their low mass moving systems, they are better adapted to the measurement of changing pressures than either of the types previously discussed. Mechanical gages are available with ranges above and below atmospheric pressure, although they usually indicate only gage pressure (absolute pressure may be calculated by summing atmospheric pressure and gage pressure). Both indicating and recording types are available.

METHOD 114.1c

TEMPERATURE CONTROL (HOT ROOMS)

114.1.1 General. Test chambers in which conditions such as temperature, humidity, and atmospheric pressure are accurately controlled are called environmental chambers. The environmental chambers to be considered in this Standard are "hot rooms", "cold rooms", and "altitude chambers". Unless otherwise specified in this Standard or the procurement documentation, all general laboratory test method guidelines of MIL-STD-810 shall be followed.

114.1.2 Control of temperature. Hot rooms used to test power systems must have adequate temperature control to meet the requirements of the high temperature test. The average ambient air temperature shall not vary more than 5°F (3°C) throughout the test, as measured by thermocouples placed in accordance with METHOD 202.1. A typical hot room, capable of maintaining such temperature control is shown in FIGURE 114.1-1. The hot room shall have provisions to heat the intake air, to recirculate a certain amount of the heated air, to admit fresh air, to keep all the air in the room circulating and to allow the excess heat and engine exhaust to escape. The recirculated air shall not return within the hot room, but shall be conducted around the chamber in a separate duct. In order to prevent thermal shock, the rate of temperature change of the hot room shall not exceed 5°F (3°C) per minute.

114.1.3 Size of hot room. The requirements for installing the test item into the chamber shall be in accordance with MIL-STD-810 except that if testing more than one item together they shall be at least 3 feet from each other and that the distance from the test item(s) to the chamber walls or any false walls shall be at least 2.5 feet. The distance between the ceiling and the test item shall be greater than or equal to 1.5 feet.

114.1.4 Air circulation in hot room. The air in the hot room shall be in continuous motion to prevent the formation of local conditions, "hot" or "cold" spots, within the room which are different from the average temperature in the room. However, the chamber air velocity shall not exceed 5 mph. Air velocities greater than 5 mph are only allowable provided the increased velocities are necessary to maintain the specified chamber temperature but in no instance shall the velocity exceed 15 mph. In general, controlling the conditions in the hot room is easier if the air flow is from the generator end of the power system toward the engine cooling air exhaust.

114.1.5 Safety. A viewing port should be installed to allow visual inspection of the power system without entering the chamber.

**WARNING:**

**Test chamber may subject personnel to carbon monoxide (CO) poisoning and explosive mixtures. Working personnel should be aware of conditions within the test chamber prior to entering. CO and explosive mixtures detectors and a means to shutdown the power system in an emergency are required.**

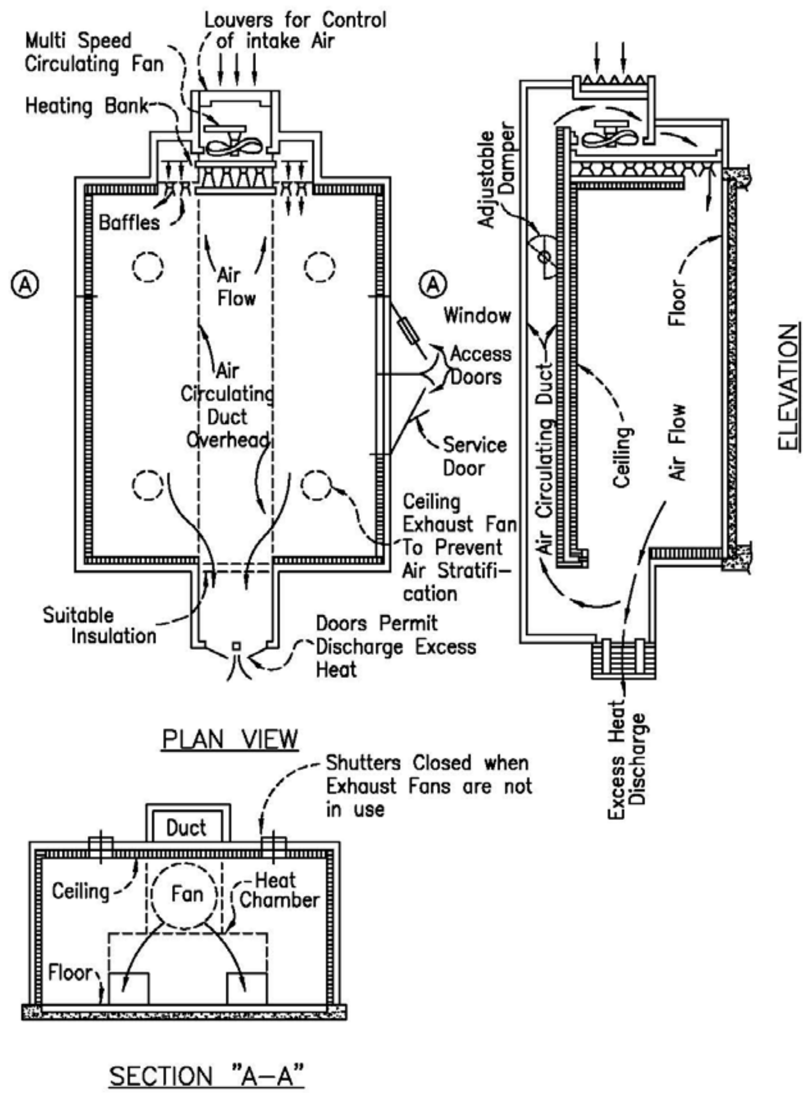



FIGURE 114.1-1 Layout for typical hot room.

# METHOD 114.2b

## TEMPERATURE CONTROL (COLD ROOMS)

114.2.1 General. Test chambers in which conditions such as temperature, humidity, and atmospheric pressure are accurately controlled are called environmental chambers. The environmental chambers to be considered in this Standard are "hot rooms", "cold rooms", and "altitude chambers". Unless otherwise specified in this Standard or the procurement documentation, all general laboratory test method guidelines of MIL-STD-810 shall be followed.

114.2.2 Control of temperature. Cold rooms used to test power systems must have adequate temperature control to meet the requirements of the cold test. The average ambient air temperature shall be uniform within 5°F (3°C) throughout the test as measured by thermocouples placed in accordance with METHOD 202.1. A typical cold room, capable of maintaining such temperature control is shown in FIGURE 114.2-1. The cold room shall have provisions to dry and chill the intake air, to recirculate the chilled air, to keep all the air in the room circulating, to remove the heat generated by the power system, and to allow the engine exhaust to escape. In order to prevent thermal shock, the rate of temperature change of the cold room shall not exceed 5°F (3°C) per minute.

An estimate of the amount of heat generated by a power system operating at rated load is 1/3 of the total heat as useful power, 1/3 as exhaust heat and 1/3 as engine heat to be removed by the engine cooling system. This is true for spark or compression ignition engines. For operation in a cold room the exhaust system must be vapor tight, not only due to the poisonous gases but because even a slight leak will emit water vapor to the room which will freeze to the cooling coils, thus lowering the ability of the coils to transfer heat. In addition to being vapor tight the exhaust system may be insulated to prevent excessive heat transfer to the room.

The fresh air intake to the chamber must have provisions to dry air entering the cold room as well as chill it to the ambient temperature of the cold room. A suggested method of drying the air is to pass it through dry silica gel. The air dryer must have sufficient capacity to supply dry air for the duration of the operational portion of the cold test(s). Dry air is defined as air having a dew point of at least 5°F (3°C) less than chamber ambient.

114.2.3 Size of cold room. The requirements for installing the test item into the chamber shall be in accordance with MIL-STD-810 except that if testing more than one item together they shall be at least 3 feet from each other and that the distance from the test item(s) to the chamber walls or any false walls shall be at least 2.5 feet. The distance between the ceiling and the test item shall be greater than or equal to 1.5 feet.

114.2.4 Air circulation in cold room. The air in the cold room shall be in continuous motion to prevent the formation of local conditions, "hot" or "cold" spots within the room which are different from the average temperature in the room. Large quantities of air must be circulated through the cooling coils in order to remove the heat generated by the equipment under test; however, any air movement generates heat within the cold room and the optimum condition of air flow within the cold room must be found individually for each cold room design.

114.2.5 Atmosphere within cold room. The ambient atmosphere within the cold room shall, at all times, be chilled normal air. At no time shall the room be cooled by the direct injection of carbon dioxide ($C0_2$) or any other gas or liquid other than normal air. Should the atmosphere of the room become contaminated by any foreign gas which can affect the results of the test, stop the test, clear the room of the foreign gas and restart the test.

114.2.6 Safety. A viewing port should be installed to allow visual inspection of the power system without entering the chamber.

**WARNING:**

**Test chamber may subject personnel to carbon monoxide (CO) poisoning and explosive mixtures. Working personnel should be aware of conditions within the test chamber prior to entering. CO and explosive mixtures detectors and a means to shutdown the power system in an emergency are required.**

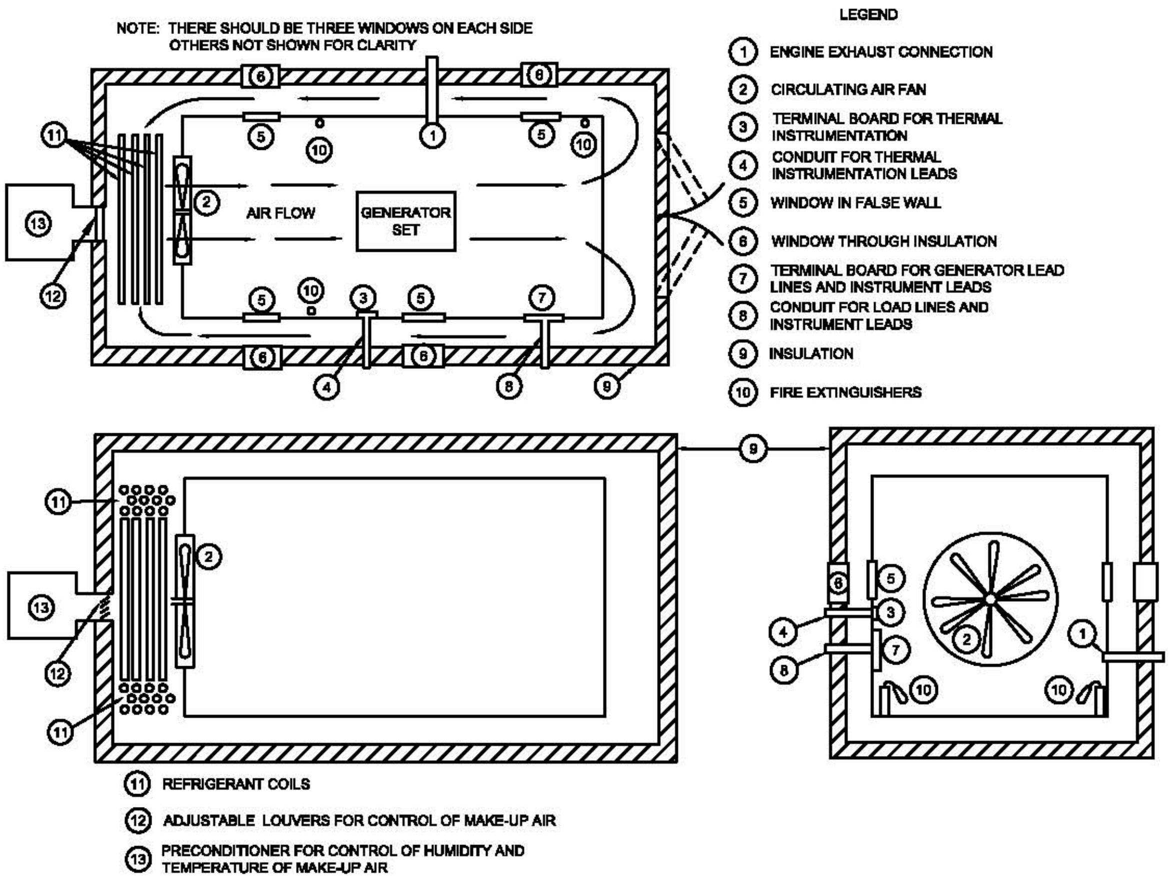



FIGURE 114.2-1 Schematic diagram of controlled low temperature chamber.

# METHOD 114.3b

## TEMPERATURE CONTROL (ALTITUDE CHAMBERS)

114.3.1 General. Test chambers in which conditions such as temperature, humidity, and atmospheric pressure are accurately controlled are called environmental chambers. The environmental chambers to be considered in this Standard are "hot rooms", "cold rooms", and "altitude chambers". Unless otherwise specified in this Standard or the procurement documentation, all general laboratory test method guidelines of MIL-STD-810 shall be followed.

114.3.2 Control of temperature. Altitude chambers used to test power systems must have adequate temperature control to meet the requirements of the altitude operation test. The average air temperature shall be uniform within 5°F (3°C) around the power system, and it shall not vary more than 5°F (3°C) throughout the test, as measured by 8 thermocouples placed in accordance with METHOD 202.1. The altitude chamber shall have provisions to heat the intake air, to recirculate a certain amount of the heated air, to keep all the air in the room circulating, to rid the chamber of excess heat, to rid the chamber of engine exhaust while maintaining the exhaust back pressure at the same value as it would be if it was exhausting into the chamber proper.

114.3.3 Size of altitude chamber. The requirements for installing the test item into the chamber shall be in accordance with MIL-STD-810 except that if testing more than one item together they shall be at least 3 feet from each other and that the distance from the test item(s) to the chamber walls or any false walls shall be at least 2.5 feet. The distance between the ceiling and the test item shall be greater than or equal to 1.5 feet.

114.3.4 Control of pressure. A means of controlling and maintaining the pressure of the chamber must be provided. The pressure shall be controlled to within ±50 feet of the specified altitude value. Do not use an altitude change rate in excess of 32.8 ft/s (10 m/s).

114.3.5 Air circulation. The air in the altitude chamber shall be in continuous motion to prevent the formation of local conditions within the chamber which are different from the average in the chamber. Controlling the conditions in the chamber is easier if the air flow is from the generator end of the power system toward the engine cooling air exhaust.

114.3.6 Safety. A viewing port should be installed to allow visual inspection of the power system without entering the chamber.

**WARNING:**

**Test chamber may subject personnel to carbon monoxide (CO) poisoning and explosive mixtures. Working personnel should be aware of conditions within the test chamber prior to entering. CO and explosive mixtures detectors and a means to shutdown the power system in an emergency are required.**

# METHOD 115.1b

## MEASUREMENT OF SOUND LEVEL

115.1.1 General. Sound is a vibration that propagates as a typically audible mechanical wave of pressure and displacement, through a medium such as air or water. For some applications a power system should operate as quietly as possible without impairing its operating efficiency. Some manufacturing specifications contain requirements for limits of operating noise; in terms of units of standard reference sound level. The standard reference level is defined as 0.0002 microbar (a pressure of 0.0002 dyne per square centimeter) at 1,000 Hertz.

115.1.2 Sound level meter. A sound level meter is an instrument for reading, in terms of a standard reference sound level, the sound level at its microphone. The instrument consists essentially of a microphone, electronic amplifying and filtering equipment, octave band analyzer and an indicating meter calibrator. The American National Standards Institute (ANSI) Standards for these meters include those listed in MIL-STD-1474 for octave, half-octave, and third-octave band filter sets.

In accordance with MIL-STD-1474, the test site shall be a uniform flat grass surface, free of ice, snow, or vegetation over 5.9 inches (0.15 meter) tall. MIL-STD-1474 requires that the test site be free of reflecting surfaces such as buildings, trees, hillsides, or load bank(s) within a 98 ft (30 meter) radius; however for MIL-STD-705 testing, the test site shall be free of reflecting surfaces such as buildings, trees, hillsides, or load bank(s) within a 164 ft (50 meter) radius. The equipment shall be positioned in the center of the test site. An anechoic or hemi-anechoic chamber may be substituted for outdoor measurements.

In accordance with MIL-STD-1474, take the audio noise Sound Pressure Level (SPL) readings with the power system(s) not operating (ambient), at no load and rated load or as specified in procurement documentation. The ambient noise level must be at least 10 dB below the power system’s noise level for a valid test.

# METHOD 116.1c

## DETERMINATION OF PHASE ROTATION

116.1.1 General. Phase rotation is the order of the phase voltages at the output terminals of a three-phase generator. During any cycle, an AC voltage varies from zero volts to a maximum, to zero, to a minimum, and finally back to zero. When each of the voltages of a three-phase system is observed simultaneously, the time of arrival at the maximum voltage of each phase is different. If phase one reaches a maximum first, followed by phase two and then phase three, the phase rotation is 1-2-3. If phase one reaches maximum, followed by phase three and then phase two, the phase rotation is 1-3-2. This orientation of the leads is important since a three-phase motor will run in one direction when connected 1-2-3, and in the reverse direction if connected 1-3-2. Moreover, if two power systems are to be operated in parallel, the phase rotation of the connections must be the same for both power systems, or a short circuit will occur.

116.1.2 Phase rotation indicators. Commercially available phase indicators may be used.

METHOD 117.1c

DETERMINATION OF PHASE RELATIONSHIP

117.1.1 General. Two or more AC power systems may be operated in parallel provided that their (1) phase sequences, (2) voltages and (3) frequencies are the same. Some power systems contain paralleling aid devices which must be tested to determine the exact phase relationship between the power systems at the time they are allowed to parallel.

117.1.2 Phase angle meter. The phase angle meter employs pulse measurement of the difference in time between zero and crossover of the compared voltages. The phase angle meter differentiates the input waves and the difference signal is displayed on a direct reading meter in electrical degrees.

117.1.3 Other methods. Phase relationships can be determined in various ways using instruments other than the aforementioned types. These other methods include, but are not limited to, the use of oscilloscopes; however, the set-ups, procedures and interpretations of results of these other methods are usually complex. Before electing to use any other method, careful consideration should be given to its acceptability, ease of comprehension and potential for misinterpretation. If such a method is intended to be used for government acceptance or qualification tests, prior approval of such use shall be obtained through the government contracting officer as early in the program as possible.

METHOD 118.1

LOAD BANKS

118.1.1 General. An electrical load bank is a set (bank) of electrical elements that are passive (resistive, inductive, capacitive) or active (motors, batteries). They are usually located adjacent to each other to form a consolidated set of any of these elements or any combination of them. A load bank is used to replace distributed or dispersed load elements contained in a power distribution system or electrical network for the purpose of providing a concentrated load. A load bank contains all the essential electrical characteristics necessary to terminate the circuit and functions in the same manner as the load which it is intended to replace. Load banks are intended to cover a specific range of characteristics and normally operate at DC or at AC frequencies 50, 60, or 400 Hz.

118.1.2 Load banks. Load banks can be appropriately categorized as support equipment and may be classified according to their principle(s) of operation as resistive, reactive or combination resistive and reactive.

118.1.2.1 Resistive load banks. Resistive type load banks directly convert all of the electrical energy applied to them to heat.

118.1.2.2 Reactive load banks. Reactive types operate on the principle of either capacitance or inductance. Reactive inductance types, also referred to as impedance types, are used with this Standard's procedures and tests when lagging power factor conditions are required. Some of the electrical energy applies to reactive inductance load banks is converted to heat, but much of it is temporarily stored as magnetic energy, which can be reconverted to electrical energy and returned to the supply system. Reactive capacitance types of load banks create leading power factor conditions, and are not used with any procedures or tests in this Standard.

118.1.3 Uses of load banks. Load banks may be further classified according to their use or application.

118.1.3.1 Parasitic load banks. Diesel engines with governors are used to drive some electrical generators and are selected according to the horsepower requirements and maximum thermal efficiency for generating at maximum electrical loads. Under conditions of less than maximum electrical loads, the governored engine's fuel burning efficiency declines and maintenance problems may occur due to lower engine temperatures, incomplete burning of fuel, and resulting carbon and sludge deposits (wet stacking). Parasitic load banks are used with diesel engine-driven power systems to minimize these problems. These load banks are usually of the resistive type and are called parasitic because they are constantly connected to the output power circuit and are activated when actual power use requirements drop below pre-determined levels. Parasitic load banks may be either attached components of an electrical power system, or ancillary issued items which usually remain constantly with a particular power system or group of power systems. Parasitic loads may also be used during maintenance and service checks to verify power system conditions under various load conditions.

118.1.3.2 Mobile load banks. These load banks may be resistive, reactive, or combination resistive and reactive. Mobile load banks are mounted on wheeled, trailable carriages and are used for service and maintenance checks, inspection and testing. They may also be used as parasitic loads.

118.1.3.3 Portable and semi-portable load banks. Portable and semi-portable load banks may be resistive, reactive, or combination resistive and reactive. Load banks are generally used for evaluation and testing at designated power factors in this Standard, and are combination resistive and reactive semi-portable load banks. Purely resistive type portable load banks are also sometimes used, in conjunction with other reactive only types, for evaluation and testing at power factors less than unity. Portable and semi-portable load banks may be transported by person, vehicle, aircraft, railway car, or marine vessel depending on the size and weight of the load banks. They may also be used for the same purposes as parasitic and mobile load banks.

118.1.4 Load bank characteristics.

118.1.4.1 Load bank capacity. The capacity or load range of load banks must equal or be greater than the rated power output of the power system being evaluated or tested; therefore connect load bank sections in series, parallel, or series-parallel to attain required loads. In three-phase circuits, balanced loading is provided by connecting equal load sections across the three power system line output terminals.

118.1.4.2 Description. The load bank shall provide a 0 - 100% kW resistive load and a 0 - 100% Kilovolt-ampere reactive (KVAR) load for each of the six conditions resulting from the connections of 120/208 volts or 240/416 volts at 50, 60, or 400 Hertz. A stepped selection of any balanced three phase load from 0 - 100% kW and 0 - 100% KVAR shall be provided in addition to provisions for 100 percent unbalanced load on any phase. The load bank shall operate continuously without damage.

118.1.4.2.1 Load steps. The load bank steps shall be such that any load between 0 and 100% of the load bank rating can be obtained. An example of the steps of one phase of a typical load bank is as follows:

| Step No. | kW or KVAR (per phase) |
|---|---|
| 1 | 0-3 1/3 (variable) |
| 2 | 3 |
| 3 | 6 |
| 4 | 9 |
| 5 | 12 |
| 6 | 15 |
| 7 | 18 |
| 8 | 21 |
| 9 | 24 |
| 10 | 27 |

| Step No. | kW or KVAR (per phase) |
|---|---|
| 11 | 30 |
| 12 | 33 |
| 13 | 36 |

118.1.4.3 Resistive elements. The resistive elements shall be fabricated from a corrosion-resistant, low resistance-temperature coefficient alloy wire having a change of cold to hot resistance. The resistors shall be insulated from ground (1800 volts) and shall have a power factor greater than 0.995 at 400 Hertz. When individual coils are stretched to their installed length, there shall be at least three wire diameters clearance between adjacent coil turns.

118.1.4.4 Reactive elements. The reactors shall be of iron core construction with clearances which limit the flux density in the iron to at least fifty percent below the saturation point. Wave form distortion shall be less than one half of one percent. Power factor of the reactors shall be less than 0.05 at 400 Hertz. Reactor coils shall be tapped for use at 50, 60 and/or 400 Hertz.

118.1.4.4.1 Temperature rises. Allowable temperature rise of windings shall not exceed the requirements of TABLE 118.1-I.

TABLE 118.1-I. Maximum temperature rise of windings.

| Method | Class of Insulation per MIL-DTL-917 | | |
|---|---|---|---|
| | Class A | Class B | Class F |
| | | | |
| By thermometer | 65°C | 75°C | 85°C |
| By rise in resistance | 75°C | 95°C | 105°C |

118.1.4.5 Operating environment temperatures and humidity. When equipped with all accessories and at specified loads within its rating, the load bank shall perform all its required functions at ambient temperatures of -65.2°F (-54°C) through 125°F (52°C) at specified relative humidities.

118.1.4.6 Load tolerances. When rated voltages at 50, 60 or 400 Hertz are applied, in each of the cases the resistive load shall be within two percent and the reactive load shall be within five percent of the control switch settings. Corresponding loads in each of the individual phases shall be balanced within three percent of each other (based on current).

118.1.4.7 Dielectric strength and insulation resistance. Reactive and resistive load elements shall withstand 1800 volts at a frequency of 60 Hertz applied between the member and ground for one minute. All other circuits shall withstand 1000 volts at 60 Hertz applied between the circuit and ground for one minute. The insulation resistance shall not be less than one megohm.

METHOD 118.1, APPENDIX A

EXAMPLE QUALIFICATION PROCEDURE FOR LOAD BANKS USED IN ACCEPTANCE TESTING OF POWER SYSTEMS

118.1.A.1 Scope. The following procedure is an example of how to qualify a load bank(s) for use in evaluating or acceptance testing for power systems, specifically the methods in this Standard. The information contained herein is intended for guidance only.

118.1.A.2 Apparatus. Accuracy and consistency of the load bank described in METHOD 118.1 may be determined using the following equipment and methods. This equipment and these methods may also be used for assurance of similar reactive types or modes of load banks. Strict adherence to the applicable technical manual or load bank manufacturer's operating instructions should assure consistent test results. Use instrumentation for measuring load conditions as described in METHOD 205.1.

118.1.A.2.1 Test instruments. Use test instruments for measurement of load bank performance that are accurate within plus or minus 0.0075 times the applicable National Institute of Standards and Technology (NIST) reference or "master". Certification of this accuracy must be traceable to NIST. Evidence of calibration within 180 days or less prior to the completion date of the load bank testing, for which the instrument is to be (or was) used, shall be available for examination by the Government's inspection representative. Recalibration may be required for reasonable cause at any time by the Government's inspection representative. If immediately following a test, an instrument is determined to be "out of calibration", or to be not calibrated, the Government's inspection representative may require repetition of the test or portions thereof.

118.1.A.3 Procedure.

118.1.A.3.1 Tests. Subject each load bank to the following tests:

118.1.A.3.1.1 Insulation resistance and ability to withstand high voltage test. For this test, disconnect all over-voltage and frequency protection devices. With all load contactors closed, measure the resistance with a standard megohm meter from each of the four load terminals to the ground. Apply a 60 Hz potential of 1800 V from each load terminal to ground (load bank ground connection); then after one minute, while still maintaining the 60 Hz, 1800 V potential, measure the leakage current. Record any evidence of insulation failure or damage.

118.1.A.3.1.2 Reactor saturation test. Subject one of each size reactor used in the load bank to the following saturation test at 60 and 400 Hertz: Apply voltage to the reactor in steps of 20 volts from 0 - 160 volts. Record voltage applied and current drawn by the reactor. Plot voltage versus current.

118.1.A.3.1.3 Load balance test. With the load bank connected for 120/208 volts, 60 Hertz, check the current balance for each load step of each reactive element. Set the vernier load at maximum value for each step. At each load step, determine by use of the vernier load if an overlap exists on the preceding load (line currents must be balanced). When this test is complete, reconnect the load bank for 240/416 volts, 60 Hertz and repeat the test. Repeat the test for both voltage connections using a 400 Hertz source. This test may be conducted in conjunction with the test specified in 118.1.A.3.1.4.

118.1.A.3.1.4 Load control switch step markings test. With the load bank connected for 120/208 volts, 60 Hertz, check the control panel resistive control switch markings for each step against the actual KVAR load. Check the vernier step at 0, 1, 2, and 3 KVAR points. When this test is complete, reconnect the load bank for 240/416 volts, 60 Hertz, and repeat the test. Repeat the test for both voltage connections, using a 400 Hertz source. This test may be conducted in conjunction with the tests specified in 118.1.A.3.1.3.

118.1.A.3.1.5 Harmonic content test. With all reactive load elements energized at 120 volts, 60 Hertz, determine for each harmonic (1st through 15th) its percent with respect to the fundamental frequency. Repeat the test with all the reactive load elements energized at 120 volts, 400 Hertz.

118.1.A.3.1.6 Full 1oad run test. Connect the complete load bank (all circuits operative) for 120/208 volts, 60 Hertz and operate at rated capacity continuously for twelve hours. Rated capacity is that load which is produced with all load circuits energized at their maximum values and at nominal voltage. Prior to the start of this twelve hour run, select one reactive load element. After the twelve hour run, determine the temperature rise of the selected element.

118.1.A.4 Results. Compare the results to the applicable requirements.

118.1.A.5 Requirements. The requirements for each test are as follows:

a. Insulation resistance and ability to withstand high voltage test. Ohmic resistance values of less than five megohms shall constitute failure of this test. Measurements obtained not within specified limits shall constitute failure of this test, as will any other evidence of insulation failure or damage.

b. Reactor saturation test. Any evidence of saturation (departure from a straight line voltage – current relationship) where the flux density in the iron is not at least fifty percent below the saturation point shall constitute failure of this test.

c. Load balance test. Under any of the load conditions, a difference in current between any two phases exceeding three percent of the lowest phase current shall constitute failure of this test. Non-overlapping of load steps shall constitute failure of this test.

d. Load control switch step markings test. Under any of the load conditions, a difference of five percent between the control switch markings and the actual load shall constitute failure of this test.

e. Harmonic content test. Any harmonic exceeding two percent of the fundamental shall constitute failure of this test.

f. Full 1oad run test. Any failure or damage or evidence of impending failure or damage during or after the twelve hour run shall constitute failure of this test. Failure to meet the temperature rise limits specified in TABLE 118.1-I shall constitute failure of this test.

# METHOD 201.1c

## ELECTRICAL INSTRUMENTS: CARE, INSPECTION, USE, AND REQUIRED ACCURACY

201.1.1 General. Instruments and equipment commonly used in testing shall comply with the following requirements.

201.1.2 Care, inspection and use of instruments. All test instruments shall be cared for in accordance with manufacturer's recommendations. While using these instruments, care must be taken in accordance with National Electric Code (NEC) requirements.

201.1.3 Accuracy of instruments. The accuracy of the instruments shall be in accordance with 4.2.

201.1.4 Procurement document requirements. The following item must be specified in the individual procurement documents:

a. Accuracy of instruments used for acceptance testing shall be in accordance with this Standard or as specified in the procurement documentation.

# METHOD 202.1c

## THERMAL INSTRUMENTATION

202.1.1 General. Thermal instrumentation includes instructions for locating various measuring devices for determining temperature of components and materials, and the surrounding (ambient) air.

The usual methods of obtaining temperatures at the various locations are: contact, resistance, or embedded detector. Each of these temperature measurement methods are discussed in detail in METHOD 110.1.

202.1.2 Power system and power distribution system components.

202.1.2.1 Contact method. The contact method of temperature measurement is used in the following locations: generator bearing housing or housings, generator frame, stator coils, intake and exhaust cooling air, collector rings, commutator, pole tips, rotor windings, engine coolant, lube oil (by immersing the detector), engine components, distribution system components, breakers, buss bars, cables, contactors, and other locations as applicable. Temperature measurements on moving components must be taken immediately once the moving part is at rest. The contact detector can be either the thermocouple type or the resistance type.

202.1.2.2 Resistance method. This method is applicable for measuring the temperature of the generator output winding, the generator field winding and exciter field winding. This method shall not be used on a rotating winding whose resistance at ambient temperature is less than 1.0 ohm.

The application of the devices and the formula for calculating the temperature rise are given in METHOD 110.1.

202.1.2.3 Embedded detector method. Usually, only power systems rated at 500 kW, or larger, are equipped with embedded detectors for the determination of the temperature of the electrical windings. The temperature of stationary windings will be measured periodically by this method during a test, while that of rotating windings will be taken at a standstill, immediately following shutdown.

Embedded detectors are of two types: the thermocouple type and the resistance type. Either of these types may be used as stationary or rotating detectors.

Before measuring temperatures by the embedded detector method, make sure that the detectors have been properly located in accordance with the applicable procurement document.

202.1.2.4 Thermal imaging method. This method is applicable for measuring temperatures in situations that require a rapid scan of a surface area that is non-invasive and non-destructive. The imagery can capture a vast array of temperatures in real-time and be saved for future usage. A thermal camera can be focused on all electrical and mechanical parts of a power system to determine temperatures while the power system is in operation.

202.1.3 Ambient air temperature.

202.1.3.1 Apparatus. Use thermometers and thermocouples to measure ambient air temperature. Expose these devices directly to the ambient air. When chambers are used, separate the thermal sensing devices used for controlling the chamber temperature from the apparatus used for measuring and recording the chamber ambient.

202.1.3.2 Location.

202.1.3.2.1 Environmental chambers. Take precautions to insure that no thermometer or thermocouple is located in either "hot" or "cold" spots in the chamber. Place the thermometers or thermocouples at the following positions:

Unhoused power system – Place thermometers or thermocouples to measure the ambient air temperature at a distance of approximately 1 foot diagonally outboard from the corners of the power system as the air approaches the power system. Record and average a minimum of two thermometers or thermocouples to establish the ambient air temperature specified in the applicable test document. Maintain a one foot minimum distance of the thermometer or thermocouple from walls or obstructions. Do not locate the temperature measurement devices near the engine exhaust outlet or in the cooling air exhaust from the power system.

Housed power system – Place thermometers or thermocouples to measure the ambient air temperature at the generator air intake to the housing. Take this measurement by a minimum of two thermometers or thermocouples. Record and average the outputs to establish the ambient air temperature specified in the appropriate test document.

Housed distribution system – Place thermometers or thermocouples to measure the ambient air temperature at the air intake, if applicable. If no air intake exists, measure the ambient air temperature at a distance of approximately 1 foot diagonally outboard from the corners of the housing. Take this measurement by a minimum of two thermometers or thermocouples. Record and average the outputs to establish the ambient air temperature specified in the appropriate test document.

202.1.4 Control panel temperatures. Take the temperature within the control panel enclosure using a thermocouple. Mount the thermocouple in the space behind the control panel and so located that it is surrounded only by air and is not in contact with any object. When testing a power system on which the control panel has been opened for inspection, always close the control panel before measuring the temperature of the enclosure behind it.

202.1.5 Winterization heater temperatures.

202.1.5.1 Coolant type heaters. For winterization heaters that heat and circulate the engine coolant, measure the temperature of the coolant at both its inlet and outlet to the heater. Take the temperature by thermometers or thermocouples located in the piping at these points.

202.1.5.2 Hot air type heaters. For heaters that heat and circulate uncontaminated hot air, measure the temperature of the air at its inlet and outlet to the heater. Measure the temperatures by thermocouples located in the heater ducts at these points.

202.1.5.3 Exhaust gas measurements (both types of heaters). Measure the heater exhaust gas temperature by a thermocouple located as close as possible to the point at which the exhaust gases leave the heater. When the exhaust gas is used in heating the oil pan, measure the temperature of the exhaust gas after passing through or around the oil pan.

# METHOD 203.1c

## DATA SHEETS AND RECORD ENTRIES

203.1.1 General. Tests do not fulfill their purpose unless complete and accurate data is recorded.

203.1.2 Data. The acceptance or rejection of a power system under test is dependent on whether the data or calculations made from the data meet the requirements of the procurement documentation.

To avoid accepting equipment which fails to meet the requirements of the procurement documents, and to be absolutely certain that any rejects fail to meet these requirements, repeat any test procedure if there is any doubt as to the accuracy of the recorded data.

Carefully read all instruments. Record readings directly on the data sheet. Do not multiply by any multiplying factor before recording. Record both maximum and minimum readings for cyclic values on the data sheets.

When making readings for steady-state conditions, be certain that these conditions have been reached before recording the readings. Do not erase readings. Neatly cross out errors with a single straight line. Begin consecutive reading numbers with the first test conducted during first article (preproduction) tests and continue throughout these tests.

Repeat individual tests requiring a series of data points if an interruption occurs during the test (e.g., data points being taken for plotting a curve, etc.).

Complete, accurate, and neat data are essential when performing the tests in this Standard.

203.1.3 Data sheets. Sample data sheets for many methods are included in this Standard. The tester is not required to use a particular format but all data sheets shall include at a minimum the data points shown on each data sheet. All information needed to evaluate the test and to facilitate the obtaining of comparative data shall be included on the data sheet.

Each data sheet must be traceable to a complete series of information which will identify the power system under test and the method, in addition to the data. The following is a list of information traceable to or included on each data sheet:

a. The make, rating, model number, and serial number of the power system under test.

b. The name and number of the method.

c. Columns for all instrument readings, with the serial number of the instruments used and their multiplying factor.

d. The date on which the test is performed, the consecutive reading number and the time of each reading.

e. The names of the personnel performing the test and the observer or Government inspector.

f. Notes as necessary to clarify the conditions of the test.

g. The name or designation of the agency responsible for inspection of the unit under test.

h. Data sheet number. If more than one data sheet is used to record data at the same time, each data sheet used shall be numbered, e.g., sheet 2 of 3.

i. The ambient temperature reading.

j. References by reading number to attached charts.

k. A series of instrument readings taken within five minutes after starting the power system (only for tests requiring stabilization).

**NOTE:** Record zero instrument readings as such. Do not leave the space blank.

# METHOD 205.1c

## GENERAL INSTRUCTIONS FOR CONNECTING TESTING INSTRUMENTS

205.1.1 General. Instrument usage is of critical importance in the determination of the quantitative value of effects occurring during tests. If the apparatus is improperly connected, the resulting data will either be useless or qualitative at best.

This Method includes instructions and schematic diagrams indicating the ways of connecting the most commonly used instruments required by this Standard. Terminal posts of all instruments are not in the same place as those shown in the diagrams; therefore, judgment must be exercised in connection of any specific instrument.

**CAUTION: Always consult the manufacturer's instructions in case of doubt as to the proper utilization of any test apparatus.**

The general theory of operation of the instruments shown in the diagrams is covered in the 100 series of methods of this Standard. When recording instruments are required, connect them into the circuit in the same manner as shown for indicating instruments.

205.1.2 Calibration of instruments. Calibration requirements shall be in accordance with 4.1.

205.1.3 Selection of instruments. Prior to connecting instruments into circuits, consider the range of readings which will be required.

Accuracy of instrumentation shall be in accordance with 4.2.

205.1.4 Voltmeters. Since voltmeters are potential measuring devices, connect them in parallel. Care in selection of voltmeters is necessary since these instruments consume power in operation. Where measurement of potential of high impedance or high resistance circuits is required, use high resistance (low current drain) instruments or the instrument power drain may disturb the basic circuit. However, except for the smallest power systems, consider the power consumption of a voltmeter negligible.

205.1.4.1 AC voltmeters. Care in selection of the proper range should be exercised. When in doubt, use the highest range instrument available just to approximate the range needed for the measurement.

When the range of the available voltmeter is not adequate for the potential to be measured or when instrument isolation is required, a potential transformer may be used. FIGURE 205.1-1 shows the connection diagram for such a combination. When a potential transformer is used, affix a piece of paper with the multiplying factor on the indicating instrument showing the transformer ratio. More than one instrument may be connected to one potential transformer, but do not exceed the rated burden of the transformer.

In some instances, the range of an AC voltmeter may be extended by use of a calibrated voltage divider circuit.

Connect the voltage sensing connections for the voltmeter or the primary of the potential transformer immediately prior to the load contactor or circuit interrupter of the power system when performing the methods of this Standard. This connection standardizes the voltage measuring points and avoids voltage drops due to line loss when the power system is operating under load. Connecting the voltage sensing lines to the load side of the load contactor would open circuit all voltage sensing when the load contactor was open.

When numerous readings of potential of different circuits must be made, use a switching device to facilitate the use of a single voltmeter.

**NOTE:** The switch points must be of the non-shorting type and the voltage rating of the switch must be in excess of the maximum voltage to be measured.

**NOTE:** All figures in this Method show the voltage instrumentation sensing lines connected to the output load terminals. Connect these voltage sensing lines immediately prior to the power system load interrupter when voltage instrumentation sensing is required with the load interrupter in the "open" position.

205.1.4.2 DC voltmeters. Polarity is important when measuring DC voltages. When extreme accuracy is required, such as during calibration, and a dynamometer-type instrument is used, take readings with the leads direct and reversed and the result as the average of the two readings.

Most information contained in 205.1.4.1 (AC voltmeters) apply to DC voltmeters, but potential transformers cannot be used to extend the range of the DC voltmeter. Transfer switches, to measure voltages of different circuits with one voltmeter, are more complicated since polarity must be correct for all connections.

205.1.5 Ammeters. Since ammeters are current measuring devices, they are placed "in the line" and never "across the line".

**CAUTION: When ammeters are used, protect them with short circuiting switches so that transient current surges will not damage the instrument.**

205.1.5.1 AC ammeters. When the range of the instrument is not adequate to measure the current in the line or when the voltage is above that to which the instrument can safely be connected directly in the line, use current transformers.

**WARNING:**

**Do not open the current transformer when current is flowing in the measured circuit. The voltage in the transformer can reach its core saturation voltage, producing a high voltage across the open secondary. Such high voltages can cause arcing, be dangerous to the operating personnel, and can cause serious damage to the current transformer and/or recording instrumentation. The equipment damage may not immediately be known by the operator and can result in incorrect current measurements.**

205.1.5.2 DC ammeters. FIGURE 205.1-2 illustrates the wiring of a DC ammeter with a shunt. The instrument is essentially a millivoltmeter which measures the drop across a known resistance (the shunt). For that reason, the instrument and its leads are calibrated as a unit and must be used together. Multiple shunts may be arranged in a single case.

**CAUTION: A shorting switch is desirable across the DC ammeter to protect it from transient surges of current.**

205.1.6 Wattmeters. The range of wattmeters can be extended through the use of current transformers, potential transformers or both. When using transformers, multiply the indicated meter reading by the transformer ratio and the meter ratio to determine the actual power.

205.1.6.1 Measurement of single-phase wattages. The range of the wattmeter may be extended by the use of a potential transformer and a current transformer. FIGURE 205.1-3 shows the connection of a single-phase wattmeter with a potential transformer.

**CAUTION: When this circuit is used the current winding of the wattmeter must be rated for the line-to-ground voltage of the circuit.**

FIGURE 205.1-4 shows the connection of a single phase wattmeter with a current transformer. FIGURE 205.1-5 shows the connection of a single phase wattmeter with both potential transformer and a current transformer. Always connect the plus-or-minus binding post of the potential circuit to the same side of the circuit under test which contains the current coil of the wattmeter, to have the current and potential coils at the same potential, thus eliminating the electrostatic attraction between them. When current or potential transformers are used, connect the plus-or-minus binding post of the potential circuit to the plus-or-minus binding post of the current circuit. When both potential and current transformers are used, ground the connection between the plus-or-minus binding posts. When instrument transformers are used in the measurement of power, they must maintain the phase relationship between the input and output of the transformer at zero degrees. Any time instrument transformers are used on circuits exceeding 750 volts, ground one terminal of the transformer secondaries through a wire equivalent in current carrying capacity to No. 12 AWG copper or larger (see Rules 093.C.3, 097, and 150 of the National Electrical Safety Code IEEE C2.)

205.1.6.2 Measurement of polyphase wattages. Where unbalanced voltages or currents are encountered, use more than one meter to measure the power in a polyphase system. These meters can be combined in one unit to form a direct reading polyphase wattmeter.

When the wattage of a five-wire, three-phase unbalanced system is required, use three wattmeters connected as shown in FIGURE 205.1-6. The sum of the three readings is the required wattage.

205.1.7 Power factor. The power factor of a single-phase circuit can be determined by using a single-phase wattmeter, a voltmeter, and an ammeter. Since the wattmeter reads *EI cos θ* (volts x amperes x power factor), the wattmeter reading divided by the product of the voltmeter reading times the ammeter reading will result in the power factor (*cos θ*).

$$\frac{Watts}{Volts * Amps} = power\ factor$$

**CAUTION: The resultant power factor must be within the wattmeter operating range.**

This value may be read directly by using a single-phase power factor meter. When instrument transformers are used in the measurement of power factor, they must maintain the phase relationship between the input and output of the transformer at zero degrees.

When the power factor of a balanced three-phase system is desired, compute it by using a polyphase wattmeter, a voltmeter, and an ammeter. The wattmeter reads $\sqrt{3}$ x line-to-line voltage x phase current x power factor. The wattmeter reading divided by the product of the voltmeter reading and the ammeter reading and $\sqrt{3}$ will be the power factor (*cos θ*). This value may be obtained directly by the use of a polyphase power factor meter. Care must be taken to see that the wiring of a polyphase power factor meter is correct, or the reading will be completely erroneous. Always check the instrument against the computed value of the power factor, the first time the instrument is used in a circuit.

The system must be balanced (equal voltages, currents, and power factors on all three phases) to use a polyphase power factor meter. A single phase instrument between one line and neutral also may be used to indicate the system power factor.

The power factor of an unbalanced polyphase system is a complicated subject, beyond the scope of this Standard, and it is not required in any of the methods.

205.1.8 Reactive volt-amperes. To determine the reactive volt-amperes of a polyphase system, use a single-element wattmeter for a balanced three-phase system. Then multiply the scale reading by $\sqrt{3}$ to get the values of VAR's.

A polyphase wattmeter with a combined phase-shifting autotransformer may be used on a three-phase, three-wire system whose voltages are balanced but whose currents are not.

205.1.9 Frequency. Frequency meters are connected in circuits in a manner similar to the voltmeter.

The accuracy of frequency meter readings is influenced by the waveform of the circuit potential. When the waveform differs substantially from that of a sine wave, the readings will be erroneous. When it is desired to read the frequency of non-sinusoidal waves, use special instruments containing band pass filters. These specials instruments are not required to perform any method in this Standard.

**CAUTION: To prevent damage to frequency meters, electrically connect them to the line only when the line frequency is known to be within the range of the instrument. Most frequency meters are equipped with an on-off switch for this purpose.**

205.1.10 Load instrumentation. FIGURE 205.1-7 through FIGURE 205.1-12 show methods of using instruments in combination to measure the load conditions of a power system, and the field voltage and current of a generator. In order to simplify the diagrams, in some instances, instruments are shown without transformers or other multipliers and; therefore, the wiring principles for such accessories given in the preceding paragraphs will have to be used, where necessary, to extend the instrument ranges. The connection shown in FIGURE 205.1-11 for a three-wire, three-phase, AC power system may be used on a four-wire power system if the loads are balanced. In that case, no connections will be made to the fourth wire (neutral). The instrumentation of FIGURE 205.1-12 is necessary only where unbalanced loads are used and the methods, with few exceptions, do not call for such conditions.

205.1.11 Special test measurements. FIGURE 205.1-13 shows the connection to measure the short circuit currents of single and three phase shorts, either delta or wye connected. On FIGURE 205.1-13, three-phase shorts are shown.

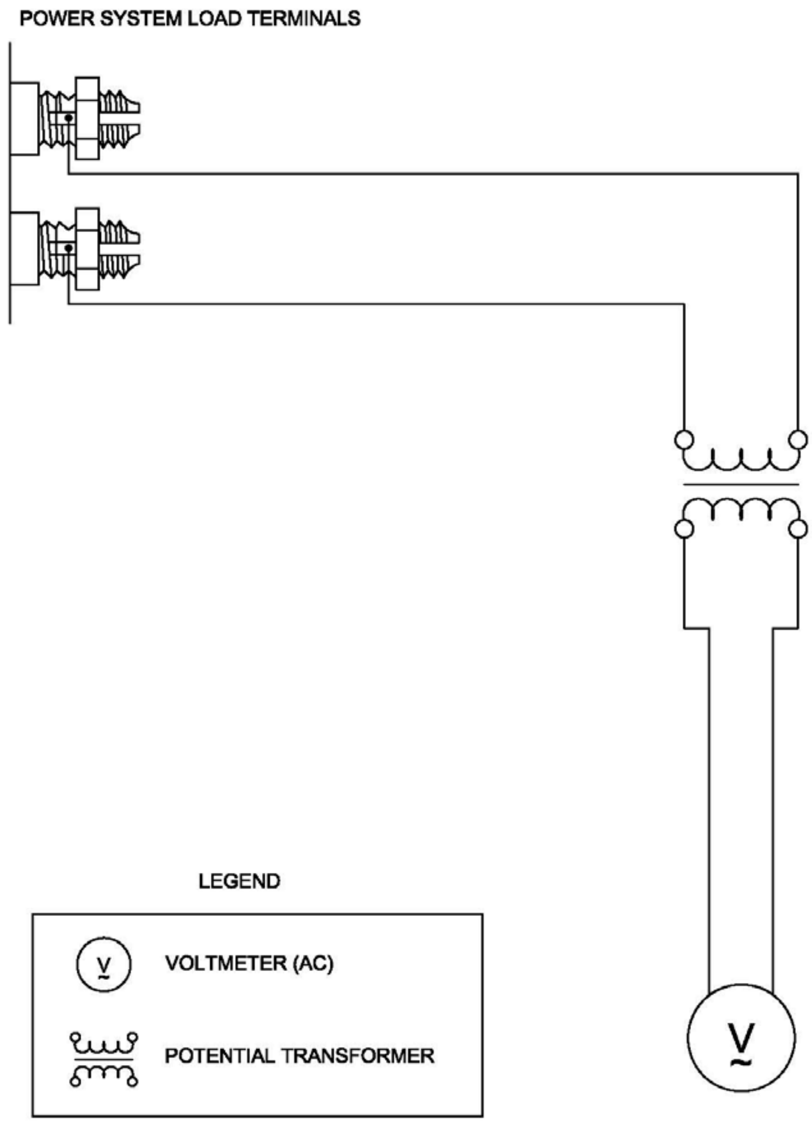
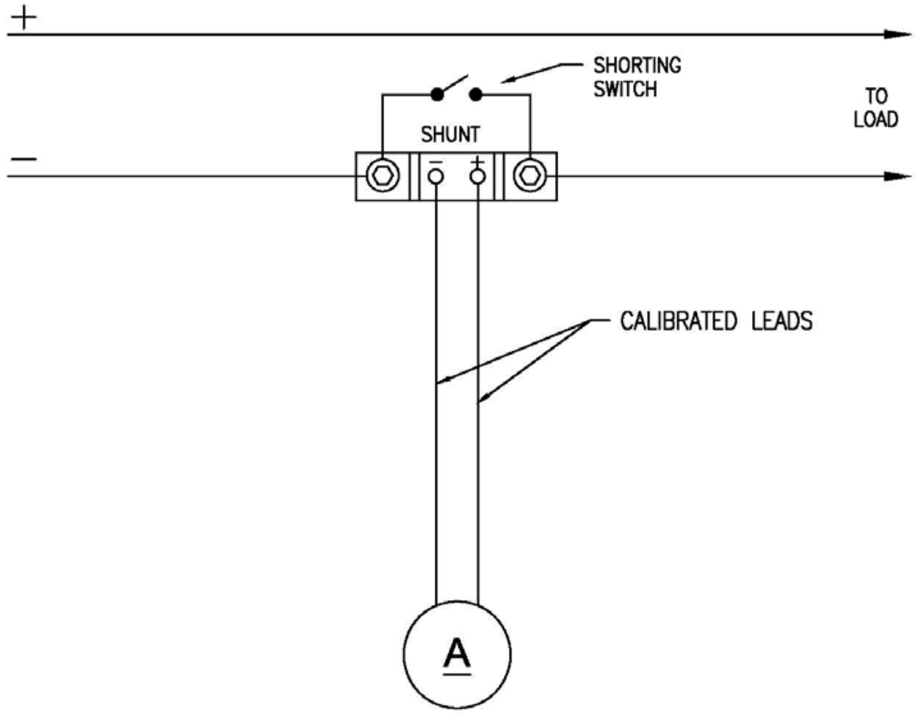



FIGURE 205.1-1 AC voltmeter with potential transformer.



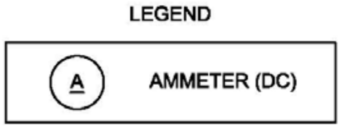




FIGURE 205.1-2 DC ammeter with shunt.

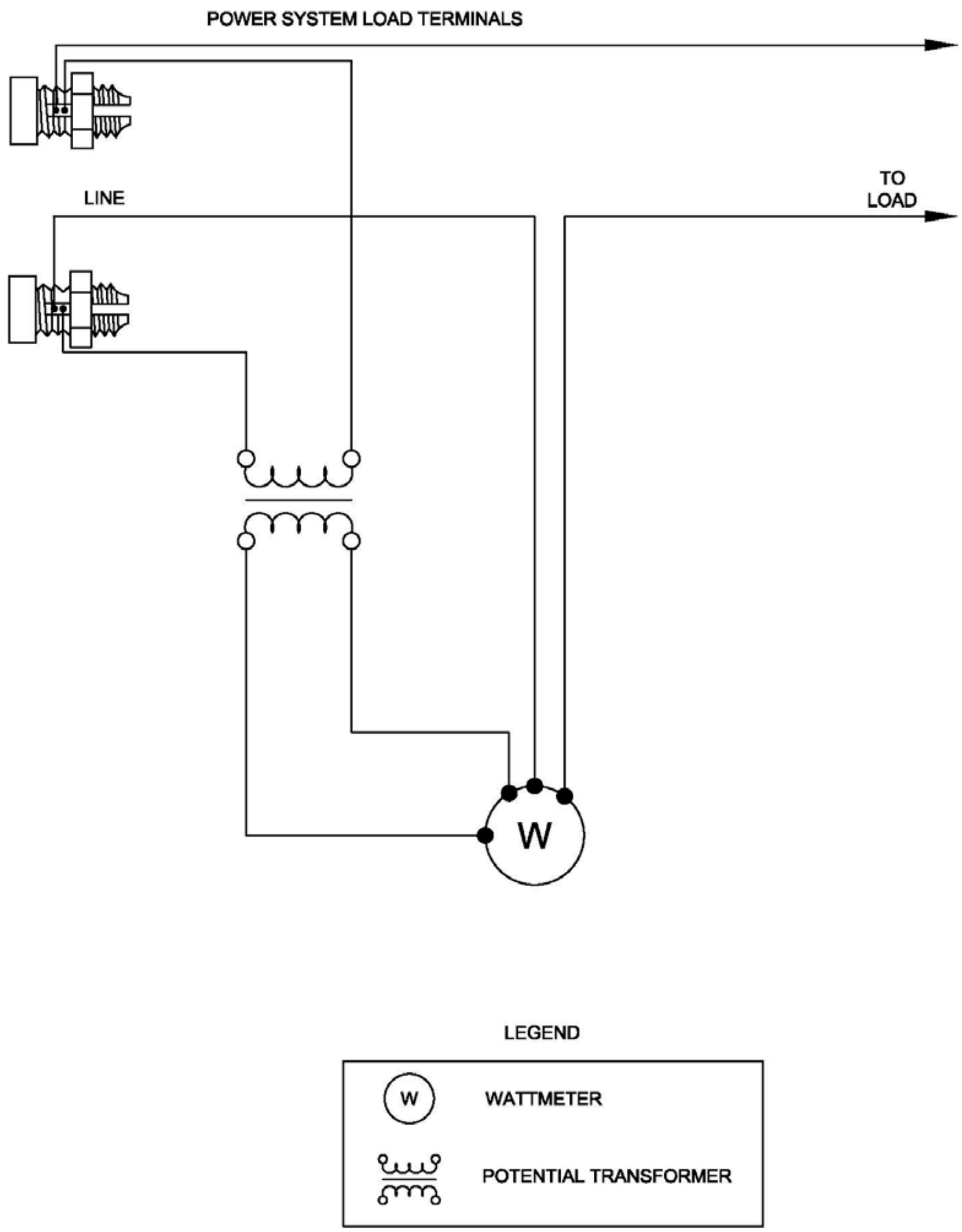



FIGURE 205.1-3 Single-phase wattmeter with potential transformer.

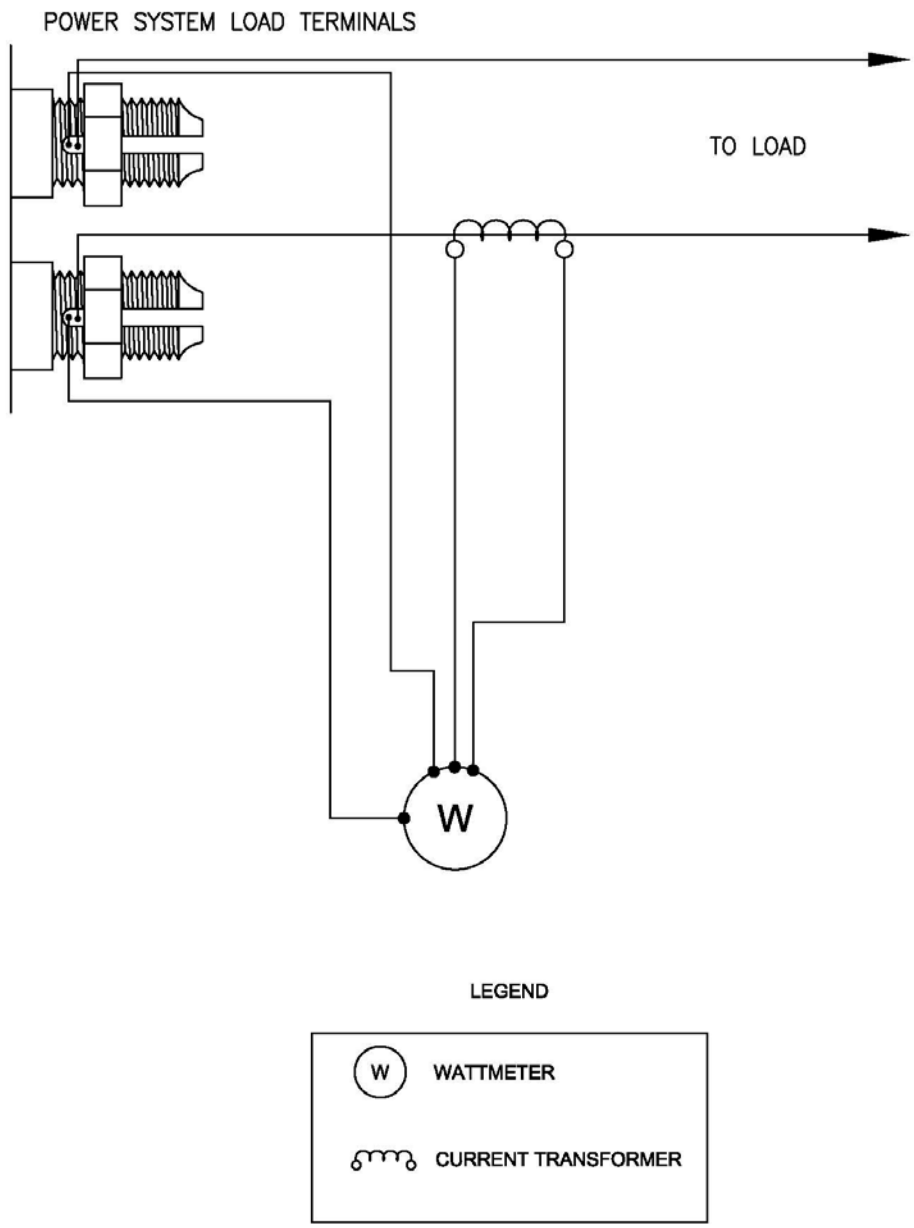



FIGURE 205.1-4 Single-phase wattmeter with current transformer.

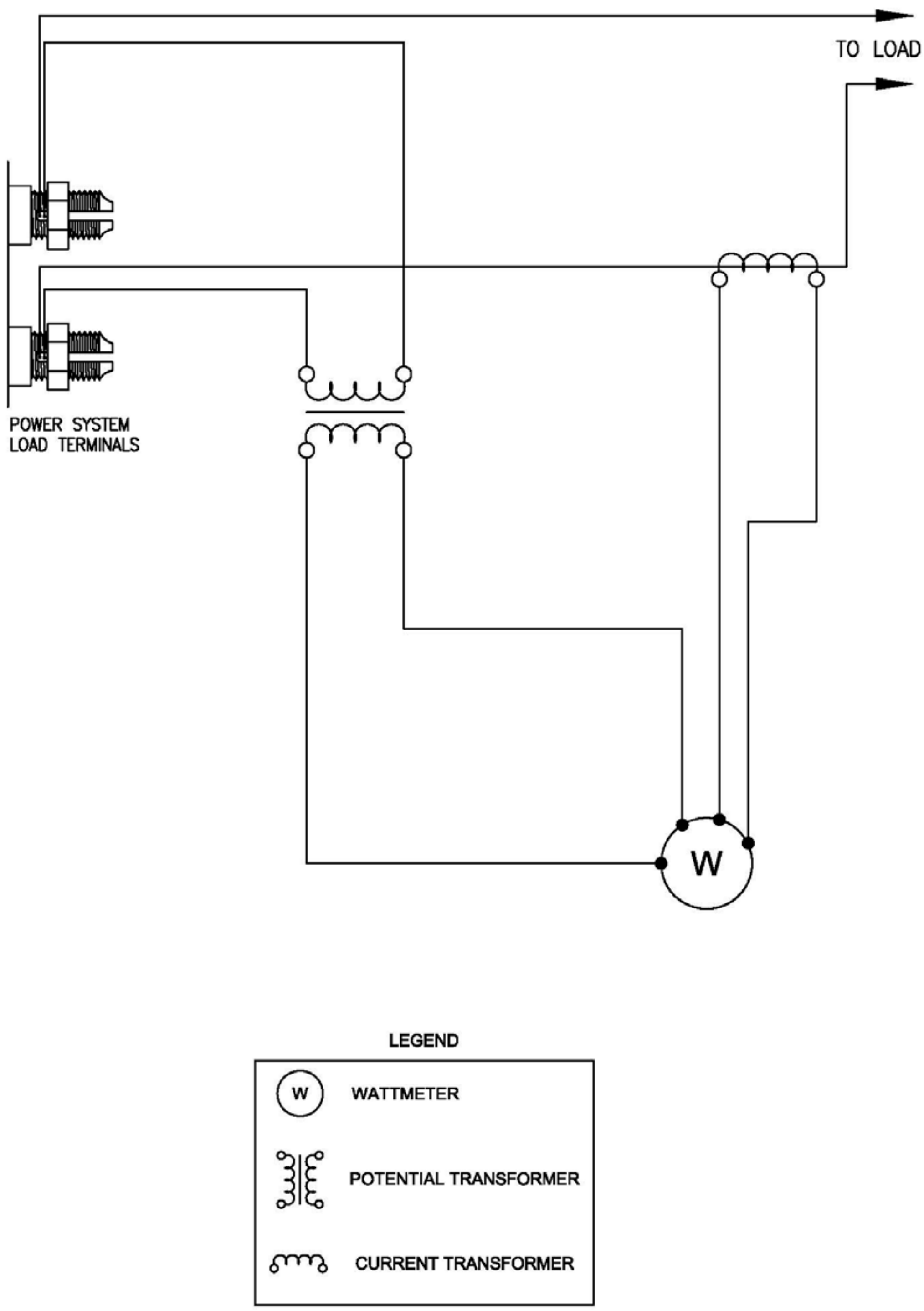



FIGURE 205.1-5  Single phase wattmeter with potential and current transformer.

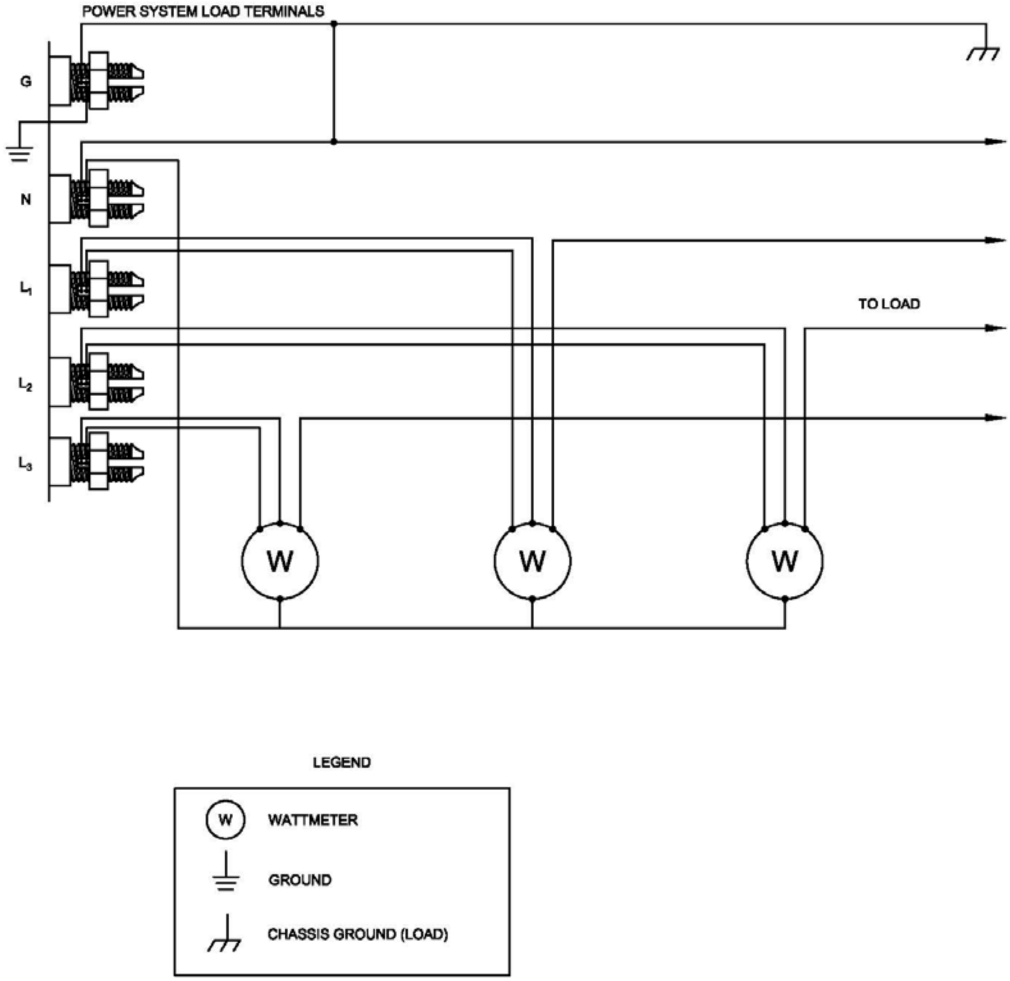



FIGURE 205.1-6  Three wattmeters used on unbalanced three-phase, five-wire system.

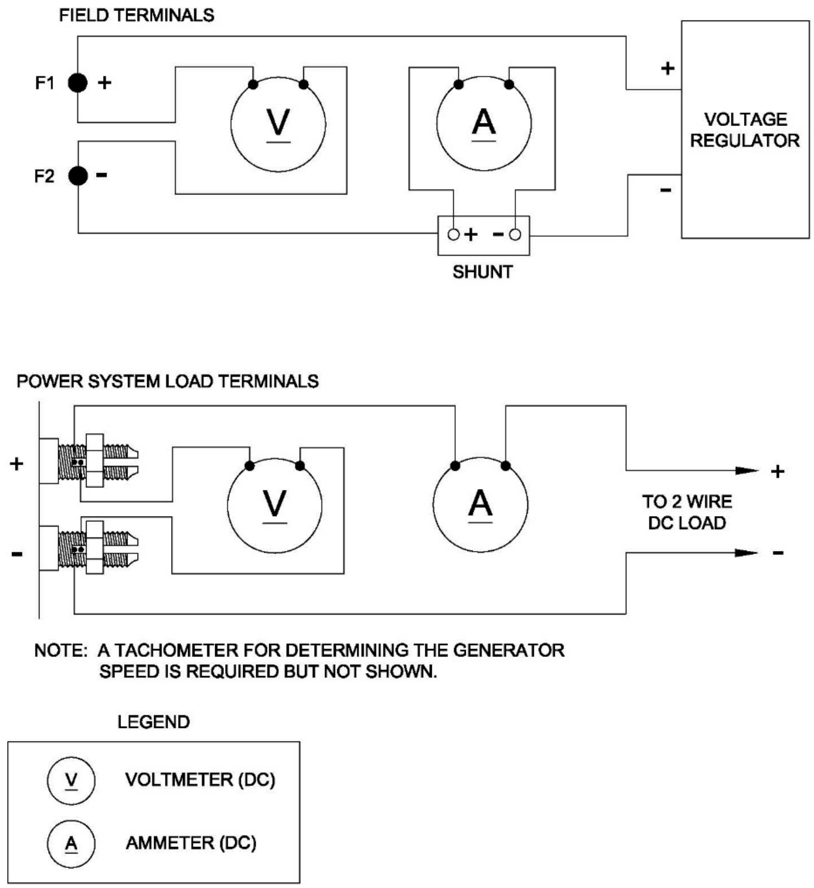



FIGURE 205.1-7 Load instrumentation for two-wire DC power system.

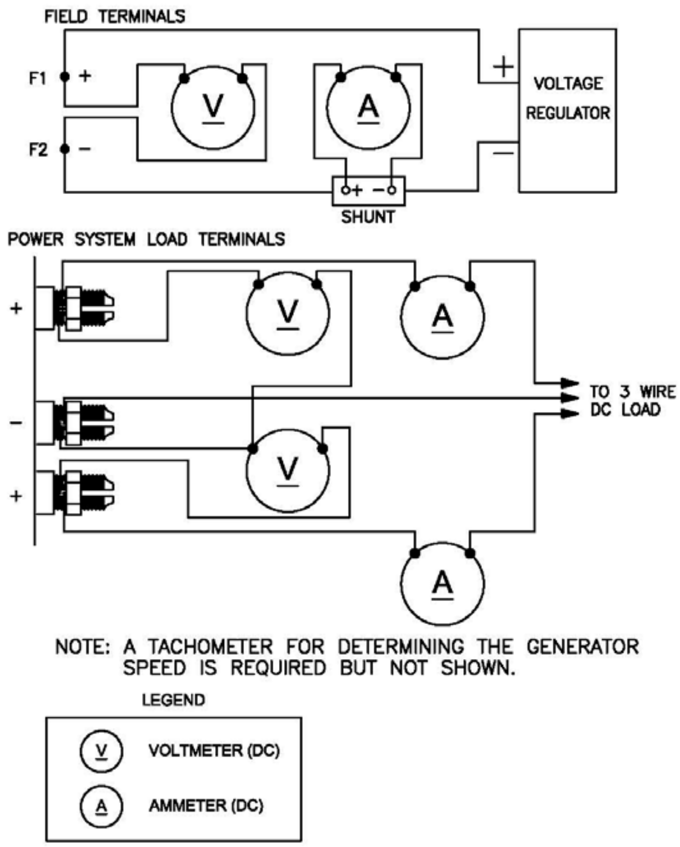



FIGURE 205.1-8  Load instrumentation for three-wire DC power system.

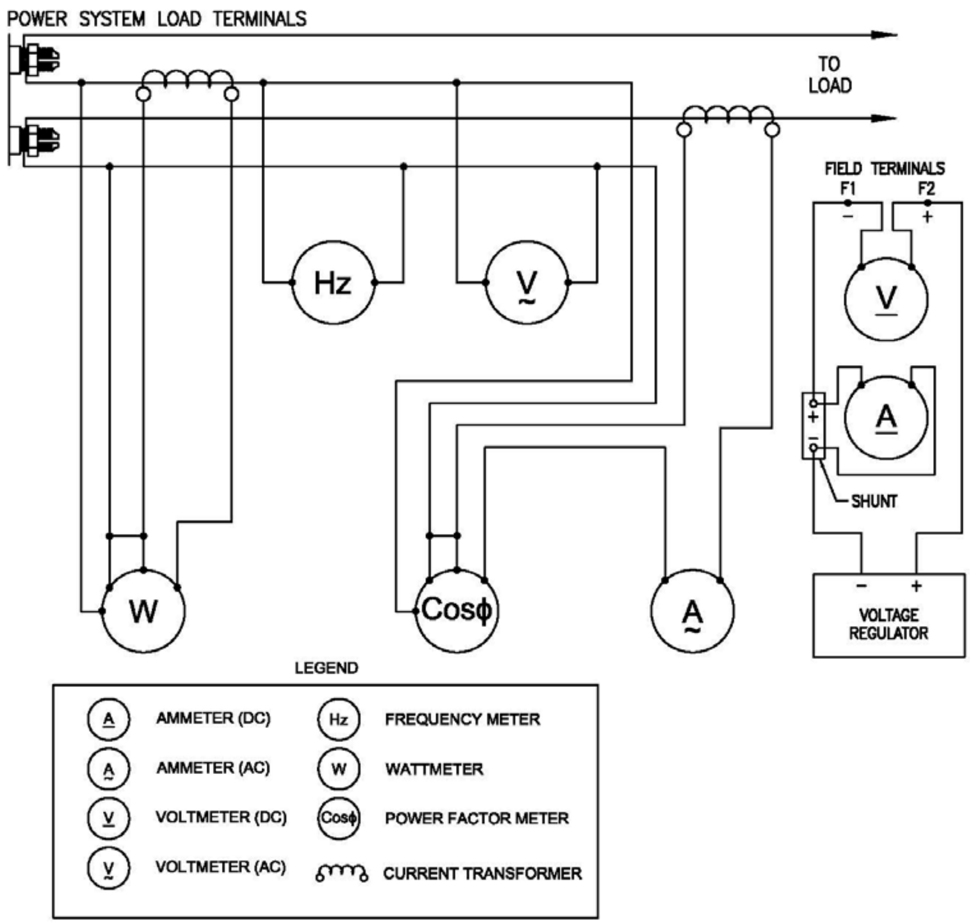



FIGURE 205.1-9 Load instrumentation for single-phase, two-wire AC power system.

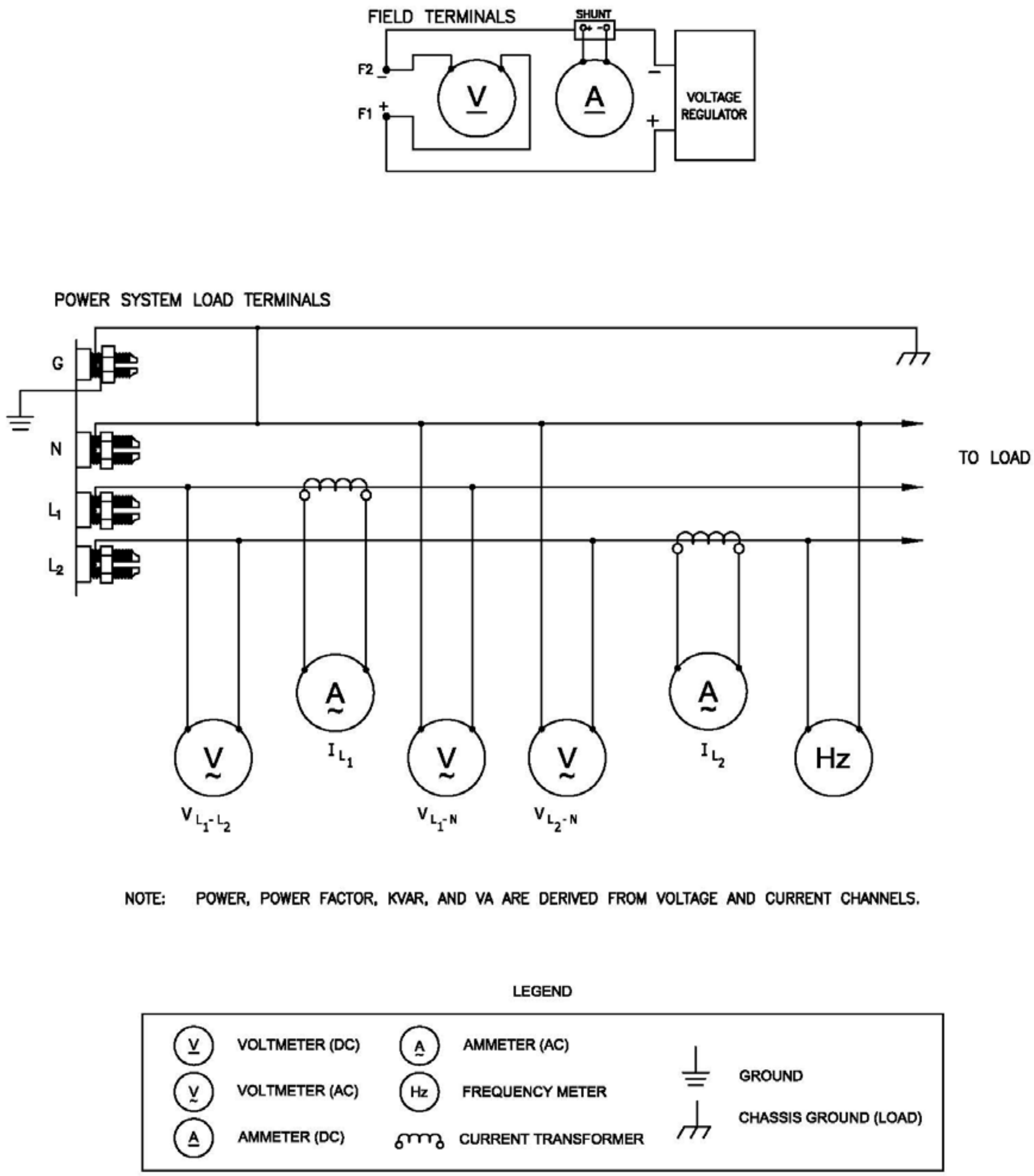



FIGURE 205.1-10 Load instrumentation for single-phase, four-wire AC power system.

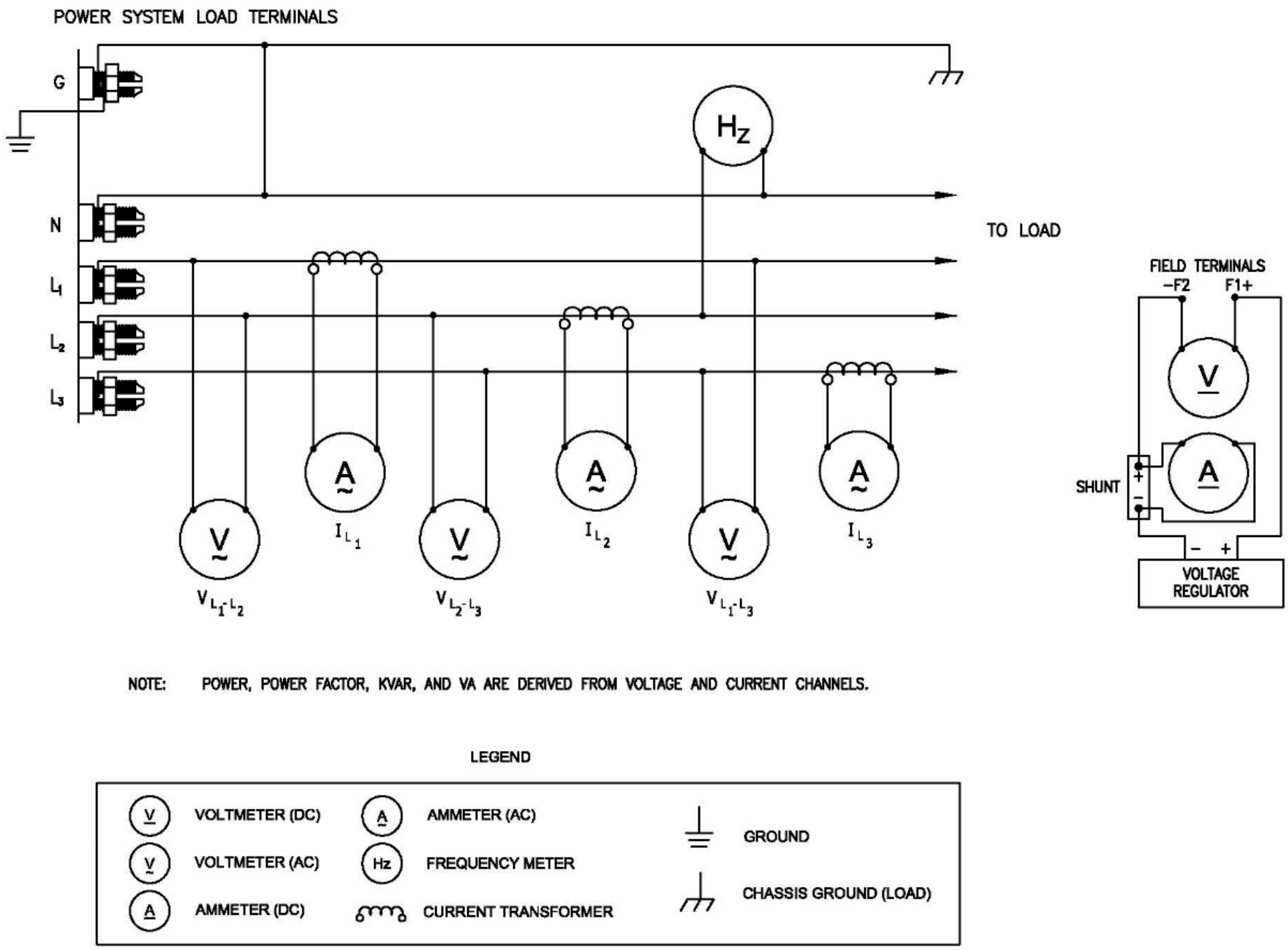



FIGURE 205.1-11 Load instrumentation for three-phase, five-wire AC power system (balanced loads).

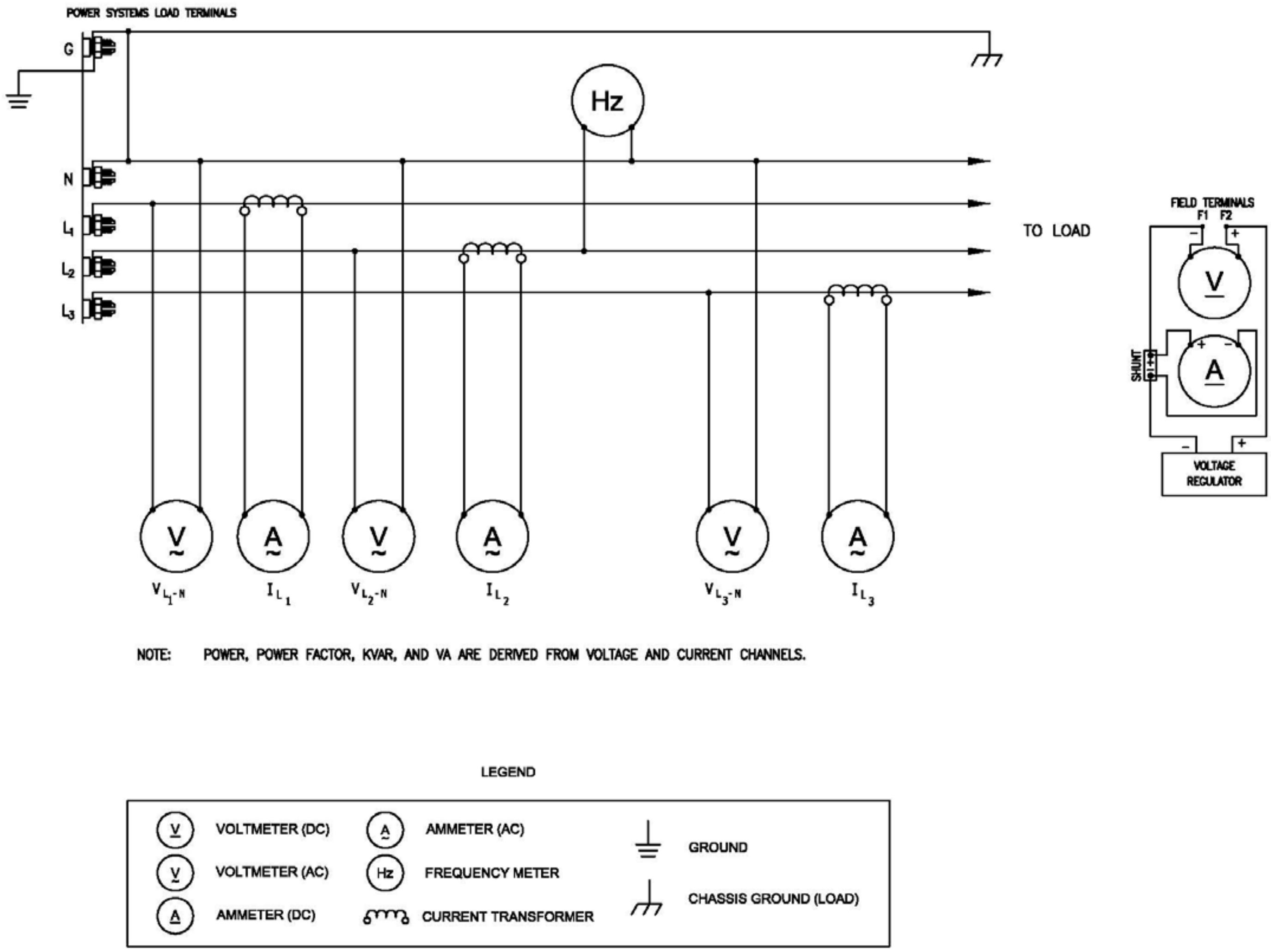



FIGURE 205.1-12 Load instrumentation for three-phase, five-wire AC power system (unbalanced loads).

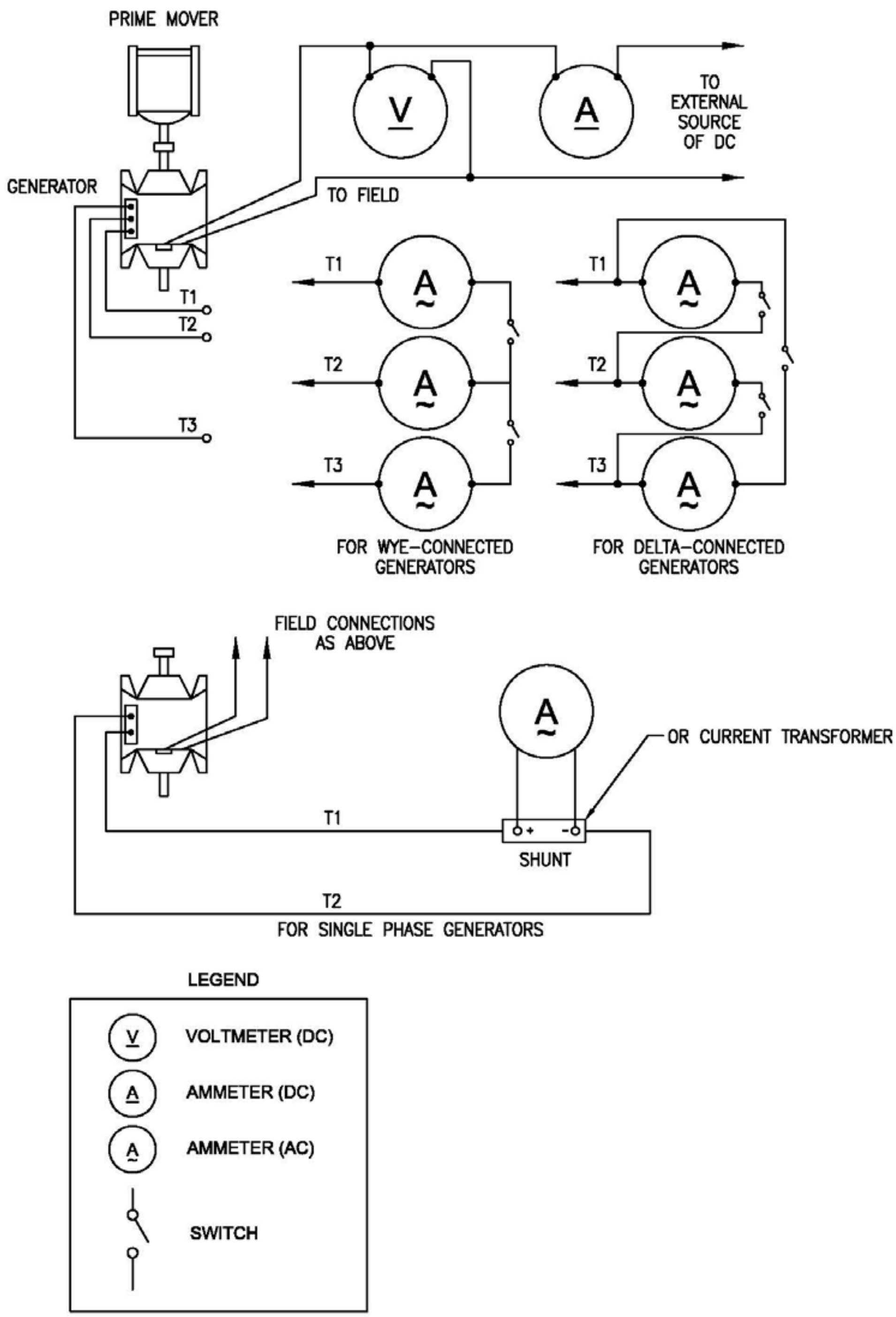



FIGURE 205.1-13 Load instrumentation for short circuit currents.

METHOD 220.1c

ENGINE PRESSURE MEASUREMENTS

220.1.1 General. The location of the pressure tap is of importance in the repeatability of engine pressure measurements. The pressure shall be measured in inches of water ($H_2O$) or mercury (Hg).

220.1.2 Air intake pressure.

220.1.2.1 Spark ignition engines. The intake manifold pressure shall be measured by a manometer connected to a pressure tap located approximately 2 inches from the carburetor flange. On small engines where a pressure tap may interfere with carburetion, the intake manifold pressure data may be omitted at the discretion of the testing agency.

220.1.2.2 Compression ignition engines. Pressure of the intake air in the manifold for naturally aspirated engines shall be measured by a manometer connected to a pressure tap near the inlet flange of the manifold. For engines with scavenging air blowers, turbochargers, or superchargers, the air pressure shall be measured by a manometer connected to a pressure tap located on the discharge side of the blower.

220.1.3 Exhaust gas pressure. The mean exhaust gas pressure shall be measured by a manometer connected to a tap located approximately 2 inches beyond the outlet flange of the exhaust manifold or turbocharger. The back pressure imposed by the laboratory or manufacturer's plant exhaust system during tests at rated net continuous load and speed shall not be less than that existing at the same load and speed with the power system exhausting directly to the atmosphere through its own exhaust system. Increase the back pressure above this minimum value if a higher test pressure is specified in the procurement documents.

# METHOD 220.2c

## PRESSURE AND TEMPERATURE CORRECTIONS TO (SPARK AND COMPRESSION IGNITION) ENGINE DATA

220.2.1 General. Ambient air pressure, water vapor pressure, and the intake air temperature variations have considerable effect on the operational characteristics of engines. Correction for these variations is needed in order to assure that engine output data is uniform.

220.2.2 Measurement of atmospheric moisture. The quantity of moisture mixed with the air under different conditions of temperature and degrees of saturation may be measured in several distinctly different ways. One method is to observe the temperature of evaporation, that is the difference between the temperatures indicated by wet-bulb and dry-bulb thermometers.

Additional information on atmospheric moisture measurement can be found in ANSI/ASHRAE 41.6 and in the ASHRAE brochure on psychrometry.

220.2.3 Correcting intake manifold pressure observations. Determine the moisture vapor pressure for a given combination of temperature and relative humidity by obtaining wet-bulb and dry-bulb temperatures. Subtract the moisture vapor pressure from the observed value of the manifold pressure to obtain the dry absolute manifold pressure at the observed temperature. Convert the dry absolute manifold pressure at the observed temperature to a dry absolute manifold pressure at the standard carburetor inlet temperature of 60°F (15.5°C) by applying the following formula:

$$D.A.M.P.\,at\,T_S = D.A.M.P.\,at\,T_o\left[\frac{460+60}{T_o+460}\right]$$

Where:

*D.A.M.P.* is the Dry Absolute Manifold Pressure.

$T_s$ is the standard carburetor inlet air temperature (60°F).

$T_o$ is the observed temperature in °F.

220.2.4 Correcting maximum power values. Correct all values of observed maximum power system output power to standard conditions of pressure and temperature (sea level and 60°F), unless otherwise specified in the procurement document. Correct the observed power system output value by applying the following formula:

$$Corrected\ watts = (Observed\ watts)\frac{29.92}{B-E}\sqrt{\frac{460+T}{460+60}}$$

(For sea level and 60°F)

Where:

*B* is the barometer inches of mercury (corrected for temperature).

*E* is the water vapor pressure (inches of mercury).

*T* is the intake air temperature (°F).

# METHOD 221.1b

## TEMPERATURE CORRECTIONS TO RESISTANCE MEASUREMENTS

221.1.1 General. The resistance of a conductor varies with the temperature. The resistance of metals and most alloys increases with the temperature, while the resistance of carbon and electrolytes decreases with the temperature.

221.1.2 Procedure. When the resistance $R_t$ of a winding has been determined by test at a winding temperature $T_t$, correct the resistance in ohms to a specified temperature $T_s$ by the following equation:

$$R_s = R_t \frac{T_s + k}{T_t + k}$$

Where:

$R_s$ is the winding resistance, corrected to specified temperature, $T_s$.

$T_s$ is the specified temperature, °C.

$R_t$ is the test value of winding resistance.

$T_t$ is the temperature of winding when resistance was measured, °C.

$k$ is the characteristic constant for the winding material.

**NOTE:** *k* for 100 percent pure copper = 234.5; *k* for hard drawn 97.3 percent copper = 241.5. Data for different materials may be found in various standard engineering handbooks.

For testing, correct all values of observed resistance of windings to a standard temperature of 77°F (25°C) unless otherwise specified in the procurement document.

# METHOD 222.1b

## BATTERY SERVICING AND CONDITION ASSURANCE PRIOR TO "COLD STARTING" TESTS

222.1.1 General. Flooded electrolyte (unsealed) lead-acid and the maintenance-free sealed Valve Regulated Lead-Acid (VRLA) batteries are used to start power systems at cold temperatures. These batteries require cleaning, functional testing, and adding electrolyte or distilled water as needed to enable them to function as intended. These batteries require specific procedures and safety guards to test, charge, and store. VRLA batteries only require cleaning and regular functional testing. Functional testing of batteries can be accomplished by using a battery analyzer. The more accurate method of analyzing a battery is monitoring the voltage drop over 15-30 seconds with a carbon pile load. This Method provides guidance to ensure proper preparation of batteries before starting any test in this Standard.

Any additional battery types proposed for power system tests shall be approved by the procuring activity. Other types of batteries may be used for cold start testing of power systems. Since these other types are not used on DOD power systems, they are not discussed in detail here.

The tests in this Standard, when used for first article or production acceptance, are intended to verify power systems have been properly manufactured. These tests are not used to test batteries. Batteries are qualified under their own programs, before being specified for use on power systems. Batteries used during first article or production acceptance testing are test support equipment. If full battery output capability is not assured prior to power system testing, inadequate battery performance may invalidate an otherwise valid test sequence.

**NOTE**: When the tests in this Standard are used for evaluation during equipment research and development, the use or non-use of the procedures below depends upon the purpose for which the test data will be used. For example, total system reliability or operational readiness assessments, evaluations of component compatibilities and standardization studies would probably not require the use of these battery conditioning procedures.

222.1.2 Preparation of batteries for charging. New batteries should be used for the cold starting tests in this Standard to further minimize possibilities of invalid tests due to improper battery conditions.

222.1.2.1 Preparation of flooded electrolyte (unsealed) lead-acid batteries for charging. Flooded electrolyte (unsealed) lead-acid batteries may be received in either the "wet" or "dry" condition. Wet battery cells already contain the electrolyte solution, whereas dry batteries require electrolyte solution. Some batteries may have sealing devices over each cell for shipment and storage, which must be dislodged (and can be discarded or left inside the cells) prior to filling. Wet batteries may require "topping off" with distilled water to bring the electrolyte to its correct level, but do not attempt topping off of wet batteries or filling of dry batteries until the battery has stabilized at a temperature between 60°F (15.6°C) and 100°F (37.8°C). Verify stabilization by three consecutive checks of the battery or electrolyte temperature, 10 minutes apart and varying within +5°F (2.8°C) of each other, within the 60°F to 100°F range. Make final check and adjustment of the electrolyte level 30 minutes after any previous additions of distilled water or electrolyte.

The typical electrolyte for dry lead-acid batteries is a 30% solution of sulfuric acid ($H_2SO_4$) and distilled water having a specific gravity between 1.260 and 1.280 at 80°F (26.7°C). Wet lead-acid batteries contain the same solution, but normally only distilled water is added to them after receipt. For temperatures below 0°F (-17.7°C), battery performance is better when 1.280 specific gravity solution is used. Other batteries may have different requirements which shall be in agreement with the manufacturer's recommendations.

**WARNING:**

**All battery electrolytes are highly corrosive and can severely damage eyes, skin, and other body tissues. Therefore, wear protective clothing, gloves and goggles when handling these chemicals and while near any battery charging operations.**

After adjusting electrolyte levels, thoroughly wash, neutralize and dry battery tops and cases. Use washing and neutralizing solutions (such as sodium bicarbonate) recommended in the applicable manufacturer's data. Do not allow washing or neutralizing solutions to enter the battery cells. After drying, place the battery on a dry wooden board or similar material that will electrically and chemically isolate the battery case from ground and surrounding material. Keep the battery insulated throughout charging and storage operations prior to use for the cold starting tests in this Standard.

222.1.2.2 Preparation of other than unsealed lead-acid batteries for charging. Clean the battery in accordance with manufacturer's recommendations. Keep the battery insulated throughout charging and storage operations prior to use for the cold starting tests in this Standard.

222.1.3 Battery charging equipment and connections.

**WARNING:**

**Batteries being charged may produce highly explosive hydrogen gas during the charging process. Keep sparks, open flames and other ignition sources away from the charging area. Do not smoke during battery charging operations. Charging areas must be well ventilated. Failure to comply may result in death or injury to personnel.**

222.1.3.1 Battery charging equipment and connections for flooded electrolyte (unsealed) lead-acid and VRLA batteries. Charging equipment for lead-acid batteries can consist of any suitable DC power system with the necessary metering and instrumentation.

222.1.3.2 Battery charging equipment and connections for other than flooded electrolyte (unsealed) lead-acid and VRLA batteries. Other batteries generally require their own special charging equipment as well as special discharging fixtures, which will be identified in the applicable manufacturer's data.

**WARNING:**

**Improper charging or discharging of batteries can result in a condition called "thermal runaway", which is dangerous to personnel and destructive to the battery.**

222.1.4 Standard battery ratings. Battery ratings refer to the total number of Ampere-hours (Ah) that can be expended during a specified period of continuous discharging at a specified constant temperature and at a specified constant discharge rate. Batteries are commonly rated by maximum current ratings referred to as Cold Cranking Amps (CCA). This rating is a measurement of the amps a battery can deliver at 0°F for 30 seconds and not drop below 7.2 volts in a nominal 12 volt battery.

Ampere-hour (Ah) ratings are usually found on deep cycle batteries. The standard for this rating is based on an amp load for 20 hours. A 100 Ah rated battery translates to about 5 amps an hour, 5 x 20 = 100 Ah.

Further details about these ratings are outlined in the Society of Automotive Engineers (SAE) Standard J537 and outlined in Department of the Army Technical Manual 9-6140-200-13.

222.1.5 State-of-charge assurance. The state-of-charge of a battery at any point in time is determined by various methods. These methods may not establish how long the battery will operate at given discharge rate accurately. Batteries should be charged in accordance with TM 9-6140-200-13 and TB 9-6140-252-13 and monitor the charging current. When the current is less than one Ampere for 3 hours, the battery is charged. Use a load tester and battery analyzer to determine battery performance.

222.1.6 Pre-conditioning of batteries. Pre-condition batteries according to the power system technical manual, if applicable, or the manufacturer's recommendations prior to testing. Technical Manual 9-6140-200-13 is an example of a publication with the recommended charging procedures for automotive lead-acid starting batteries.

222.1.7 Stabilization period after charging. Batteries should be allowed to rest for about 24 hours after charging and before use. Final state-of-charge determinations should not be made until after the stabilization period. Throughout the stabilization period, the battery should be kept on a dry wooden board or similar non-conductive material that isolates the battery case from the ground. Battery terminals should be kept covered with suitable plastic caps, grease or wax; temperatures around the battery should be kept between 60°F (15.6°C) and 80°F (26.7°C); the battery exterior should remain dry and the relative humidity around the battery should not exceed 65 percent.

222.1.8 Installing batteries in power systems. Clean the battery posts and cable terminals thoroughly per the manufacturer's instructions. Do not use a wire brush or other metal cleaning tools. Non-abrasive brushes or cloth are recommended for cleaning battery posts.

After installation, apply approximately 1/8" (3 mm) thick coating of petroleum jelly, automotive and artillery grease (GAA) compound or similar, completely covering the battery posts and cable terminals.

# METHOD 301.1d

## INSULATION RESISTANCE TEST

| WARNING: |
| --- |
| **OBSERVE SAFETY REGULATIONS. The voltages used in this Method are dangerous to human life. Contact with the leads or the windings under test may cause severe, and possibly fatal, shock. Arrange the high voltage leads so that they are not in a position to be accidentally touched. Keep clear of all energized parts. Always reduce the test voltage to zero and ground the winding under test before making any mechanical or electrical adjustments on the equipment. When grounding windings which have been tested, always connect the connection wire to ground first, and then to the winding. Never perform this test without at least one other person assisting. Securely ground the generator frame to the building ground or earth ground.** |

301.1.1 General. To assure that the current leakage is kept to a minimum, the insulation resistance must be as high as practicable.

301.1.2 Apparatus. Use instrumentation as described and illustrated in 105.1.5.3. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

301.1.3 Procedure.

301.1.3.1 Preparation for test.

a. Disconnect the circuit under test from all other circuits.

> **Note:** Each circuit of each generator presents an individual problem and no specific instructions can be given here.

b. Disconnect all radio suppression capacitors from the circuit to be tested.

c. In the case where several windings constitute a circuit, all leads of the circuit may be connected together and the resistance measured between this connection and ground.

d. Ground all circuits except the one being tested.

e. When testing a stator element, connect the ground lead from the test apparatus to the generator frame (ground). When testing elements that rotate, connect the test apparatus ground lead to the shaft.

f. Connect the other lead to the circuit under test.

301.1.3.2 Test.

a. Operate the test apparatus in accordance with the manufacturer's instructions.

b. Record the insulation resistance after one minute of operation per METHOD 203.1 (see FIGURE 301.1-1). Also record ambient temperature.

c. Turn off test apparatus. Ground the winding under test and the test lead before disconnecting apparatus leads or touching circuit under test.

d. Remove the leads to the circuit under test and repeat the procedure for all other circuits to be tested.

e. After all circuits are tested, reconnect all circuits to original configuration.

301.1.4 Results. Compare the results with the procurement document requirements.

301.1.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. Minimum allowable insulation resistance.

b. Circuits to be subjected to this Method.

**DESCRIPTION:** 10 KW, 60 HZ
120 V, SINGLE PHASE
GENERATOR ONLY

**MFGR.** ENGENSETS, INC.

**MODEL NO.** SF-10-0-MD

**SERIAL NO.** 21108

**REF.** MIL-STD-705/301.1

**PHILADELPHIA REGION**
**DEFENSE CONRACT ADMINISTRATION SERVICE**

INSULATION RESISTANCE TEST

**TEST NO.** 1

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L WRIGHT

**PROJ. ENGR.** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | | | 1701 | | | | | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | WINDINGS | | RESISTANCE | | | | | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | | | OHMS | | | | | | | | | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 123 | 0931 | ROTOR | | | >200M | | | | | | | | | | | | 77 |
| | | | | | | | | | | | | | | | | | |
| 124 | 0933 | STATOR | | | >200M | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 125 | 0938 | FIELD | | | >200M | | | | | | | | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY

FIGURE 301.1-1 Typical test record for insulation resistance.

METHOD 302.1c

HIGH POTENTIAL TEST

**WARNING:**

**OBSERVE SAFETY REGULATIONS. The voltages used in this Method are dangerous to human life. Contact with the leads or the windings under test may cause severe, and possibly fatal, shock. Arrange the high voltage leads so that they are not in a position to be accidentally touched. Keep clear of all energized parts. Always reduce the test voltage to zero and ground the winding under test before making any mechanical or electrical adjustments on the equipment. When grounding windings which have been tested, always connect the connection wire to ground first, and then to the winding. Never perform this test without at least one other person assisting. Securely ground the generator frame to the building ground or earth ground.**

302.1.1 General. The generator insulation materials must be capable of withstanding, without damage, voltages higher than rated for definite periods of time to preclude damage during transient loading and short circuit conditions. This test should be performed after the equipment is completely assembled so that damage to the insulation which might have occurred during manufacture and assembly will be detected.

302.1.2 Apparatus. Use a variable alternating current, high voltage, current-limited power source. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

302.1.3 Procedure.

302.1.3.1 Preparation for test.

a. Adequately ground the high potential apparatus to a solid electrical ground in accordance with instructions accompanying the apparatus. Also, connect the main frame of the power system and all windings of the generator, not under test, to the same ground.

b. Unless semiconductors are specifically designed to withstand the specified test voltage, remove or disconnect them from the circuit along with any radio suppression capacitors prior to conducting the tests.

c. Raise, or remove, brushes from commutator and slip rings, if applicable.

d. Isolate the generator power output windings, the generator field windings, and the exciter armature and field windings if a part of the power generating source. Do this by disconnecting the various windings from the associated control circuits or other connections. Test static excitation systems feeding the field excitation from the AC generator with all capacitors disconnected, unless such capacitors are designed to withstand the specified test voltage.

e. Connect the high voltage lead from the test apparatus to the winding or circuit under test. Connect all other windings and circuits securely to ground.

302.1.3.2 Test.

a. Turn on the test apparatus in accordance with the manufacturer's instructions, after making sure that the initially applied voltage will not be greater than 600 volts.

b. Raise the test voltage approximately uniformly to the required value. Do this increase in not less than 10 seconds nor more than 30 seconds. Unless otherwise specified in the procurement document, the maximum test voltage for power output windings shall be equal to 1,000 volts plus twice the highest rated voltage of the generator. The test voltage for field windings shall be equal to 10 times the exciter ceiling voltage but in no case less than 1,500 volts nor more than 3,500 volts. Record on the data sheet the maximum voltage reached per METHOD 203.1 (see FIGURE 302.1-1).

c. Apply the maximum voltage for 1 minute. Record the voltage applied, including any breakdown in insulation observed.

d. After 1 minute, gradually reduce the voltage to the voltage initially applied. Do not do this reduction in less than 5 seconds.

e. Turn off the test apparatus.

**WARNING:**

**Ground the high voltage lead of the test apparatus to make sure that no charge remains on the windings which have been under test.**

f. Remove the high voltage lead from the winding and proceed with the tests of the remaining circuits to be tested. Make sure that all the circuits not under test are securely grounded.

g. After test is completed, reconnect all circuits to original configuration.

302.1.4 Results. Compare the results with the procurement document requirements.

302.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Test value of applied voltages, if different than those specified in 302.1.3.2.

b. Windings to be tested, if other than those specified in 302.1.3.

c. Definition of insulation breakdown.

| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V, SINGLE PHASE<br>GENERATOR ONLY<br><br>**MFGR.** ENGENSETS, INC.<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 1677<br><br>**REF.** MIL-STD-705/302.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONRACT ADMINISTRATION SERVICE**<br><br>HIGH POTENTIAL TEST | **TEST NO.** 1<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR.** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST→** | | | | | | | | 008 | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | WINDINGS | | | | | | MAXIUM VOLTAGE APPLIES | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | | | | | | | VOLTS | | | | | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 202 | 0805 | POWER OUTPUT LEADS | | | | | | | 1450 | | | | | | | | 74 |
| | | | | | | | | | | | | | | | | | |
| 203 | 0815 | FIELD | | | | | | | 1500 | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 204 | 0820 | EXCITER ARMATURE | | | | | | | 1500 | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 205 | 0825 | EXCITER FIELD | | | | | | | 1500 | | | | | | | | |
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| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 302.1-1 Typical test record for high potential test.

# METHOD 401.1c

## WINDING RESISTANCE TEST

401.1.1 General. Winding resistance measurements are commonly used to determine temperature rises, to compare winding resistance with design data, to compare production models against first article models, and to detect defective windings.

401.1.2 Apparatus. Use instrumentation for measuring winding resistances as described and illustrated in METHOD 105.1. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

401.1.3 Procedure.

401.1.3.1 Preparation for test.

a. Isolate the winding whose resistance is to be measured by disconnecting one end from all other circuits.

b. Make winding resistance measurements by one of the following approved methods: Wheatstone Bridge; Kelvin Bridge; drop-in potential; or comparison. These methods are described in METHOD 105.1.

c. Connect the measuring apparatus across the winding in accordance with the apparatus manufacturer's instructions. If the drop-in potential or comparison methods are employed, measure the voltage only on the portion of the circuit to be included in the resistance measurements. Since these measurements are used in comparing one reading against another, take measurements of the voltage at the same location of like windings.

d. Make cold resistance measurements with the power system at approximately the surrounding ambient temperature; that is, take the measurements after the power system has been inoperative for a sufficient time (approximately 12 hours) to bring the major generator mass temperature to within 3°C of the ambient temperature.

401.1.3.2 Test. Operate the test apparatus in accordance with the applicable method selected and record the resistance value for the winding(s) under test per METHOD 203.1 (see FIGURE 401.1-1). The resistance values shall be recorded in accordance with 4.2.

When this method is used for temperature change determination, take measurements as fast as possible (see METHOD 110.1). Also record the ambient temperature at which the resistance readings are taken.

401.1.4 Results. Compare the corrected (see METHOD 221.1) values determined by these measurements with procurement document or design requirements, or use them in other computations.

401.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The minimum and maximum allowable resistance values for each component tested, if applicable.

b. The standard temperature to which these measurements are to be corrected, if applicable.

**DESCRIPTION:** 10 KW, 60 HZ
120 V, SINGLE PHASE
POWER SYSTEM

**MFGR.** ENGENSETS, INC.

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 21067

**REF.** MIL-STD-705/401.1

**PHILADELPHIA REGION**
**DEFENSE CONRACT ADMINISTRATION SERVICE**

WINDING RESISTANCE TEST

**TEST NO.** 32

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L WRIGHT

**PROJ. ENGR.** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 320 | | | | | | | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | DIAL READING | | MULTIPLIER | | LEAD RESIS | | WINDING RESIS | | | WINDING | | | WINDING RESIS CORR TO EDGE | | | AVG AMB TEMP |
| **TEMP** | HRS | | | | | OHMS | | OHMS | | | | | | | OHMS | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 199 | 1015 | 7310 | | $10^{-3}$ | | 0.09 | | 7.22 | | | GEN FIELD | | | | 70.8 | | 77 |
| 200 | 1018 | 3838 | | $10^{-2}$ | | 0.09 | | 38.29 | | | EXC FIELD | | | | 36.73 | | |
| 201 | 1022 | 1.642 | | 0.05 | | - | | 0.0821 | | | $T_1 - T_4$ | | | | 0.0807 | | |
| 202 | 1024 | 1.642 | | 0.05 | | - | | 0.0821 | | | $T_2 - T_5$ | | | | 0.0807 | | |
| 203 | 1026 | 1.647 | | 0.05 | | - | | 0.0824 | | | $T_3 - T_6$ | | | | 0.0810 | | |
| 204 | 1031 | 1.642 | | 0.05 | | - | | 0.0821 | | | $T_7 - T_{10}$ | | | | 0.0807 | | |
| 205 | 1033 | 1.643 | | 0.05 | | - | | 0.0821 | | | $T_8 - T_{11}$ | | | | 0.0807 | | |
| 206 | 1034 | 1.647 | | 0.05 | | - | | 0.0824 | | | $T_9 - T_{12}$ | | | | 0.0810 | | |
| | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | |

SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSES ONLY

**NOTES:** GENERATOR STABILIZED AT ROOM TEMPERATURE 24 HOUR PRIOR TO MEASUREMENT

FIGURE 401.1-1 Typical test record for winding resistance test.

METHOD 410.1c

OPEN CIRCUIT SATURATION CURVE TEST

410.1.1 General. The open circuit saturation curve is used by design engineers in conjunction with the short circuit and zero power factor saturation curves to determine certain performance characteristics of the generator under various load conditions. It is used also in comparison with data obtained from tests on production models as a check to ascertain that the quality of the iron or the length of the air gap in the production generators has not been changed from that of the first article model.

410.1.2 Apparatus. Use instrumentation for measuring terminal voltage, generator speed, and exciter field voltage and current (generator field voltage and current, if applicable) as described and illustrated in the 100 series methods as applicable. In addition, use a prime mover having a steady state speed regulation not greater than ±1 percent of rated speed and a separate, variable DC source for excitation. Use a voltmeter having an accuracy in accordance with 4.2 for measuring the terminal voltage. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

410.1.3 Procedure.

410.1.3.1 Preparation for test.

a. Mechanically connect the generator to the prime mover and provide the external excitation supply to the generator. Observe correct polarity when connecting the DC supply to field windings.

b. Connect the instrumentation as illustrated in METHOD 205.1 for the applicable voltage connection.

410.1.3.2 Test.

a. Start and operate the prime mover such that the generator is operating at rated speed, open-circuited and zero excitation. Record all instrumentation per METHOD 203.1 (see FIGURE 410.1-1).

b. Increase the applied voltage to the field to increase the field current in steps from zero upward to give approximately 20, 40, 60, 80, 90, 95, 100, 105, 110, 120, and 130 percent of rated generator voltage (unless otherwise specified in the procurement document). Record all instrumentation at each step. Take all readings with rising field current and without interruption.

**NOTE:** Should it become necessary to decrease the excitation, reduce the field current to zero and then increase to the desired value.

c. When performing this test on three phase machines, take readings of the terminal voltage (line-to-line) of all three phases to check phase balance. Take these readings under constant conditions of excitation and speed.

410.1.4 Results. Plot the open-circuit saturation curve (FIGURE 410.1-2) of generator terminal voltage (vertical axis) versus exciter field current (and generator field current, if applicable) (horizontal axis). If the knee of the curve is not well defined, repeat 410.1.3.2 taking additional readings as needed to better establish this portion of the curve. Compare the results with the procurement document requirements.

410.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

b. Maximum value of no load exciter field current, if applicable.

c. Maximum value of no load generator field current, if applicable.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V, SINGLE PHASE<br>GENERATOR ONLY<br><br>**MFGR.** ENGENSETS, INC.<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 4019<br><br>**REF.** MIL-STD-705/410.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONRACT ADMINISTRATION SERVICE**<br><br>OPEN CIRCUIT SATURATION<br>CURVE TEST | **TEST NO.** 3<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR.** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 187 | | 183 | | | 110 | 217 | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | FREQUENCY | | | EXCITER FIELD | | | | | | | | | | AVG AMB TEMP |
| **TEMP** | HRS | | VOLTS | HZ | | | VOLTS | OHMS | | | | | | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 291 | 0815 | | 8.2 | 60.0 | | | 0 | 0 | | | | | | | | | 77 |
| 292 | | | 24.0 | 60.0 | | | 1.2 | 0.23 | | | | | | | | | |
| 293 | | | 48.0 | 60.0 | | | 2.4 | 0.47 | | | | | | | | | |
| 294 | | | 72.0 | 60.0 | | | 3.7 | 0.73 | | | | | | | | | |
| 295 | | | 96.0 | 60.0 | | | 5.0 | 0.95 | | | | | | | | | |
| 296 | | | 108.0 | 60.0 | | | 6.0 | 1.10 | | | | | | | | | |
| 297 | | | 114.0 | 60.0 | | | 6.8 | 1.25 | | | | | | | | | |
| 298 | | | 120.0 | 60.0 | | | 7.5 | 1.35 | | | | | | | | | |
| 299 | | | 128.0 | 60.0 | | | 8.5 | 1.45 | | | | | | | | | |
| 300 | | | 132.0 | 60.0 | | | 10.2 | 1.55 | | | | | | | | | |
| 301 | | | 144.0 | 60.0 | | | 12.1 | 2.15 | | | | | | | | | |
| 302 | 0835 | | 156.0 | 60.0 | | | 15.0 | 3.22 | | | | | | | | | 76 |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | EXCITER FIELD CURRENT MEASURED USING A 4 AMP, 100 mV, SHUNT #1176 | | | | | | | | | | | | | | | | |

FIGURE 410.1-1 Typical test record for open circuit saturation curve test.

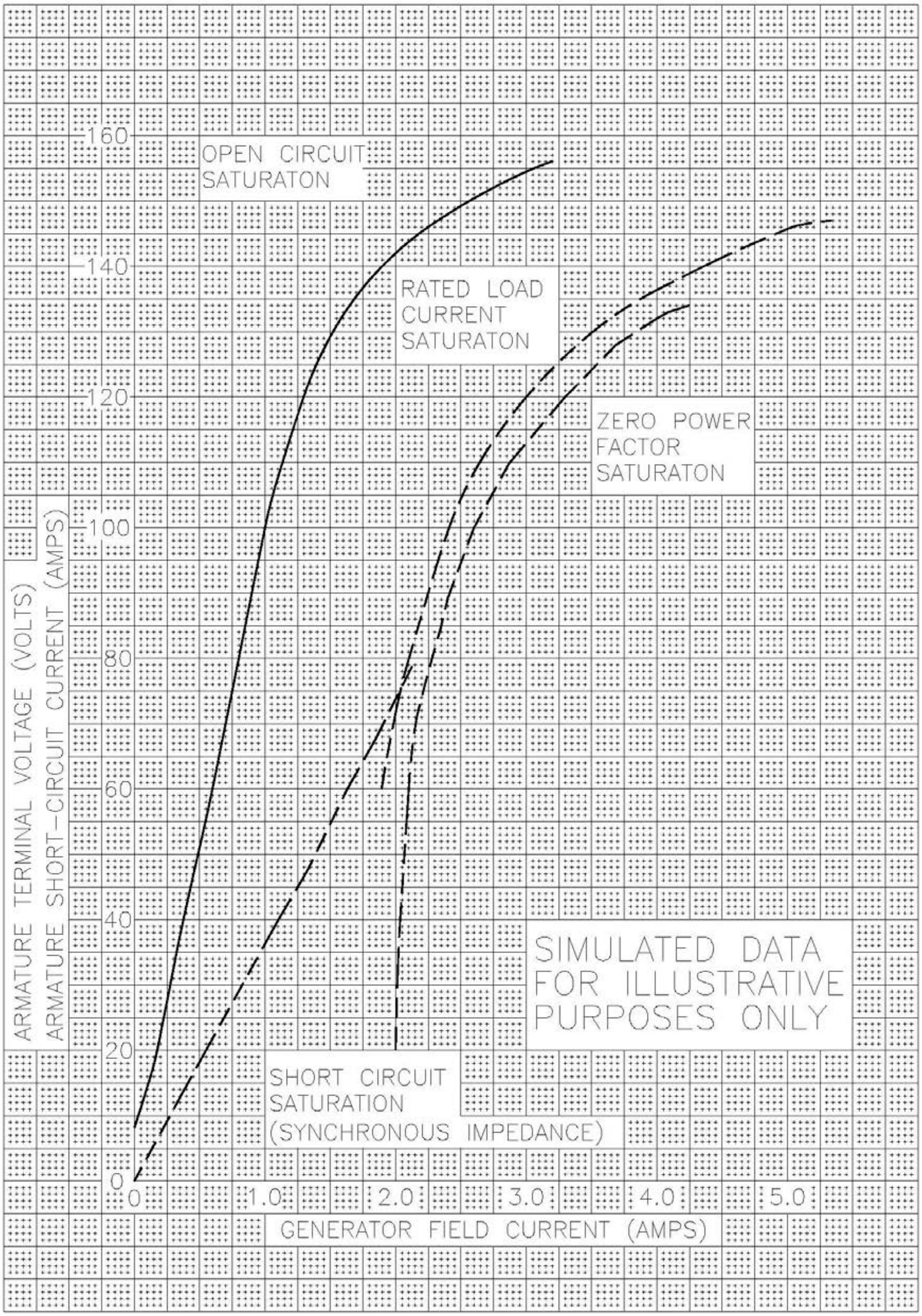


FIGURE 410.1-2 Family of saturation curves.

# METHOD 411.1c

## SYNCHRONOUS IMPEDANCE CURVE TEST
## (SHORT-CIRCUIT SATURATION CURVE)

411.1.1 General. Synchronous impedance curves assist in determining the performance of an alternating current (AC) generator during periods of short circuit. This information is needed to properly design protective devices and to assure designers that the air gap, coils and steel meet requirements.

411.1.2 Apparatus. Use instrumentation for measuring line current, field voltage and current and generator speed as described and illustrated in the 100 series methods as applicable. In addition, use a prime mover capable of driving the generator at rated speed with the short-circuit applied and having a speed regulation not greater than ±1 percent of rated speed and a separate direct current (DC) source for excitation. Use instruments for measuring the field and short circuit currents that have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

411.1.3 Procedure.

411.1.4 Preparation for test.

a. Mechanically connect the generator to the prime mover and connect the external excitation supply to the generator.

b. Connect the instrumentation as illustrated in METHOD 205.1, for the applicable voltage connection.

c. Apply the short-circuit to the generator terminals through the ammeters.

**NOTE:** The short-circuit leads shall be as short as possible to reduce heating effects.

411.1.4.1 Test.

a. Start and operate the prime mover such that the generator is operating at rated speed, short-circuited and zero excitation. Record all instrumentation per METHOD 203.1 (see FIGURE 411.1-1).

b. Increase the field current until 100 percent of rated current exists in each phase. Record the current in all three phases to check current balance. If the current is not balanced within ±1 percent of each other, or within the tolerance specified in the procurement document, correct the cause of the unbalance before proceeding with the test. If the current cannot be balanced, stop test and record failure.

c. After the phase balance is determined to be within tolerance, increase the field excitation until 150 percent of rated current is present in each phase.

**CAUTION: Do not maintain overload current long enough to cause generator overheating.**

d. Record all instrument readings.

e. Reduce the field excitation in steps to obtain 125, 100, 75, 50 and 25 percent of armature current in each phase. Record instrument indications at each step. Take all readings without interruption.

411.1.5 Results. Plot the synchronous impedance or short-circuit saturation curve (FIGURE 411.1-2) of generator armature short-circuit current (vertical axis) versus generator or exciter field current (horizontal axis). Compare the results with the requirements of the procurement document.

411.1.6 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection(s) and speed(s) at which this Method is to be performed.

b. The allowable current variation, if other than as specified herein.

| | | |
|---|---|---|
| **DESCRIPTION:** 15 KW, 60 HZ<br>120/208 V, 3 PHASE<br>GENERATOR ONLY<br><br>**MFGR.** ENGENSETS, INC.<br><br>**MODEL NO.** SF-15.0-MD<br><br>**SERIAL NO.** 1077<br><br>**REF.** MIL-STD-705/411.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONRACT ADMINISTRATION SERVICE**<br><br>SYNCHRONOUS IMPEDANCE CURVE TEST | **TEST NO.** 6<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR.** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 163 | | | | 1156 | 105 | | 377 | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | LINE CURRENT L1 | LINE CURRENT L2 | LINE CURRENT L3 | | GENERATOR FIELD | | | SPEED | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | AMPS | AMPS | AMPS | | VOLTS | AMPS | | | RPM | | | | | | | °F |
| **SYM** | | X 20 | X 20 | X 20 | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 157 | 1115 | STARTED | | DRIVE | MOTOR | | | | | 1800 | | | | | | | 77 |
| 158 | 1120 | 2.60 | 2.60 | 2.60 | | 38.1 | 1.42 | | | 1800 | | | | | | | 77 |
| 159 | 1121 | 3.90 | 3.90 | 3.90 | | 45.2 | 2.21 | | | 1800 | | | | | | | 77 |
| 160 | 1121 | 3.25 | 3.25 | 3.25 | | 42.3 | 1.69 | | | 1800 | | | | | | | 77 |
| 161 | 1122 | 2.60 | 2.60 | 2.60 | | 38.1 | 1.42 | | | 1800 | | | | | | | 77 |
| 162 | 1123 | 1.95 | 1.95 | 1.95 | | 29.8 | 1.11 | | | 1800 | | | | | | | 77 |
| 163 | 1124 | 1.30 | 1.30 | 1.30 | | 21.8 | 0.81 | | | 1800 | | | | | | | 77 |
| 164 | 1125 | 0.65 | 0.65 | 0.65 | | 10.7 | 0.40 | | | 1800 | | | | | | | 77 |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY

**NOTES**
- AC CURRENT MESURED USING CT# L1-1306; L2-1307; L3-1308
- GENERATOR FIELD CURRENT MEASURED USING 3A, 50mV SHUNT #1358

FIGURE 411.1-1 Typical test record for synchronous impedance curve test.

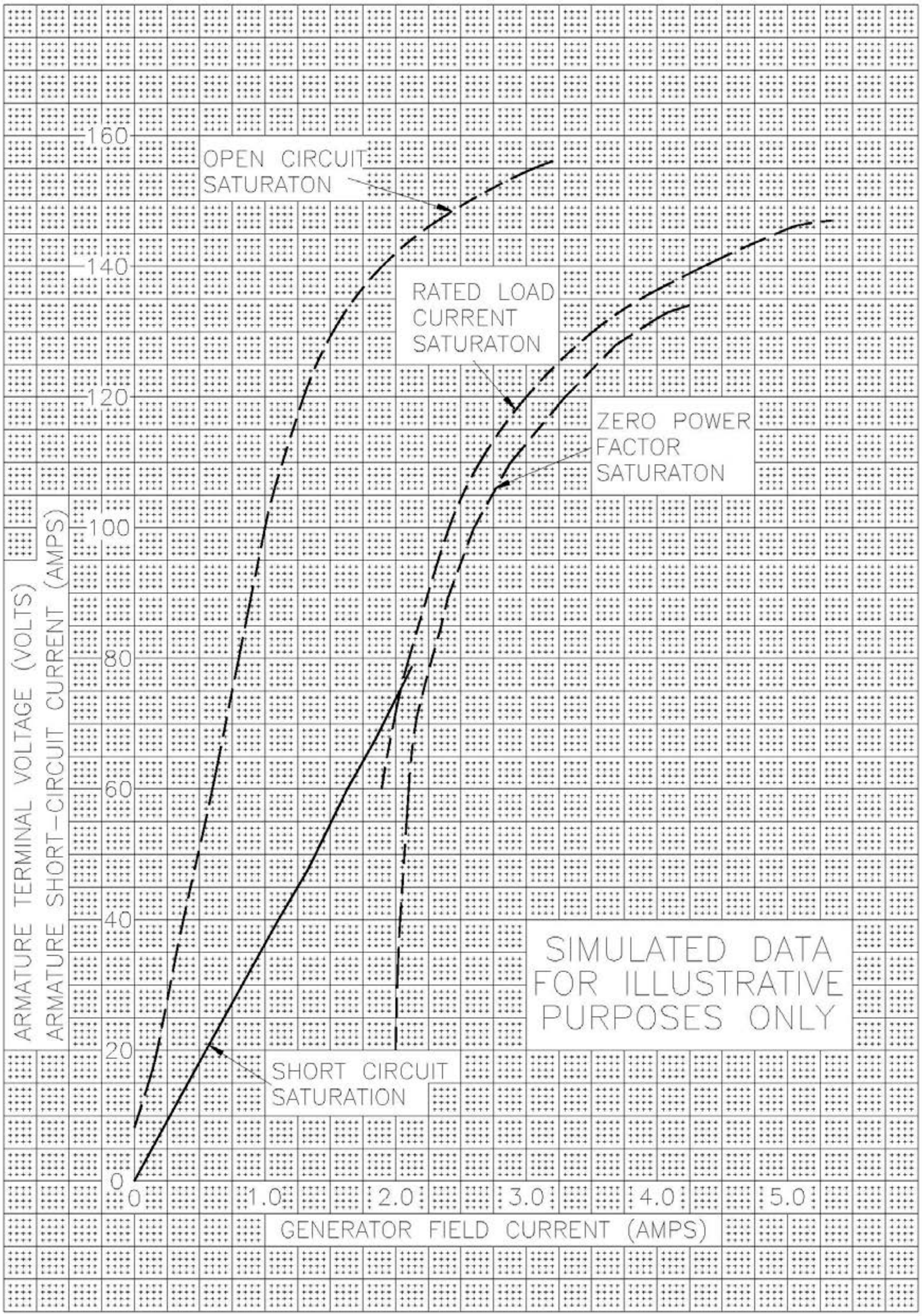


FIGURE 411.1-2 Family of saturation curves.

# METHOD 412.1c

## ZERO POWER FACTOR SATURATION CURVE TEST

412.1.1 General. The zero power factor saturation curve is used by design engineers in conjunction with the short-circuit and open-circuit saturation curves to determine certain performance characteristics of the generator under various load conditions. The family of generator saturation curves can be used to approximate the generator field current for any load condition.

412.1.2 Apparatus. Use instrumentation for measuring load conditions and generator field voltage and current as described and illustrated in the 100 series methods as applicable. In addition, use a prime mover capable of maintaining constant rated speed of the generator under all load conditions of this Method within ±1 percent and a source of DC power for generator excitation. Use instruments for measuring the field current and terminal voltage that have an accuracy in accordance with 4.2. Use a power factor meter capable of indicating power factor to 0.3 lagging. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

412.1.3 Procedure.

412.1.3.1 Preparation for test.

a. Mechanically connect the prime mover to the generator and provide the external excitation supply to the generator.

b. Connect the load and field instrumentation in accordance with the applicable figure of METHOD 205.1, for the voltage connection and frequency specified in the procurement document.

412.1.3.2 Test.

a. Start and operate the prime mover such that the generator is operating at rated speed with zero excitation. Adjust the low power factor load to minimum reactance.

**NOTE:** During all portions of this Method the power factor of the load shall not exceed 0.40 and shall not be less than 0.30. Load current on polyphase generators shall be balanced.

b. Increase the field current until the generator is supplying rated load current.

c. Record all instrument readings per METHOD 203.1 (see FIGURE 412.1-1).

d. Increase the load slightly, then increase the field current until the generator is again supplying rated load current. Adjust the excitation of the generator to approximately 20 percent rated voltage while maintaining the load current constant at the rated value.

e. Record all instrument readings.

f. Repeat steps d and e above to obtain at least seven equally spaced steps of terminal voltage up to and including 130 percent of rated voltage, unless otherwise specified in the procurement document. Take all readings without interruption.

412.1.4 Results. Plot the zero-power-factor saturation curve (FIGURE 412.1-2) of terminal voltage (vertical axis) versus generator or exciter field current (horizontal axis). Compare the results with the requirements of the procurement document.

412.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection(s) and speed(s) at which this Method is to be performed.

b. The limiting terminal voltage, if other than as specified herein.

**DESCRIPTION:** 10 KW, 60 HZ
120 V, SINGLE PHASE
GENERATOR ONLY

**MFGR.** ENGENSETS, INC.

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 21067

**REF.** MIL-STD-705/412.1

**PHILADELPHIA REGION**
**DEFENSE CONRACT ADMINISTRATION SERVICE**

ZERO POWER FACTOR
SATURATION CURVE TEST

**TEST NO.** 7

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L WRIGHT

**PROJ. ENGR.** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 076 | | 163 | | 377 | | 1156 | 105 | 261 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | SPEED | | GENERATOR FIELD | | POWER FACTOR | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | | RPMS | VOLTS | AMPS | | | | | | | | °F |
| **SYM** | | | | X 40 | X 1 | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 165 | 1115 | STARTED | | PRIME | MOVER | | | | | | | | | | | | |
| 166 | 1117 | | 0 | 0 | 0 | | 3600 | 0 | 0 | | | | | | | | 78 |
| 167 | 1118 | | 22.3 | 2.60 | 104 | | 3600 | 8.7 | 2.01 | | 0.38 | | | | | | |
| 168 | 1119 | | 44.4 | 2.60 | 104 | | 3600 | 9.8 | 2.10 | | 0.34 | | | | | | |
| 169 | 1120 | | 66.7 | 2.60 | 104 | | 3600 | 11.0 | 2.20 | | 0.39 | | | | | | |
| 170 | 1121 | | 89.0 | 2.60 | 104 | | 3600 | 11.5 | 2.45 | | 0.31 | | | | | | |
| 171 | 1122 | | 111.0 | 2.60 | 104 | | 3600 | 12.8 | 2.92 | | 0.31 | | | | | | |
| 172 | 1123 | | 133.5 | 2.60 | 104 | | 3600 | 19.5 | 4.23 | | 0.35 | | | | | | |
| 173 | 1124 | | 156.0 | 2.60 | 104 | | 3600 | 27.8 | 7.61 | | 0.38 | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING CT #1309 | | | | | | | | | | | | | | | | |
| | GENERATOR FIELD CURRENT MEASURED USING 10A, 50mV SHUNT #1718 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 412.1-1 Typical test record for zero power factor saturation curve test.

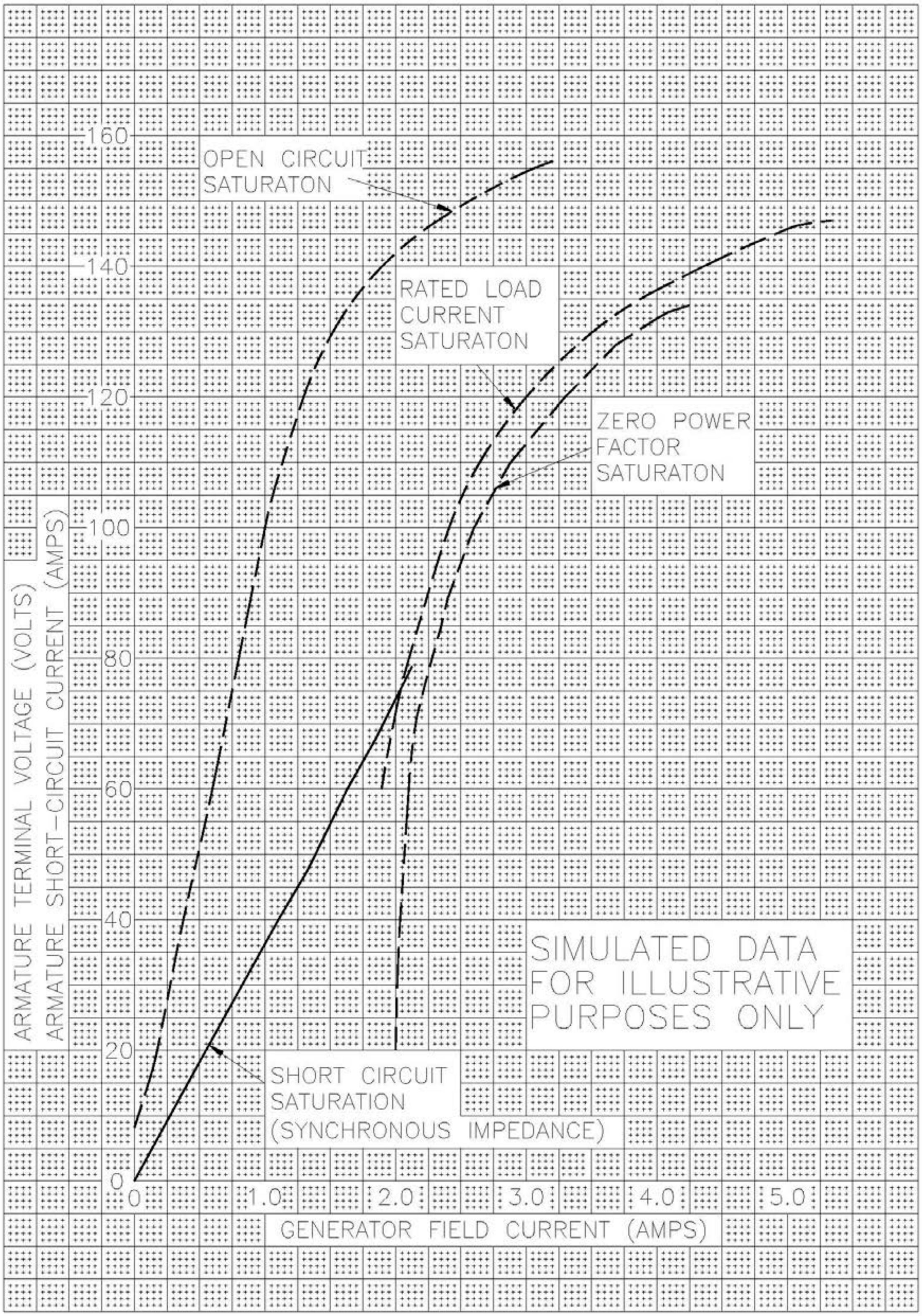


FIGURE 412.1-2 Family of saturation curves.

METHOD 413.1c

RATED LOAD CURRENT SATURATION CURVE TEST

413.1.1 General. The rated load current saturation curve is used by design engineers as an aid in determining the field current requirements of the generator. The family of generator saturation curves can be used to approximate the generator field current for any load condition.

413.1.2 Apparatus. Use instrumentation for measuring load conditions and field voltage and current as described and illustrated in the 100 series methods as applicable. In addition, use a separate variable DC source for generator excitation and a prime mover capable of maintaining the generator speed within ±1 percent of rated speed under all load conditions of this Method. Use instruments for measuring the terminal voltage and field current that have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

413.1.3 Procedure.

413.1.3.1 Preparation for test.

a. Mechanically connect the generator to the prime mover and provide the external excitation supply to the generator.

b. Connect the load and instrumentation to the generator in accordance with the applicable figure of METHOD 205.1, for the voltage connection and frequency specified in the procurement document.

413.1.3.2 Test - AC generators.

a. Start the prime mover and operate the generator at rated frequency, rated load current and rated power factor (0.8 lagging if not otherwise specified), and at approximately 50 percent of rated voltage.

**NOTE**: The load current of polyphase generators shall be balanced.

b. After the conditions of step a above have been reached, record all instrument readings per METHOD 203.1 (see FIGURE 413.1-1).

c. Reduce the field current to zero using the adjustment on the DC source.

d. Increase the field current in steps from zero upward while adjusting the load for rated generator output current and rated power factor to vary the terminal voltage to approximately 70, 80, 90, 95, 100, 105, 110, 120, and 130 percent of rated voltage, unless otherwise specified in the procurement document. Take all readings with a rising field current. Should it become necessary to decrease the excitation, reduce the field current to zero and then increase to the desired value. Then increase the field current to obtain the desired output voltage. Record all instrument readings at each step. Take all readings without interruption. Take sufficient additional steps to clearly define the curve (FIGURE 413.1-1).

413.1.3.3 Test - DC generators.

a. Start the prime mover and operate the power system at rated speed, rated load current, and approximately 20 percent of rated voltage.

b. After the conditions of step a above have been reached, record all instrument readings per METHOD 203.1.

c. Reduce the field current to zero using the rheostat on the separate DC source.

d. Increase the field current in steps to obtain 20, 40, 60, 80, 90, 95, 100, 105, 110, 120, and 130 percent of generator rated voltage (unless otherwise specified in the procurement document) while adjusting the load for rated generator output current. Take all readings with a rising field current. Should it become necessary to decrease the excitation, reduce the field current to zero and then increase to the desired value. Record all instrument readings at each step. Take all readings without interruption.

413.1.4 Results. Plot a curve of terminal voltage versus generator or exciter field current (FIGURE 413.1-2) from the data obtained. Compare the results with the procurement document requirements.

413.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

b. The maximum allowable generator or exciter field current.

c. The maximum terminal voltage, if other than as specified herein.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V, SINGLE PHASE<br>GENERATOR ONLY<br><br>**MFGR.** ENGENSETS, INC.<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/413.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONRACT ADMINISTRATION SERVICE**<br><br>RATED LOAD CURRENT<br>SATURATION CURVE TEST | **TEST NO.** 88<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR.** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 103 | | 206 | | 314 | | 418 | | 60 | | | 138 | 262 | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | GENERATOR FIELD | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | | | HZ | | VOLTS | AMPS | | | °F |
| **SYM** | | | | X 40 | X 1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 173 | 1316 | | 60 | 2.60 | 104 | 0.125 | 5.0 | | 0.80 | | 60.0 | | 26.1 | 1.87 | | | 79 |
| 174 | 1318 | REDUCED FIELD CURRENT TO ZERO | | | | | | | | | | | | | | | |
| 175 | 1320 | | 60 | 2.60 | 104 | 0.125 | 5.0 | | 0.80 | | 60.0 | | 26.1 | 1.87 | | | |
| 176 | | | 70.3 | 2.60 | 104 | 0.146 | 5.85 | | 0.80 | | 60.0 | | 27.8 | 1.98 | | | |
| 177 | | | 80.4 | 2.60 | 104 | 0.168 | 6.7 | | 0.80 | | 60.0 | | 28.5 | 2.13 | | | |
| 178 | | | 90.1 | 2.60 | 104 | 0.188 | 7.5 | | 0.80 | | 60.0 | | 30.5 | 2.27 | | | |
| 179 | | | 100.3 | 2.60 | 104 | 0.208 | 8.35 | | 0.80 | | 60.0 | | 32.5 | 2.42 | SIMULATED DATA | | |
| 180 | | | 109.8 | 2.60 | 104 | 0.229 | 9.15 | | 0.80 | | 60.0 | | 34.8 | 2.68 | FOR ILLUSTRATIVE | | |
| 181 | | | 115.6 | 2.60 | 104 | 0.240 | 9.6 | | 0.80 | | 60.0 | | 37.5 | 2.79 | PURPOSE ONLY | | |
| 182 | | | 120.2 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 60.0 | | 40.5 | 3.00 | | | |
| 183 | | | 125.7 | 2.60 | 104 | 0.262 | 10.5 | | 0.80 | | 60.0 | | 43.7 | 3.31 | | | |
| 184 | | | 130.1 | 2.60 | 104 | 0.270 | 10.8 | | 0.80 | | 60.0 | | 47.4 | 3.58 | | | |
| 185 | | | 136.0 | 2.60 | 104 | 0.282 | 11.3 | | 0.80 | | 60.0 | | 51.5 | 4.02 | | | |
| 186 | | | 142.1 | 2.60 | 104 | 0.295 | 11.8 | | 0.80 | | 60.0 | | 55.8 | 4.53 | | | |
| 187 | 1335 | | 146.8 | 2.60 | 104 | 0.305 | 12.2 | | 0.80 | | 60.0 | | 60.3 | 5.31 | | | 79 |
| **NOTES** | LINE CURRENT MEASURED USING CT #1305 | | | | | | | | | | | | | | | | |
| | GENERATOR FIELD CURRENT MEASURED USING 10A, 50mV SHUNT #2071 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 413.1-1 Typical test record for rated load current saturation curve test.

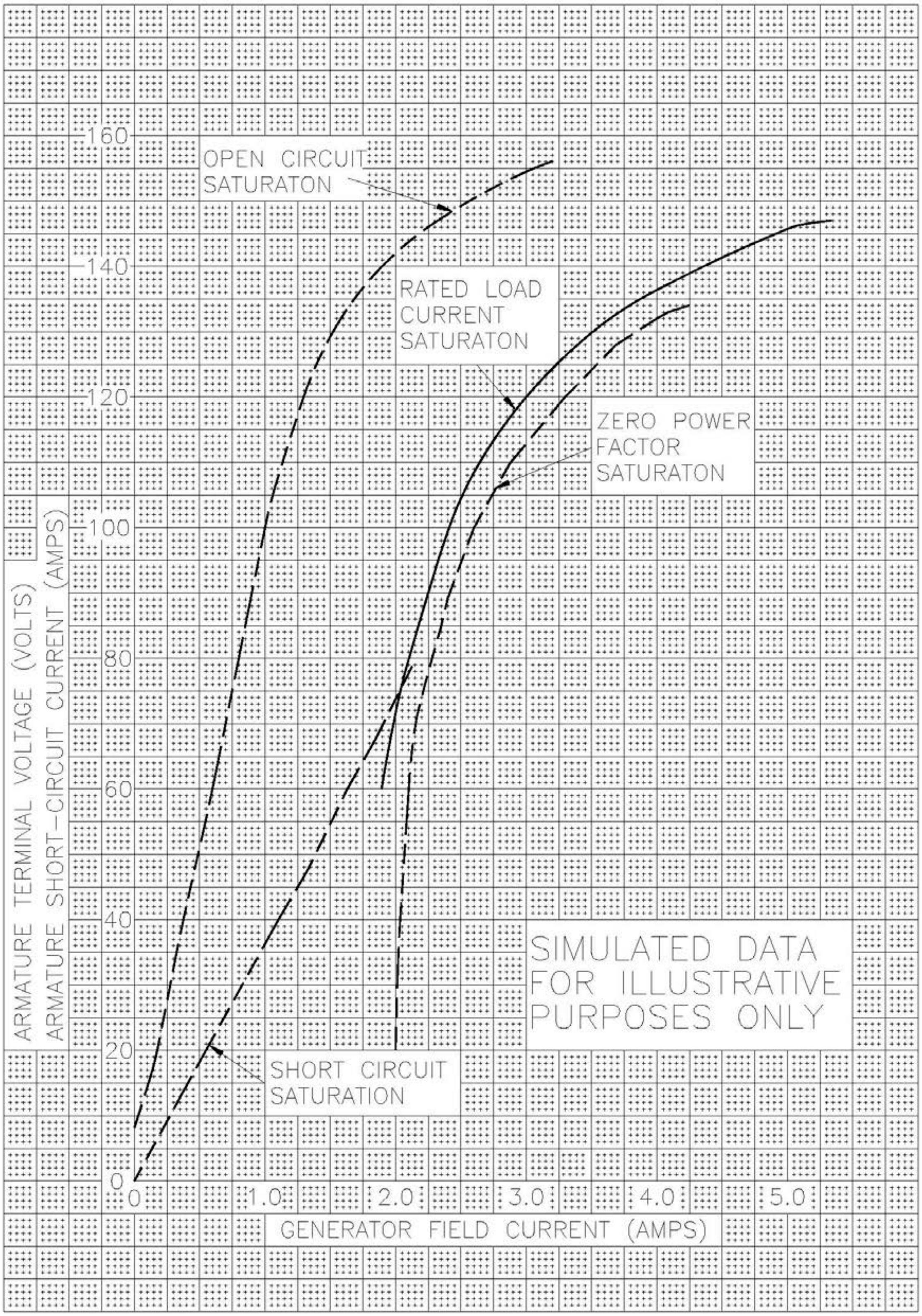


FIGURE 413.1-2 Family of saturation curves.

# METHOD 414.1c

## ROTATING EXCITER SATURATION CURVE TEST (CONSTANT RESISTIVE LOAD)

**NOTE**: Method 414.1c was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

414.1.1 General. The saturation curve for a rotating exciter aids the design engineer in determining the suitability of a particular exciter for use with a particular generator.

414.1.2 Apparatus. Instrumentation for measuring exciter output voltage, exciter field current and exciter speed shall be as described and illustrated in MIL-HDBK-705. In addition a prime mover capable of driving the exciter at rated speed with a speed regulation not greater than ±1 percent of rated speed, a separate variable dc source for excitation and a resistive load equivalent to the generator field resistance at 75 °C shall be required. Instruments for measuring the dc terminal voltage and exciter field current shall have an accuracy in accordance of ±0.5 percent of reading or better.

414.1.3 Procedure.

414.1.3.1 Preparation for test.

a. Connect the instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1.

b. Connect the resistive load to the output of the exciter. (Slip rings may be necessary if the generator is not so equipped.)

NOTE: In order to obtain zero exciter field current, it may be necessary to open the exciter field circuit. To prevent high voltage hazard to personnel, the exciter field current should be reduced to the minimum possible value before opening the field.

414.1.3.2 Test.

a. On exciters with brushes, check that the brush settings are positioned in accordance with the manufacturer's recommendation.

b. Start and operate the prime mover such that the exciter is operating at its rated speed. Adjust the exciter field current to obtain nominal exciter voltage. Operate the exciter under these conditions for a 30 minute period. Read and record all instrumentation initially and every 10 minutes thereafter.

c. Reduce the exciter field current to zero. Read and record all instrumentation (See FIGURE 414.1-I).

d. Increase the exciter current in steps to obtain exciter terminal voltages of approximately 20, 40, 60, 80, 90, 95, 100, 105, 110, 120, and 130 percent of nominal exciter voltage. Read and record all instrumentation at each step. All readings shall be taken without interruption.

414.1.4 Results. Plot a curve of exciter terminal voltage versus exciter field current (FIGURE 414.1-II), using the data obtained above. This curve shall be known as "the loaded exciter saturation curve". Compare this curve with the requirements of the applicable generator or the procurement document.

414.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The nominal exciter voltage.

b. Exciter rated speed.

c. Exciter ceiling voltage, if applicable.

d. Generator field resistance or current value.

**DESCRIPTION:** 15KW, 60HZ
120/208V, 3-PHASE
EXCITER ONLY

**MFGR:** ENGENSETS, INC

**MODEL NO.** T-107

**SERIAL NO.** 59328

**REF.** MIL-STD-705/414.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

ROTATING EXCITER SATURATION
CURVE TEST

**TEST NO.** 2

**SHEET:** 1 OF 1

**DATE:** FEBRUARY 8, 1971

**RECORDER:** L WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 312 | | 166 | | 618 | | | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | EXCITER VOLTAGE | | EXCITER FIELD CURRENT | | SPEED | | | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | | AMPS | | RPM | | | | | | | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 188 | 0910 | | 100.0 | | 2.30 | | 1800 | STARTED UNIT | | | | | | | | | 74 |
| 189 | 0920 | | 100.1 | | 2.30 | | 1800 | END OF 30 MINUTES OPERATION | | | | | | | | | 75 |
| 190 | 0930 | | 100.1 | | 2.30 | | 1800 | | | | | | | | | | 76 |
| 191 | 0940 | | 100.1 | | 2.30 | | 1800 | | | | | | | | | | 77 |
| 192 | 0942 | | 0 | | 0 | | 1800 | | | | | | | | | | 78 |
| 193 | 0944 | | 20.0 | | 0.38 | | 1800 | | | | | | | | | | |
| 194 | 0945 | | 40.0 | | 0.78 | | 1800 | | | | | | | | | | |
| 195 | 0946 | | 60.0 | | 1.20 | | 1800 | | | | | | | | | | |
| 196 | 0947 | | 80.0 | | 1.75 | | 1800 | | | | | | | | | | |
| 197 | 0950 | | 90.1 | | 2.03 | | 1800 | | | | | | | | | | |
| 198 | 0951 | | 95.0 | | 2.17 | | 1800 | | | | | | | | | | |
| 199 | 0953 | | 100.0 | | 2.30 | | 1800 | | | | | | | | | | |
| 200 | 0954 | | 105.0 | | 2.48 | | 1800 | | | | | | | | | | |
| 201 | 0958 | | 110.0 | | 2.70 | | 1800 | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| 202 | 0959 | | 120.1 | | 3.28 | | 1800 | | | | | | | | | | |
| 203 | 1000 | | 130.0 | | 4.25 | | 1800 | | | | | | | | | | 80 |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | EXCITER FIELD CURRENT MEASURED USING A 5A, 100mV SHUNT NO. 1177 | | | | | | | | | | | | | | | | |
| | GENERATOR RESISTANCE = 3.31 Ω | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 414.1-I Typical test record for rotating exciter saturation curve test.

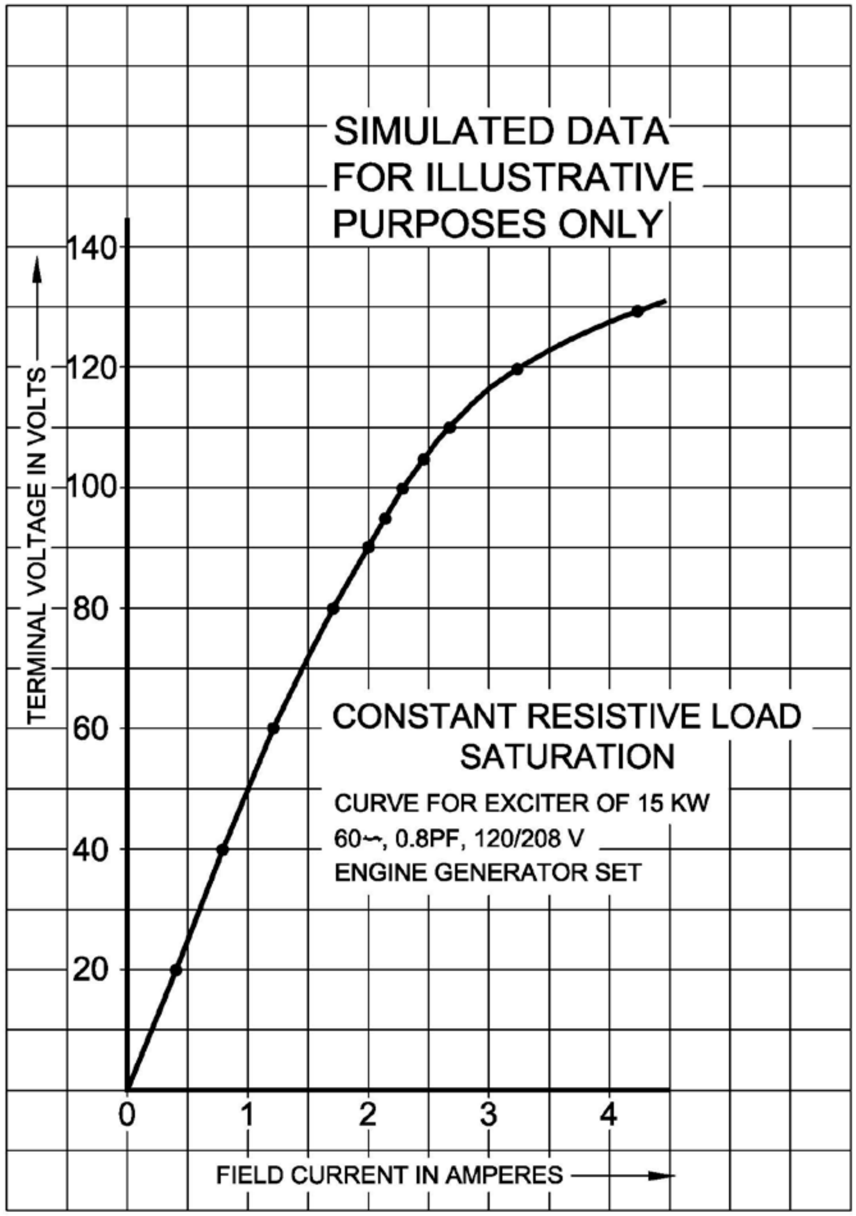


FIGURE 414.1-II Sample loaded exciter saturation curve.

METHOD 415.0b

SUMMATION OF LOSSES TEST

**NOTE**: Method 415.0b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

415.0.1 General. The internal generator losses are inversely related to the efficiency. The efficiency of a generator determines the capacity of the prime mover necessary for proper operation. The summation of losses test allows design engineers to investigate the problem of increasing the efficiency of a generator.

415.0.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, set temperatures and prime mover output power shall be as described and illustrated in MIL-HDBK-705. In addition, a prime mover (dynamotor or dc motor) shall be required. If a dc motor is used, a curve of power output (in kW) against input current at a constant input voltage shall be furnished (see FIGURE 415.0-I and FIGURE 415.0-V). If a calibrated dc motor is used as the prime mover, a constant voltage power supply corresponding to the motor calibration curve shall be used. The dc motor, if used, shall have a horsepower rating of not less than 25 percent nor more than 50 percent of the generator kilowatt rating. A separate variable source of dc power for generator excitation shall be provided. A direct reading torque meter (connected between the prime mover and generator) may be utilized for calculating actual generator input power. Electrical instrumentation used for the following tests shall have an accuracy of ±0.5 percent of reading or better.

415.0.3 Procedure.

415.0.3.1 Preparation for test.

a. Mechanically connect the generator assembly, including its cooling fan to the prime mover and provide the external excitation supply to the generator.

b. Connect the load and field instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, for the voltage connection and frequency specified in the procurement document.

c. As applicable, connect the instrumentation necessary to measure the output power of the prime mover. The instrumentation requirements of a dynamotor shall be connected in accordance with the manufacturer's instructions; the instrumentation for a calibrated dc motor shall be connected to measure the motor input voltage and current and the field voltage and current similar to that shown in MIL-HDBK-705, method 205.1, figure 205.1.XLI and figure 205.1.XLII.

415.0.3.2 Test.

415.0.3.2.1 Bearing friction and windage loss.

a. Raise the brushes, if applicable, so that they do not touch the slip rings or the commutator.

b. The friction and windage loss is the power input to the machine being tested, with zero excitation.

c. Start and operate the prime mover at rated generator speed until the bearing(s) reach constant temperature so the bearing friction becomes stable.

d. Record the data necessary to compute the output power of the prime mover (motor input power or dynamometer constant and scale reading).

e. Compute the prime mover output power in kW. This value represents the bearing friction and windage loss of the generator.

415.0.3.2.2 Brush friction loss.

a. Adjust the brush pressure on all generator brushes to the pressure recommended on the power generating source or in the technical manual.

b. Start and operate the prime mover at rated generator speed until the bearing(s) reach constant temperature so that bearing friction becomes stable.

c. Record the data necessary to compute the output power of the prime mover (motor input power or dynamometer constant and scale reading).

d. Compute the prime mover output power in kW and subtract the prime mover output power found in 415.0.3.2.1e. This difference represents the brush friction loss.

415.0.3.2.3 Brush contact loss.

a. Adjust the brush pressure on all generator brushes to the pressure recommended on the power generating source or in the technical manual.

b. Start and operate the prime mover at rated generator speed until the bearing(s) reach constant temperature so that bearing friction becomes stable. For dc generators, apply a short circuit to the output terminals and adjust the excitation to obtain rated load current. For ac generators adjust the field current to its value at rated load.

c. With a low-range voltmeter (range of approximately 3 volts), read and record the voltage between the brush bracket holder and at least four equally spaced points along the commutator brush span (see FIGURE 415.0-IX).

d. Repeat steps b and c above for all other load conditions specified in the procurement document.

e. For each load condition average the four voltage readings found for that load condition.

f. Compute the brush contact loss by multiplying twice the average voltage found in step e above by the load current under which the average was found.

g. For the summation of losses the brush contact loss shall be taken as the loss found with the generator operating at rated load multiplied by the number of pairs of brushes on the commutator or slip rings.

415.0.3.2.4 Open-circuit core loss (ac generator only).

a. Start and operate the prime mover at rated generator speed, without generator excitation, until the bearing(s) reach constant temperature and friction becomes stable. (Two-hour operation will be sufficient with no more than a 3 °C change in the average ambient temperature).

b. Using the external excitation supply raise the terminal voltage from zero to give approximately 20, 40, 60, 80, 90, 100, 105, 110, 120, and 130 percent of rated voltage.

c. Simultaneously read and record the generator field current and voltage, the generator terminal voltage and the data necessary to compute the output power of the prime mover for each step, including the zero step. All readings shall be taken with a rising field current. Should it be necessary to reduce the excitation current it must be reduced to zero and then returned to the desired value (see FIGURE 415.0-VI).

d. From the prime mover output power at each step subtract the bearing friction and windage loss and, if applicable, the brush friction loss to obtain the open circuit core loss for each field current value.

e. Plot a curve of generator open-circuit core loss versus terminal voltage (see FIGURE 415.0-II). The value of open-circuit core loss at rated voltage shall be used in this summation of losses.

415.0.3.2.5 Open-circuit core loss (dc generators only).

a. Start and operate the prime mover at rated generator speed, without generator excitation, until the bearing(s) reach constant temperature and friction become stable. (Two-hour operation will be sufficient with not more than a 3 °C change in the average ambient temperature).

b. Using the external excitation supply, raise the terminal voltage from zero to its rated value.

c. Simultaneously read and record the field voltage and current, the generator terminal voltage and the prime mover output power in kW (see FIGURE 415.0-VII).

d. Calculate the internal generator voltages corresponding to 25, 50, 75, and 100 percent of rated load by adding the armature circuit (armature, brushes, commutating field, and series field) voltage drops due to resistance at each of the above load conditions to the rated terminal voltage.

e. Using the external excitation supply raise the terminal voltage to obtain each of the values calculated in step d above.

f. Simultaneously read and record the generator field voltage and current, the generator terminal voltage and the prime mover output power in kW at each step.

g. From the prime mover output at each step subtract the bearing friction and windage loss and, if applicable, the brush friction loss to obtain the open circuit core loss for each terminal voltage step.

h. Plot a curve of generator open-circuit core loss versus generator terminal voltage (see FIGURE 415.0-III). The value of open-circuit core loss which corresponds to the calculated internal voltage at rated load shall be used in this summation of losses.

415.0.3.2.6 Armature $I^2R$ Loss.

a. The armature $I^2R$ loss is defined as the product of the square of the armature current under any specified load and the resistance of the armature winding as measured in accordance with MIL-HDBK-705, method 105.1, corrected to 25 °C plus the stabilized temperature rise of the armature winding under the same load condition. The following formula for copper windings shall be used to determine the armature resistance:

$$R_c = \frac{R_o(234.5 + T_r)}{234.5 + T_o}$$

Where:

$R_c$ is the corrected resistance.

$R_o$ is the measured resistance.

$T_r$ is the temperature rise in degrees Celsius (C°).

$T_o$ is the temperature of the winding at the time $R_o$ is measured in degrees Celsius (°C).

b. The armature $I^2R$ loss shall be calculated for rated load current in the armature winding(s) and used in this summation of losses. For a 3-phase machine the loss is the summation of the losses of the individual phase windings.

c. To determine the stabilized armature winding temperature rise perform method 680.1, Temperature Rise Test (Generator Only).

415.0.3.2.7 Field $I^2R$ loss.

a. The field $I^2R$ loss is defined as the product of the square of the field current under any specified load condition and the resistance of the field as measured in accordance with MIL-HDBK-705, method 105.1, corrected to 25 °C plus the stabilized temperature rise of the field winding under the same load condition. Use the formula given in 415.0.3.2.6a above to determine the corrected field resistance.

b. The field $I^2R$ loss shall be calculated for rated load field current in the field winding and used in the summation.

c. To determine the stabilized field winding temperature rise perform method 680.1, Temperature Rise Test (Generator Only).

415.0.3.2.8 Stray load loss.

a. Short circuit the generator through the load current transformers (or shunt). A wye connected generator shall be shorted line-to-neutral (all phases) while a delta connected generator shall be shorted line-to-line (all phases).

b. Start and operate the prime mover at rated generator speed. Adjust the external excitation supply for approximately 125 percent of rated current. (If the phase currents of a multi-phase machine are not approximately balanced, shut down the prime mover and the excitation supply and correct the trouble before proceeding.) This test shall be performed with decreasing field current. (During this test, should the field current accidentally be increased, it shall be returned to the value which will cause approximately 125 percent of rated generator current, then reduced to the desired value.)

c. Decrease the excitation to obtain approximately 100, 75, 50, and 25 percent of rated current in the short-circuit ammeters. At each of these steps, including the

125 percent step, read and record the generator output current, the speed of the generator and the prime mover output power in kW (FIGURE 415.0-VIII).

d. From the recorded values of prime mover output power subtract the bearing friction and windage loss, the brush friction loss, brush contact loss, and the armature $I^2R$ loss (which must be calculated for each current step, see 415.0.3.2.6), to obtain the stray load loss.

e. Plot a curve of stray load loss versus armature current (FIGURE 415.0-IV).

f. The value of stray load loss at the armature current corresponding to rated armature current shall be used in the summation of losses.

415.0.3.2.9 Exciter loss. Connect a "dummy" load consisting of a resistor equal to the field resistance of the generator as defined in 415.0.3.2.7.

415.0.3.2.9.1 Rotating exciter directly coupled to the generator.

a. Start and operate the prime mover at rated generator speed, without generator excitation and with slip ring or commutator brushes raised. Adjust the exciter output voltage and current to the values required to excite the generator at rated load at rated voltage and rated speed.

b. Read and record the prime mover output power in kW, and the output current and voltage of the exciter.

c. From the prime mover output power subtract the field $I^2R$ loss and the bearing friction and windage loss. This value is the exciter loss in kilowatts.

415.0.3.2.9.2 Rotating exciter separately driven.

a. Mechanically connect the exciter to a calibrated motor dynamometer (prime mover).

b. Start and operate the prime mover at the exciter's rated speed. Adjust the exciter output voltage and current to the values required to excite the generator at rated load at rated voltage and rated speed.

c. Read and record the prime mover output power in kW and the output voltage and current of the exciter.

d. From the prime mover output power subtract the field $I^2R$ loss to obtain the exciter loss in kilowatts.

415.0.3.2.9.3 Static exciter.

a. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, for the exciter input power.

b. Using a variable resistor in series with the voltage sensing lines (variable auto transformer for ac generators) adjust the input voltage to vary the excitation voltage and current. Adjust the exciter output voltage and current to the values required to excite the generator at rated load at rated voltage and rated speed.

c. Record all instrument readings.

d. From the kilowattmeter reading of the input power to the exciter, subtract the field $I^2R$ loss to obtain the exciter loss in kilowatts.

415.0.4 Results.

a. Total the following power losses:

1. Bearing friction and windage loss at rated speed.
2. Brush friction loss at rated speed, if applicable.
3. Brush contact loss at rated speed, if applicable.
4. Open-circuit core loss at rated voltage.
5. Armature $I^2R$ loss at rated current.
6. Field $I^2R$ loss at rated load.
7. Stray load loss at rated load.
8. Exciter loss at rated load, if applicable.

b. Substitute the above calculated total in the following formula to determine the efficiency of the generator.

$$Generator\ efficiency\ (in\ percent) = \frac{Rated\ kW\ output}{Rated\ kW\ output + total\ losses\ in\ kW} * 100$$

c. Compare the generator efficiency found in step b above with the requirements of the procurement document.

415.0.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection and frequency at which this method is to be performed.

b. The minimum allowable generator efficiency.

c. Load conditions at which brush contact loss is to be performed.

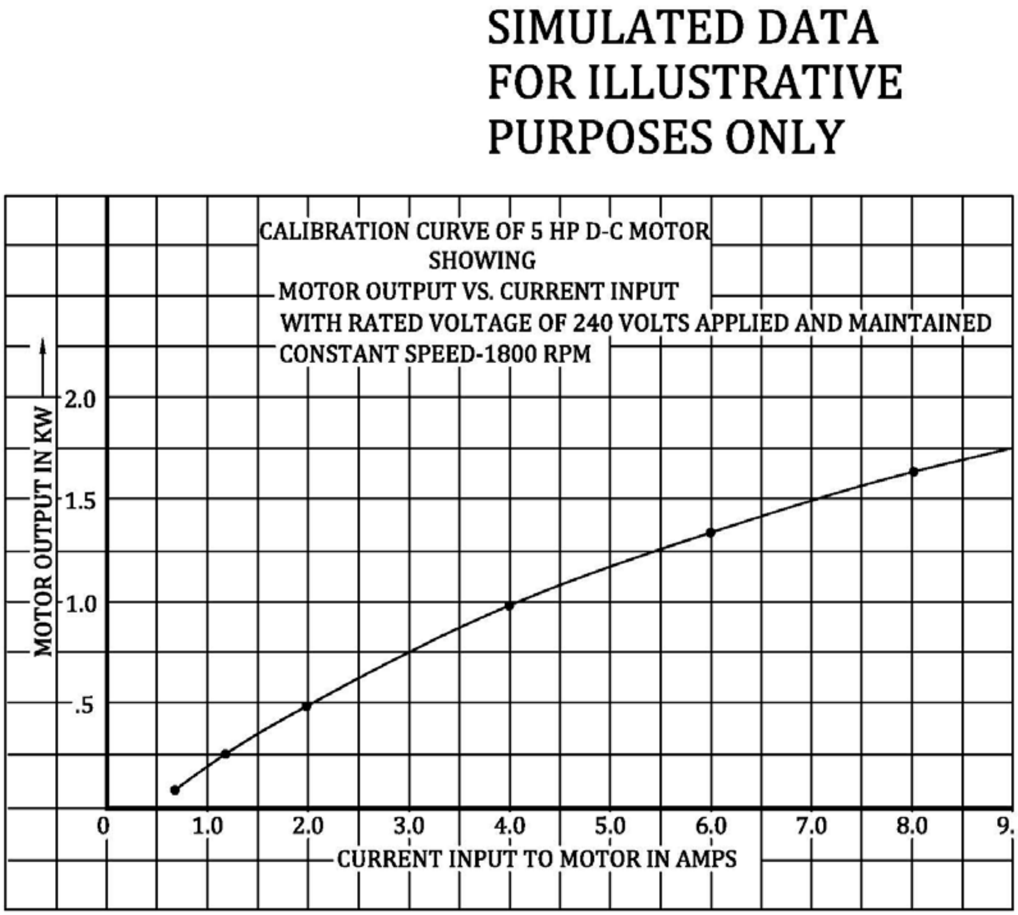


FIGURE 415.0-I Typical prime mover calibration curve.

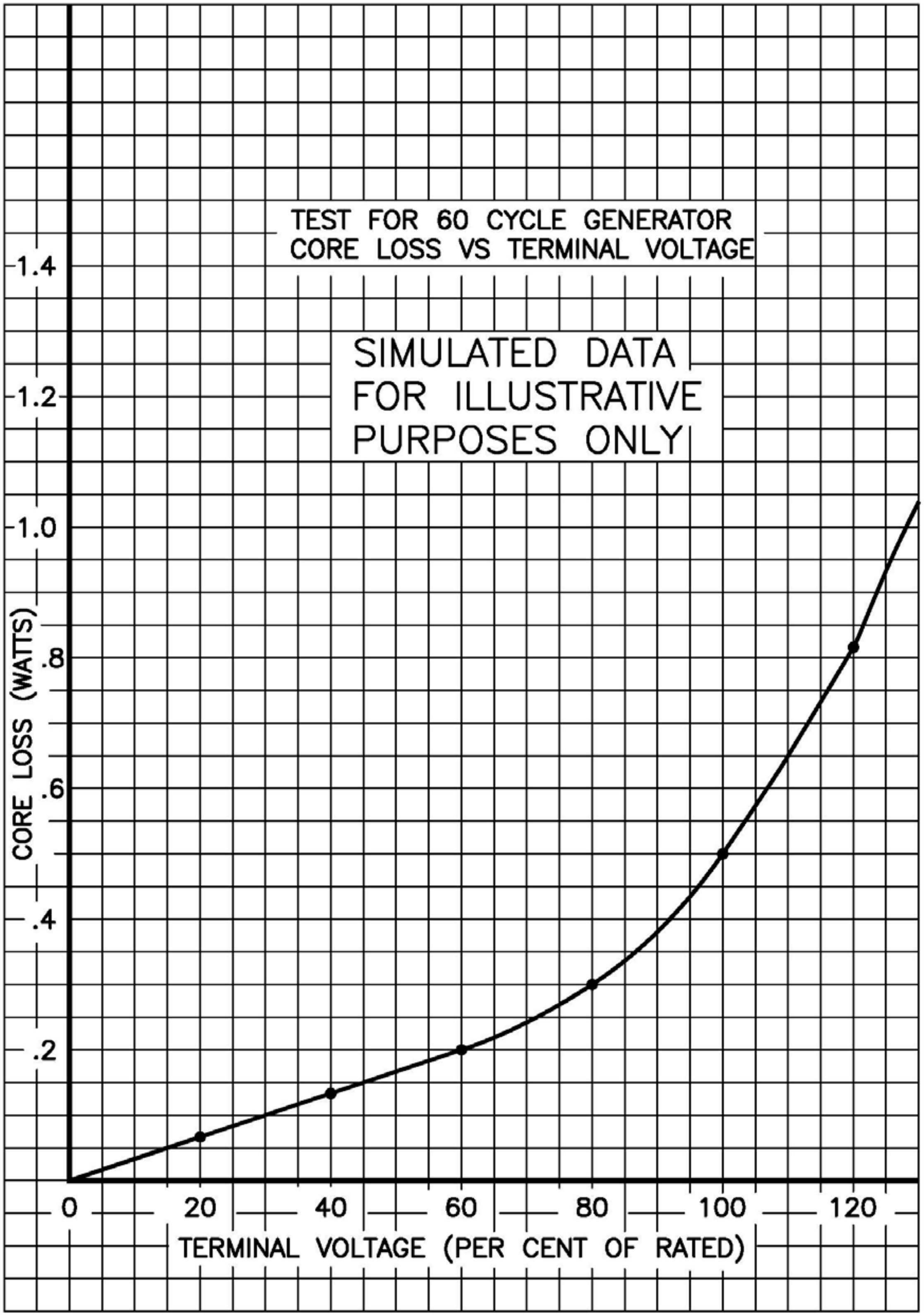


FIGURE 415.0-II Typical open-circuit core loss curve for A-C generator.

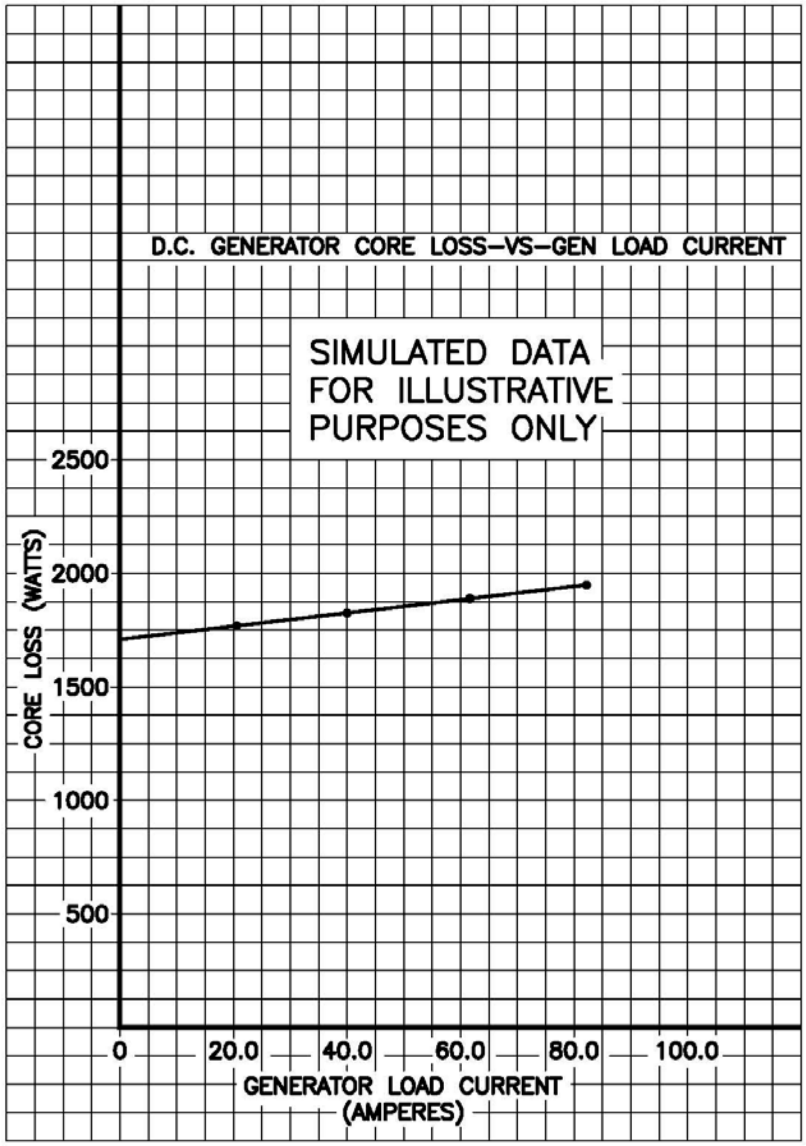


FIGURE 415.0-III Typical open circuit core loss curve for D-C generator.

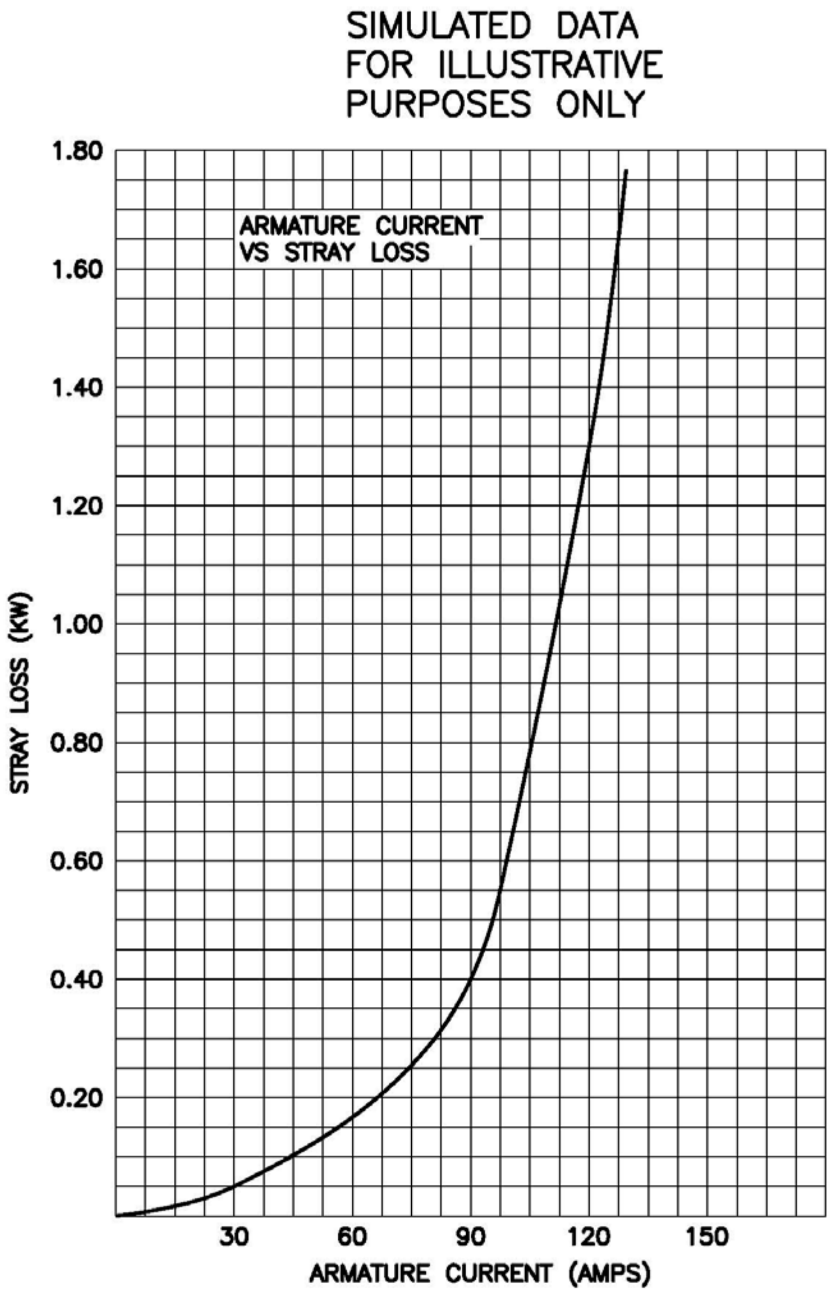


FIGURE 415.0-IV Typical stray load loss curve.

| | | |
|---|---|---|
| **DESCRIPTION:** 5HP D-C<br>240V, SHUNT WOUND<br>MOTOR ONLY<br><br>**MFGR:** DIRCURMONT, INC<br><br>**MODEL NO.** 3776779778DC<br><br>**SERIAL NO.** 1<br><br>**REF.** MIL-STD-705/415.0 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>SUMMATION OF LOSSES TEST<br>PRIME MOVER CALIBRATION CURVE | **TEST NO.** 12<br><br>**SHEET:** 1 OF 4<br><br>**DATE:** DECEMBER 14, 1970<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 1561 | 1437 | CAL | | 1176 | | | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | PRIME MOVER DC MOTOR | | MOTOR OUTPUT | | MOTOR SPEED | | | | | | | | | | | AVG AMB TEMP °F |
| **UNITS** | | AMPS | VOLTS | | KW | | RPM | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 127 | 1400 | 0.70 | 240 | | 0.075 | | 3600 | | | | | | | | | | 75 |
| 128 | 1402 | 1.20 | 240 | | 0.23 | | 3600 | | | | | | | | | | |
| 129 | 1404 | 2.00 | 240 | | 0.49 | | 3600 | | | | | | | | | | |
| 130 | 1406 | 4.00 | 240 | | 0.93 | | 3600 | | | | | | | | | | |
| 131 | 1408 | 6.00 | 240 | | 1.32 | | 3600 | | | | | | | | | | |
| 132 | 1410 | 8.00 | 240 | | 1.63 | | 3600 | | | | | | | | | | 75 |
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|---|---|---|
| **NOTES** | DC CURRENT MEASURED USING 10A, 50mV SHUNT NO. 2108 | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY |

FIGURE 415.0-V Portion of a typical test record for summation of losses test.

| **DESCRIPTION:** 10 KW, 60 HZ<br>120V, SINGLE PHASE<br>GENERATOR ONLY<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 13067<br><br>**REF.** MIL-STD-705/415.0 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>SUMMATION OF LOSSES TEST<br>OPEN-CIRCUIT CORE LOSS-AC GENERATOR | **TEST NO.** 12<br><br>**SHEET:** 2 OF 4<br><br>**DATE:** 14 DECEMBER, 1970<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST→** | | 1437 | 1561 | 1176 | | 706 | | 1432 | 1433 | FROM CURVE | | | | | | 110 | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | PRIME MOVER VOLTAGE | PRIME MOVER CURRENT | PRIME MOVER SPEED | | GENERATOR TERMINAL VOLTAGE | | GENERATOR FIELD | | PRIME MOVER OUTPUT | | BEARING FRICTION WINDAGE & BRUSH FRICTION LOSSES | | CALCULATED CORE LOSS | | GEN BEARING | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | RPM | | | VOLTS | AMPS | VOLTS | | KW | | KW | | | °F | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 164 | 1500 | 240 | 1.40 | 3600 | | | 2.0 | 0 | 0 | | .300 | | .300 | | --- | 110 | 75 |
| 165 | | 240 | 1.65 | 3600 | | | 24.0 | 0.21 | 3.50 | | .370 | | .300 | | .070 | 110 | 75 |
| 166 | | 240 | 1.87 | 3600 | | | 48.0 | 0.45 | 7.52 | | .450 | | .300 | | .150 | 111 | 75 |
| 167 | | 240 | 2.25 | 3600 | | | 72.0 | 0.66 | 11.0 | | .550 | | .300 | | .250 | 111 | 75 |
| 168 | | 240 | 3.20 | 3600 | | | 96.0 | 0.85 | 14.2 | | .770 | | .300 | | .470 | 111 | 75 |
| 168 | | 240 | 3.95 | 3600 | | | 108.0 | 1.05 | 17.5 | | .920 | | .300 | | .620 | 111 | 75 |
| 170 | | 240 | 4.40 | 3600 | | | 114.0 | 1.15 | 19.2 | | 1.02 | | .300 | | .720 | 111 | 76 |
| 171 | | 240 | 4.57 | 3600 | | | 120.0 | 1.30 | 21.7 | | 1.11 | | .300 | | .810 | 112 | 76 |
| 172 | | 240 | 5.75 | 3600 | | | 125.0 | 1.40 | 23.4 | | 1.28 | | .300 | | .980 | 112 | 76 |
| 173 | | 240 | 6.75 | 3600 | | | 132.0 | 1.61 | 26.9 | | 1.45 | | .300 | | 1.15 | 112 | 76 |
| 174 | | 240 | 8.40 | 3600 | | | 144.0 | 2.08 | 34.8 | | 1.68 | | .300 | | 1.38 | 112 | 76 |
| 175 | 1600 | 240 | 10.30 | 3600 | | | 150.0 | 2.48 | 41.6 | | 1.90 | | .300 | | 1.60 | 112 | 76 |
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| **NOTES** | PRIME MOVER S/N 1 | | | | | | | | | | | | | | | | |
| | PRIME MOVER CURRENT MEASURED USING A 20A, 100mV SHUNT NO. 2108 | | | | | | | | | | | | | | | | |
| | GENERATOR FIELD CURRENT MEASURED USING A 5A, 100mV SHUNT NO. 1176 | | | | | | | | | | | | | | | | |

FIGURE 415.0-VI Portion of a typical test record for summation of losses test.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 3600 RPM<br>120V, DIRECT CURRENT<br>GENERATOR ONLY<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** DC-10.0<br><br>**SERIAL NO.** 307<br><br>**REF.** MIL-STD-705/415.0 | **PHILADELPHIA REGION<br>DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>SUMMATION OF LOSSES TEST<br>OPEN-CIRCUIT CORE LOSS DC GENERATOR | **TEST NO.** 12<br><br>**SHEET:** 2 OF 4<br><br>**DATE:** 15 DECEMBER, 1970<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 1437 | 1561 | 1176 | | 736 | | CALCULATED | | FROM CORE | | | | | | 110 | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PRIME MOVER | | | | | | | | | | | | | | | |
| **READ NO ↓** | TIME | VOLTAGE | CURRENT | SPEED | | GENERATOR TERMINAL VOLTAGE | | LOAD CURRENT CORRESPONDING TO LOAD STEPS | | PRIME MOVER OUTPUT | | GEARING & BRUSH FRICTION AND WINDAGE LOSS | | CALCULATED CORE LOSS | | GEN BEARING | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | RPM | | | VOLTS* | | AMPS | | KW | | KW | | KW | °F | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 176 | 0915 | 240 | 11.4 | 3600 | | | 120 | | 0 | | 2.05 | | .350 | | 1.70 | 118 | 77 |
| 177 | | 240 | 11.75 | 3600 | | | 122 | | 20.8 | | 2.10 | | .350 | | 1.75 | 118 | 77 |
| 178 | | 240 | 12.3 | 3600 | | | 123 | | 44.7 | | 2.17 | | .350 | | 1.82 | 118 | 77 |
| 179 | | 240 | 12.7 | 3600 | | | 124 | | 62.5 | | 2.21 | | .350 | | 1.86 | 118 | 77 |
| 180 | | 240 | 13.1 | 3600 | | | 125 | | 83.3 | | 2.27 | | .350 | | 1.92 | 118 | 77 |

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**NOTES**
*THESE VOLTAGES CORRESPOND TO CALCULATED INTERNAL VOLTAGES FOR THE LOAD CURRENT SHOWN.
PRIME MOVER CURRENT MEASURED USING A 20A, 100mV SHUNT NO. 2108

FIGURE 415.0-VII Portion of a typical test record for summation of losses test.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60HZ<br>120V, SINGLE PHASE<br>GENERATOR ONLY<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 13067<br><br>**REF.** MIL-STD-705/415.0 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>SUMMATION OF LOSSES TEST<br>STRAY LOAD LOSS | **TEST NO.** 12<br><br>**SHEET:** 3 OF 4<br><br>**DATE:** 14 DECEMBER, 1970<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 1437 | 1561 | 1176 | | 812 | | | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | PRIME MOVER | | | | LOAD CURRENT | | $I^2R$ LOSSES (CAL) | | STRAY LOAD LOSS | | | | | | | AVG AMB TEMP |
| | | VOLTAGE | CURRENT | SPEED | | | | | | | | | | | | | |
| **UNITS** | | VOLTS | AMPS | RPM | | AMPS | AMPS | | KW | | KW | | | | | | |
| **SYM** | | | | | | X40 | X1 | | | | | | | | | | °F |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 189 | 1630 | 240 | 14.8 | 3600 | | 3.25 | 130 | | 1.25 | | 1.77 | | | | | | 75 |
| 190 | | 240 | 6.87 | 3600 | | 2.6 | 104 | | .798 | | .675 | | | | | | |
| 191 | | 240 | 3.55 | 3600 | | 1.95 | 78 | | .576 | | .275 | | | | | | |
| 192 | | 240 | 2.15 | 3600 | | 1.3 | 52 | | .384 | | .118 | | | | | | |
| 193 | 1638 | 240 | 1.17 | 3600 | | 0.65 | 26 | | .192 | | .030 | | | | | | 76 |
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SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

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|---|---|
| **NOTES** | PRIME MOVER S/N 1 |
| | PRIME MOVER CURRENT MEASURED USING A 20A, 100mV SHUNT NO. 2108 |
| | LOAD CURRENT MEASURED USING C.T. NO. 1305 |

FIGURE 415.0-VIII Portion of a typical test record for summation of losses test.

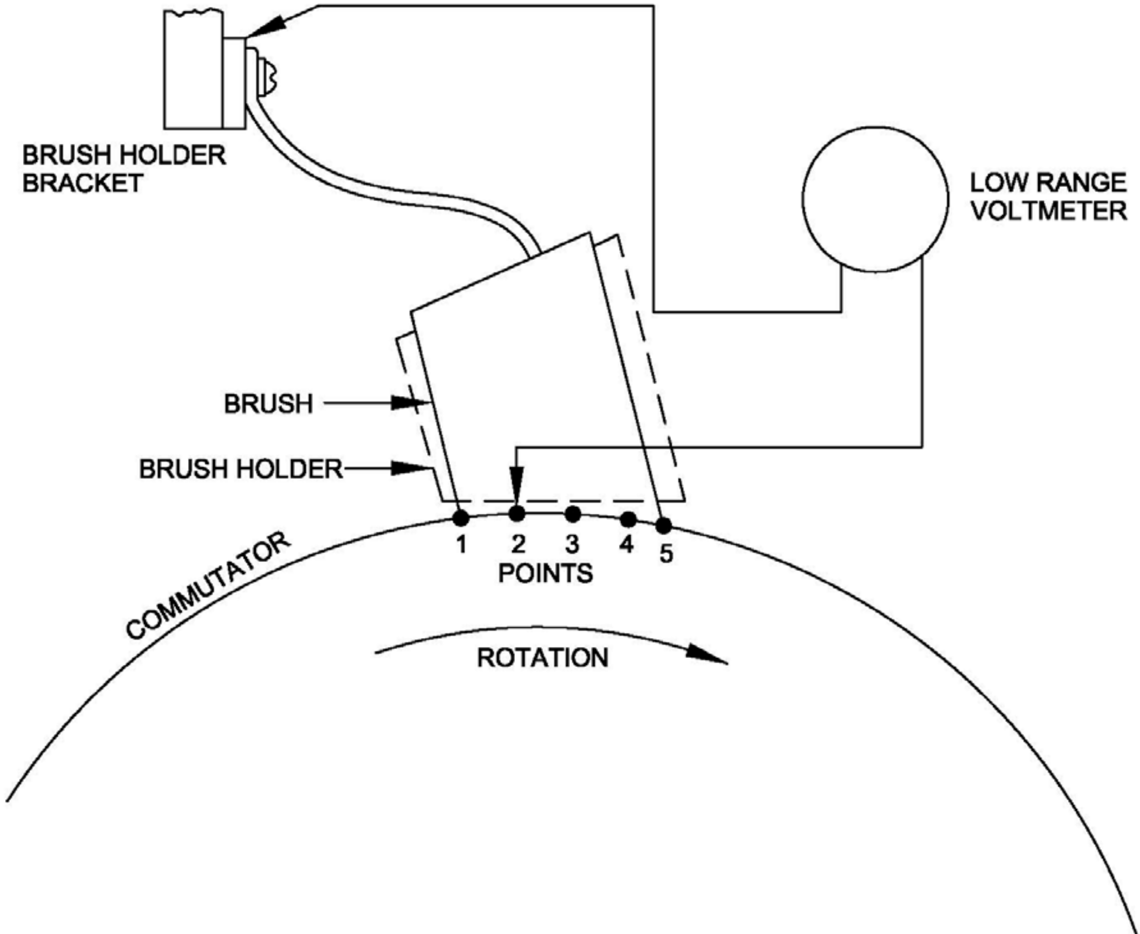


FIGURE 415.0-IX  Method of determining brush contact loss.

METHOD 415.1d

GENERATOR POWER INPUT TEST

415.1.1 General. The power required to drive the generator at rated load is important in determining the size of the prime mover and expected operating costs.

415.1.2 Apparatus. Use instrumentation for measuring load conditions, field voltage and current, ambient temperature and prime mover output power as described and illustrated in the 100 series methods as applicable. In addition, use a dynamometer or calibrated electric motor of sufficient output power to drive the generator under test at rated speed and rated load for extended periods of time. A direct reading torque meter may be connected between the prime mover and the generator for calculating actual generator power input. Electrical instrumentation used for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

415.1.3 Procedure.

415.1.3.1 Preparation for test.

a. Mechanically connect the generator assembly, including its cooling fan, to the prime mover.

b. Connect the load and field instrumentation in accordance with the applicable figure of METHOD 205.1, for the voltage connection and frequency specified in the procurement document.

415.1.3.2 Test.

a. Start and operate the prime mover such that the generator is operating at rated speed.

b. With the generator under control of its voltage regulator and exciter, apply rated load. Allow the generator to stabilize at rated load, rated voltage and rated frequency. During this period, record all instrument readings including ambient temperature at minimum intervals of 10 minutes per METHOD 203.1 (see FIGURE 415.1-1). If necessary, make adjustments to load, voltage and frequency to maintain rated load at rated voltage and frequency. Record all adjustments to load, voltage or frequency controls on the data sheet at the time of adjustment. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when four consecutive voltage and current readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment of the load, voltage, or frequency has been made.

c. With the generator stabilized at rated conditions, record all instrument readings including the instrumentation necessary to determine the output power of the prime mover.

d. Repeat 415.1.3 for any other load condition, voltage connection, frequency, or power factor specified in the procurement document.

415.1.4 Results.

a. Convert the output power of the prime mover to kW, the generator power input requirement to produce rated output.

b. Determine the efficiency of the generator by the following formula:

$$Efficiency\ (in\ percent) = \frac{Rated\ load}{Input\ power\ requirement} * 100$$

c. Compare the above results with the procurement document requirements.

415.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable power input, or minimum allowable efficiency (in percent) with the generator producing rated output power.

b. Voltage connections(s) and frequency(ies) at which this Method is to be performed.

c. Power factor(s) at which this Method is to be performed, if applicable.

d. Load condition(s) if other than rated load.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 400 HZ<br>120 V, SINGLE PHASE<br>GENERATOR ONLY<br><br>**MFGR.** ENGENSETS, INC.<br><br>**MODEL NO.** HE-10.0-MD<br><br>**SERIAL NO.** 1876<br><br>**REF.** MIL-STD-705/415.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONRACT ADMINISTRATION SERVICE**<br><br>GENERATOR POWER INPUT TEST | **TEST NO.** 6<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR.** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 716 | | 308 | | 419 | | 517 | | 556 | | 757 | 362 | 1766 | CAL | CAL | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | EXCITER FIELD | | INPUT POWER | | EFFICIENCY | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | | | HZ | VOLTS | AMPS | HP | KW | % | °F |
| **SYM** | | | | X 40 | X 1 | X 40 | X 1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 221 | 0945 | STARTED PRIME MOVER – BROUGHT GENERATOR TO RATED SPEED | | | | | | | | | | | | | | | |
| 222 | 0950 | APPLIED RATED LOAD TO GENERATOR | | | | | | | | | | | | | | | |
| 223 | 1000 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | 0.80 | | 400.0 | 17.3 | 0.76 | 15.90 | 11.90 | | 77 |
| 224 | 1010 | | 120.5 | 2.61 | 104 | 0.25 | 10.0 | | 0.80 | | 400.7 | 17.6 | 0.75 | 16.00 | 11.95 | | 78 |
| 225 | 1020 | | 121.0 | 2.65 | 104 | 0.25 | 10.0 | | 0.79 | | 401.5 | 17.6 | 0.74 | 16.10 | 12.00 | | 77 |
| 226 | 1030 | ADJUSTED VOLTAGE AND FREQUENCY TO RATED | | | | | | | | | | | | | | | |
| 227 | 1040 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | 0.80 | | 400.0 | 17.8 | 0.76 | 16.20 | 12.05 | | 78 |
| 228 | 1050 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | 0.80 | | 400.0 | 17.8 | 0.76 | 16.20 | 12.05 | | 78 |
| 229 | 1100 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | 0.80 | | 400.0 | 17.8 | 0.76 | 16.20 | 12.05 | | 78 |
| 230 | 1110 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | 0.80 | | 400.0 | 17.8 | 0.76 | 16.20 | 12.05 | 83 | 78 |

$$\text{EFFICIENCY} = \frac{R/L}{\text{INPUT POWER}} \times 100 = \frac{10.0}{12.05} \times 100 = 83\%$$

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

| **NOTES** | |
|---|---|
| | LINE CURRENT MEASURED USING CT #1042 |
| | EXCITOR FIELD CURRENT MEASURED USING 1 A, 50mV SHUNT #1612 |

FIGURE 415.1-1 Typical test record for generator power input test.

# METHOD 416.1b

## BRUSH POTENTIAL CURVE TEST

**NOTE**: Method 416.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

416.1.1 General. The brush potential or contact drop curve is a graphical method for showing the difference in potential between the brush and various points on the commutator surface under and in the vicinity of the brush face. Data for brush potential curves are obtained by reading the voltage between the brush and several points on the commutator surface near and under the brush contact face.

This curve, in conjunction with the recorded armature current, may be used to determine the brush contact loss.

416.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current and ambient temperature shall be as described and illustrated in MIL-HDBK-705. In addition, a low range dc voltmeter (0-3 volts should be sufficient) having an internal resistance of at least 100 times the brush circuit resistance, and a carbon tipped test probe shall be required.

416.1.3 Procedure.

416.1.3.1 Preparation for test.

a. Connect the load and field instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for a voltage connection and speed specified in the procurement document.

b. Connect the low range dc voltmeter as shown in FIGURE 416.1-I to one of the brush holder brackets.

416.1.3.2 Test.

a. Start and operate the generator at rated speed, rated voltage, and rated load.

b. With the low range dc voltmeter, read and record the voltage between the brush bracket holder and at least four equally distanced points along the brush span (FIGURE 416.1-I and FIGURE 416.1-II).

c. Repeat 416.1.3 for any other load condition specified in the procurement document.

416.1.4 Results.

a. Plot a curve of voltage drop across the brush versus distance along the brush span (FIGURE 416.1-III).

b. Compute the brush contact loss by multiplying twice the average voltage across the brush by the current through the brush.

c. Compare these results with the procurement document requirements.

416.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Voltage connection(s) and speed(s) at which this method is to be performed.

b. Load condition(s) at which this method is to be performed if other than as specified herein.

c. Maximum allowable average voltage drop across the brush, if applicable.

d. Maximum allowable brush contact loss, if applicable.

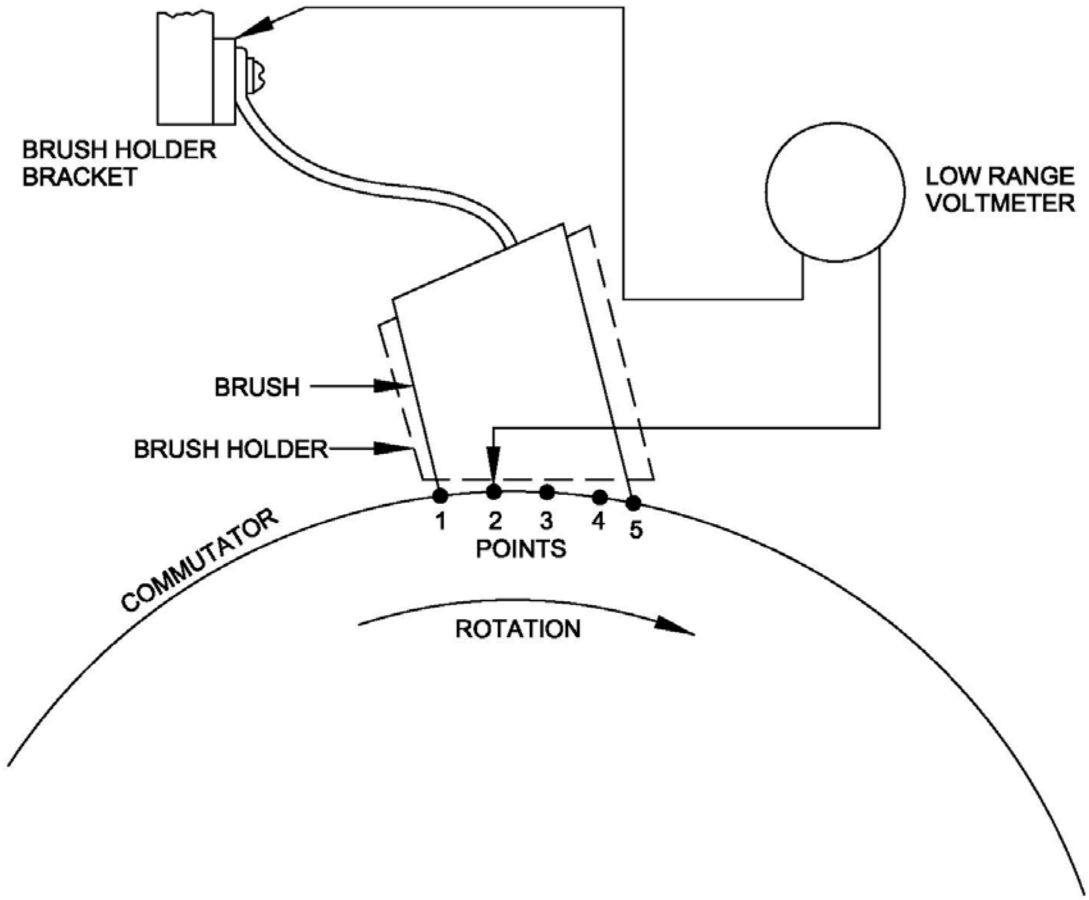


FIGURE 416.1-I Method of determining brush potential curve.

**DESCRIPTION:** 15KW, 1800 RPM
120V, DIRECT CURRENT
GENERATOR ONLY

**MFGR:** ENGENSETS, INC

**MODEL NO.** 59648

**SERIAL NO.** 3758241

**REF.** MIL-STD-705/416.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

BRUSH POTENTIAL CURVE TEST

**TEST NO.** 12

**SHEET:** 1 OF 1

**DATE:** JANUARY 11, 1971

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 077 | | 218 | | 617 | | | 015 | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | SPEED | | | PROBE POSITION 1 | 2 | 3 | 4 | 5 | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | | AMPS | | RPM | | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | | | | |
| **SYM** | | | | | | | | | | | | | | | | | °F |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | | | | | | | | | | | | | | | | | |
| | 1310 | | 120.0 | | 12.5 | | 1800 | | 2 | 3 | 4 | 3 | 2 | | | | 71 |
| | | | | | | | | | | | | | | | | | |
| | 1320 | | 120.0 | | 62.5 | | 1800 | | 1 | 1.5 | 2 | 1.5 | 1 | | | | |
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SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

| **NOTES** | |
|---|---|
| | BRUSH CONTACT WIDTH = 1”. DIRECTION OF ROTATION CLOCKWISE FACING COMMUTATOR END OF GENERATOR |
| | PROBE POSITIONS 1-5 IN CLOCKWISE DIRECTION – EQUALLY SPACED – POSITIVE (+) BRUSH USED IN TEST |
| | LINE CURRENT MEASURED USING A 200A, 50mV SHUNT NO. 1154 |

FIGURE 416.1-II Typical test record for brush potential curve test.

**SIMULATED DATA**
**FOR ILLUSTRATIVE**
**PURPOSES ONLY**

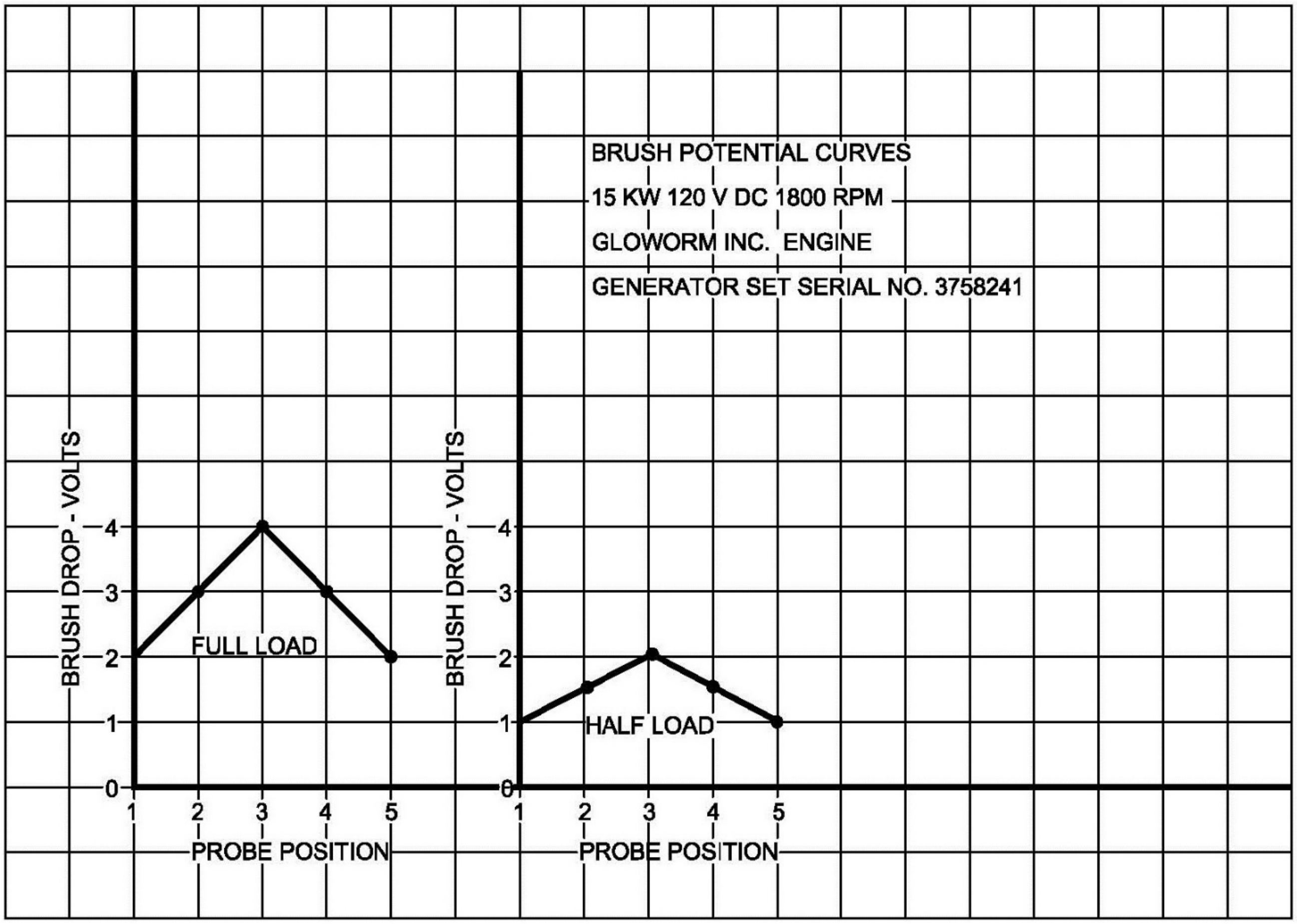



FIGURE 416.1-III Sample brush potential curve.

# METHOD 420.1c

## SHORT CIRCUIT RATIO TEST

420.1.1 General. The short circuit ratio is used by design engineers in the evaluation and comparison of the regulation and stability of generators.

420.1.2 Apparatus. Use instrumentation for measuring terminal voltage, generator speed, exciter field voltage and current (generator field voltage and current, if applicable), and line current as described and illustrated in the 100 series methods as applicable. In addition, use a prime mover having a steady state speed not greater than ±1 percent of rated speed and a separate, variable DC source for excitation. Electrical instrumentation for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

420.1.3 Procedure.

a. Perform METHOD 410.1, Open Circuit Saturation Curve Test (measure the generator field current.)

b. Perform METHOD 411.1, Synchronous Impedance Curve Test.

420.1.4 Results.

a. From the open circuit saturation curve, determine the generator field current required to generate rated open circuit armature terminal voltage. In FIGURE 420.1-1, this value is represented by the distance $I_{fgx}$.

b. From the synchronous impedance curve (the short circuit saturation curve), determine the generator field current required to produce rated armature short circuit current for a sustained symmetrical short circuit at the generator terminals. In FIGURE 420.1-1, this value is represented by the distance $I_{fsi}$.

c. Compute the short circuit ratio by dividing the value obtained in step a above, by the value obtained in step b above. This computation is represented by the following formula:

$$SCR = \frac{I_{fgx}}{I_{fsi}}$$

Where:

SCR is the short circuit ratio.

d. Compare the calculated short circuit ratio with the procurement document requirements.

420.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The allowable range of short circuit ratio, if applicable.

b. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSES ONLY

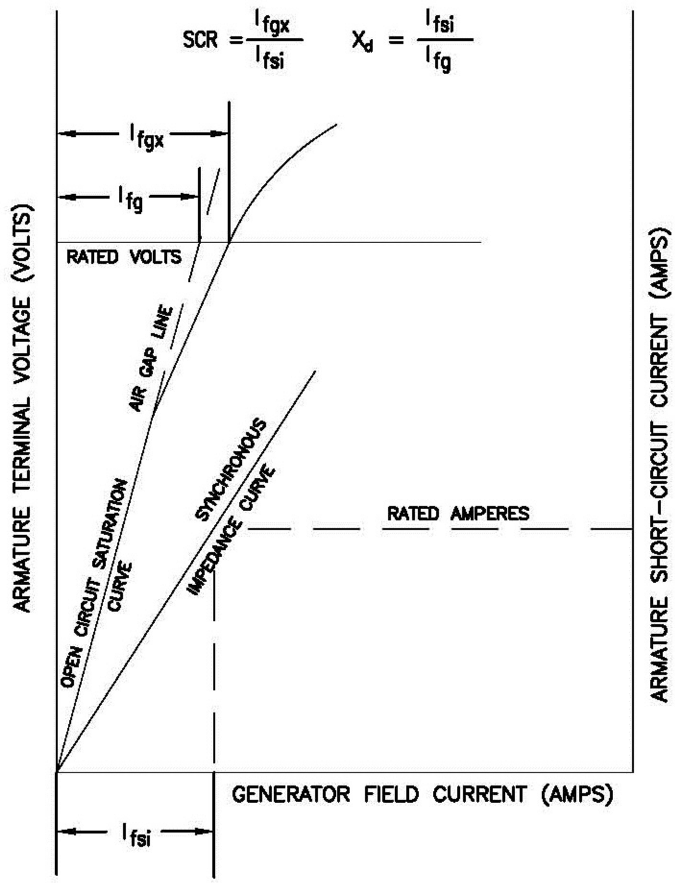



FIGURE 420.1-1 Short circuit ratio and direct-axis synchronous reactance.

METHOD 421.1c

DIRECT-AXIS SYNCHRONOUS REACTANCE TEST

421.1.1 General. The direct-axis synchronous reactance is the ratio determined by dividing the field current during a sustained symmetrical short circuit, at rated frequency required to produce rated armature current, by the value of the field current at the air-gap line of the open circuit saturation curve, at rated voltage and frequency.

> **NOTE:** The definition above is actually that of the per unit direct-axis synchronous impedance. However, this definition is used to a great extent in electrical literature and because the resistance of the machine is so small compared to the reactance, the error in using the impedance value instead of the reactance value is negligible.

421.1.2 Apparatus. Use instrumentation for measuring terminal voltage, generator speed, exciter field voltage and current (generator field voltage and current, if applicable), and line current as described and illustrated in the 100 series methods as applicable. In addition, use a prime mover having a steady state speed not greater than ±1 percent of rated speed and a separate, variable DC source for excitation. Electrical instrumentation used for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

421.1.3 Procedure.

a. Perform METHOD 410.1, Open Circuit Saturation Curve Test. Measure the generator field current.

b. Perform METHOD 411.1, Synchronous Impedance Curve Test.

421.1.4 Results.

a. From the synchronous impedance curve (the short circuit saturation curve), determine the field current required to produce rated armature current for a sustained symmetrical short circuit at the generator terminals, distance $I_{fsi}$ on FIGURE 421.1-1.

b. From the air-gap line of the open circuit saturation curve (the extended straight line part of the curve, see FIGURE 421.1-1) determine the field current which corresponds to the rated voltage, distance $I_{fg}$ on FIGURE 421.1-1.

c. Compute the direct-axis synchronous reactance by dividing the value obtained in step a above by the value obtained in step b above as represented by the following formula:

$$X_d = \frac{I_{fsi}}{I_{fg}}$$

Where:

$X_d$ is the direct-axis synchronous reactance.

d. Compare the calculated direct-axis synchronous reactance with the procurement document requirements.

421.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The allowable range of direct-axis synchronous reactance, if applicable.

b. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

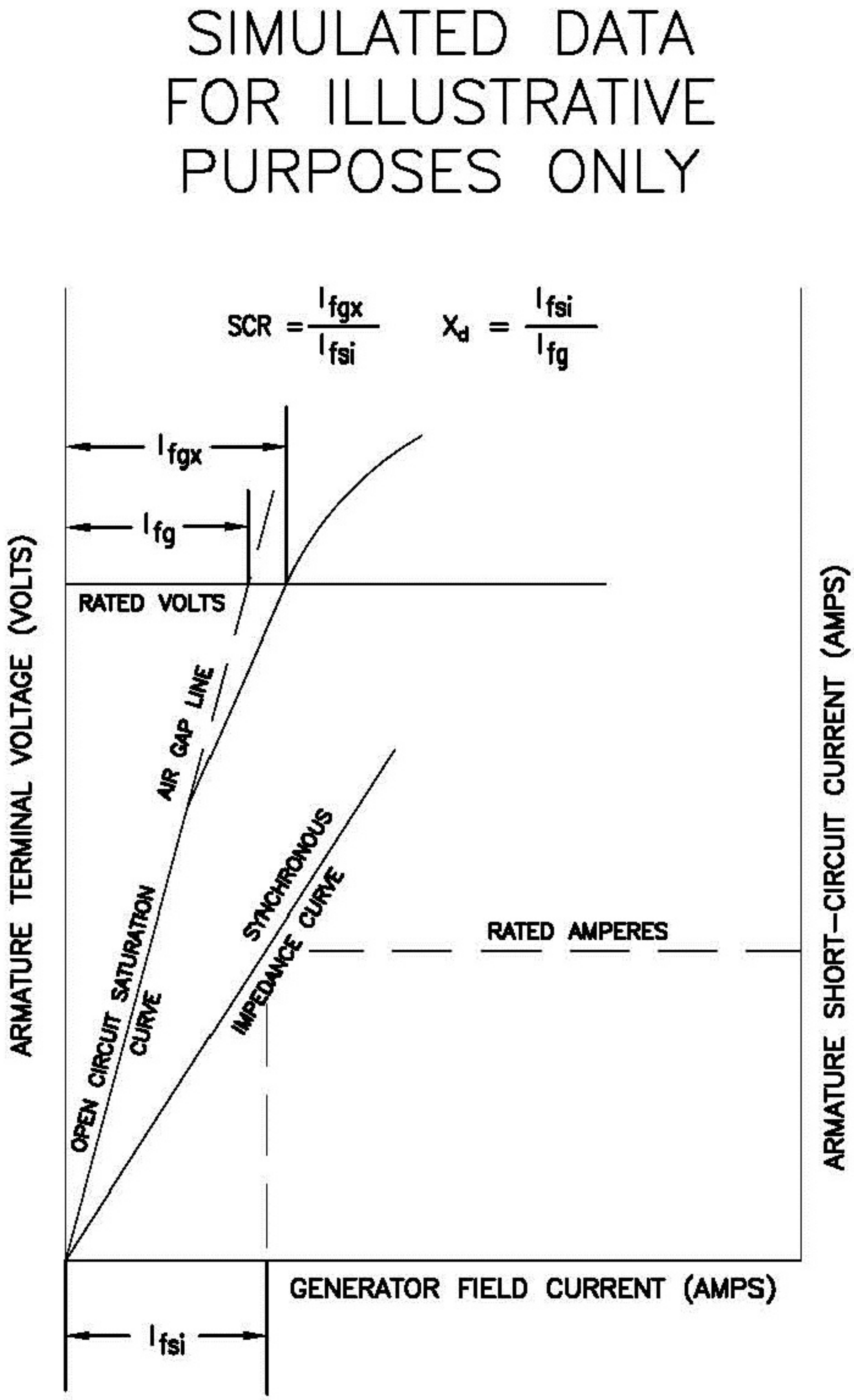



FIGURE 421.1-1 Short circuit ratio and direct-axis synchronous reactance.

METHOD 422.1c

NEGATIVE-SEQUENCE REACTANCE AND IMPEDANCE TEST

422.1.1 General. Negative-sequence reactance or impedance is used by design engineers to determine the performance of three-phase wye generators under various load conditions.

422.1.2 Apparatus. Use instrumentation for measuring load conditions (wattmeter to be low power factor type), field voltage and current, and ambient temperature as described and illustrated in the 100 series methods as applicable. In addition, use a separate, variable source of DC power for generator excitation, a prime mover, and a shorting switch. Electrical instrumentation for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

422.1.3 Procedure.

422.1.3.1 Preparation for test.

a. Mechanically connect the generator to the prime mover and provide the external excitation supply to the generator.

b. Connect the instrumentation and shorting switch in accordance with FIGURE 422.1-1 for the voltage connection specified in the procurement document.

422.1.3.2 Test.

a. Start and operate the prime mover such that the generator is at rated speed with no excitation current.

b. Close the shorting switch.

c. Increase the field current until rated current is flowing through the short-circuit.

d. Record all instrument readings per METHOD 203.1 (see FIGURE 422.1-2).

e. Repeat steps a through d for any other voltage connection specified in the procurement document if applicable.

422.1.4 Results.

Compute the negative-sequence reactance using the following formula:

$$X_2\ (in\ percent) = \frac{W I_{RP}}{V_{RP}\ (1.732) I^2} * 100$$

Where:

$X_2$ = Negative-sequence reactance

W = Power in watts

$V_{RP}$ = Rated line-to neutral (phase) voltage

$I_{RP}$ = Rated phase current

I = AC Current in amperes

Compute the negative-sequence impedance from the data obtained in this Method using the following formula:

$$Z_2\ (in\ percent) = \frac{E I_{RP}}{(1.732)\ I V_{RP}} * 100$$

Where:

$Z_2$ = negative-sequence impedance

E = Voltage between the shorted terminals and the third line terminal

$V_{RP}$ = Rated phase voltage

$I_{RP}$ = Rated phase current

I = AC current in amperes

Compare these results with the procurement document requirements.

422.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection(s) (must be three-phase wye) and frequency at which this Method is to be performed.

b. The maximum, minimum or range of allowable negative-sequence reactance, or negative-sequence impedance, if applicable.

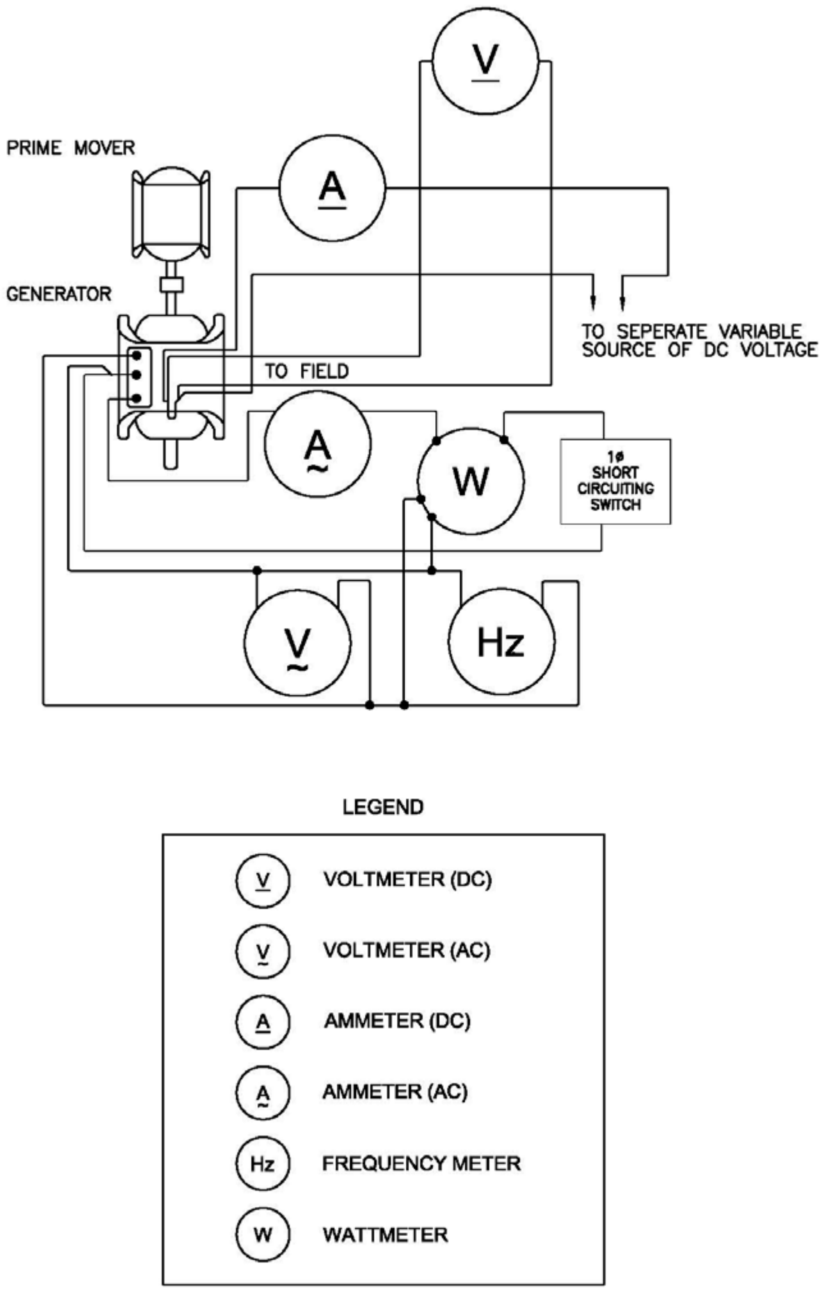



FIGURE 422.1-1 Apparatus hook-up for negative sequence reactance and impedance test.

**DESCRIPTION:** 10 KW, 60 HZ
120/280V, 3 PHASE
POWER SYSTEM

**MFGR.** ENGENSETS, INC.

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 16716

**REF.** MIL-STD-705/422.1

**PHILADELPHIA REGION**
**DEFENSE CONRACT ADMINISTRATION SERVICE**

NEGATIVE-SEQUENCE REACTANCE
AND IMPEDANCE TEST

**TEST NO.** 3

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L WRIGHT

**PROJ. ENGR.** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 329 | | 3233 | | 3767 | | 176 | 418 | 761 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | $T_1 - T_2$ CURRENT | | OUTPUT POWER | | EXCITER FIELD | | SPEED | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | WATTS | WATTS | VOLTS | AMPS | RPM | | | | | | | °F |
| **SYM** | | | | X 10 | X 1 | X 10 | X 1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 248 | 1117 | | 18.2 | 3.47 | 34.7 | 15.0 | 150 | 1.7 | 0.31 | 3600 | | | | | | | 74 |

$$X_2 = \frac{(150)(34.7)(100)}{(120)(1.732)(34.7)^2} = 2.08\%$$

$$Z_2 = \frac{(18.2)(34.7)(100)}{(120)(1.732)(34.7)} = 8.75\%$$

SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSE ONLY

**NOTES**
$T_1 - T_2$ CURRENT MEASURED USING C.T. #1305
EXCITER FIELD CURRENT MEASURED USING A 1A , 50mV SHUNT #768

FIGURE 422.1-2 Typical test record for negative-sequence reactance and impedance test.

# METHOD 423.1b

## ZERO-SEQUENCE REACTANCE TEST

**NOTE**: Method 423.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

423.1.1 General. Zero-sequence reactance is used by design engineers to determine the performance of three-phase wye connected generators under various load conditions.

423.1.2 Apparatus. Instrumentation for measuring line-to-line voltage, line current, generator speed and field current shall be as described and illustrated in MIL-HDBK-705. In addition a separate, variable source of dc power for generator excitation and a prime mover shall be required. Electrical instrumentation for this test shall have an accuracy of $\pm$0.5 percent of reading or better.

423.1.3 Procedure.

423.1.3.1 Preparation for test.

a. Mechanically connect the generator to the prime mover and provide the external excitation supply to the generator.

b. Connect the instrumentation in accordance with FIGURE 423.1-I for one “wye” voltage connection and frequency specified in the procurement document.

423.1.3.2 Test.

a. Start and operate the prime mover such that the generator is at rated speed and with zero field current.

b. Adjust the field current such that the ammeter, which short-circuits two generator phases to neutral, indicates a reading equal to three times the rated phase current.

c. Record all instrument readings (see FIGURE 423.1-II).

CAUTION: To prevent serious overheating of the generator, the field current shall be reduced to zero and the generator shut down immediately following the reading of the instruments.

423.1.4 Results.

Compute the zero-sequence reactance using the following formula:

$$X_o\ (in\ percent) = \frac{E_a I_{RP}}{I_n V_{RP}}\ X\ 100$$

Where:

$X_o$ is the zero-sequence reactance

$E_a$ is the armature voltage between the open phase and the short circuit.

$I_{RP}$ is the rated phase current

$V_{RP}$ is the rated phase voltage

$I_n$ is the current flowing between the short-circuited phase terminals through the ammeter short-circuiting these terminals to the neutral.

Compare the zero-sequence reactance with the procurement document requirements.

423.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection (must be three-phase wye) and frequency at which this method is to be performed.

b. The maximum, minimum or range of allowable zero-sequence reactance, if applicable.

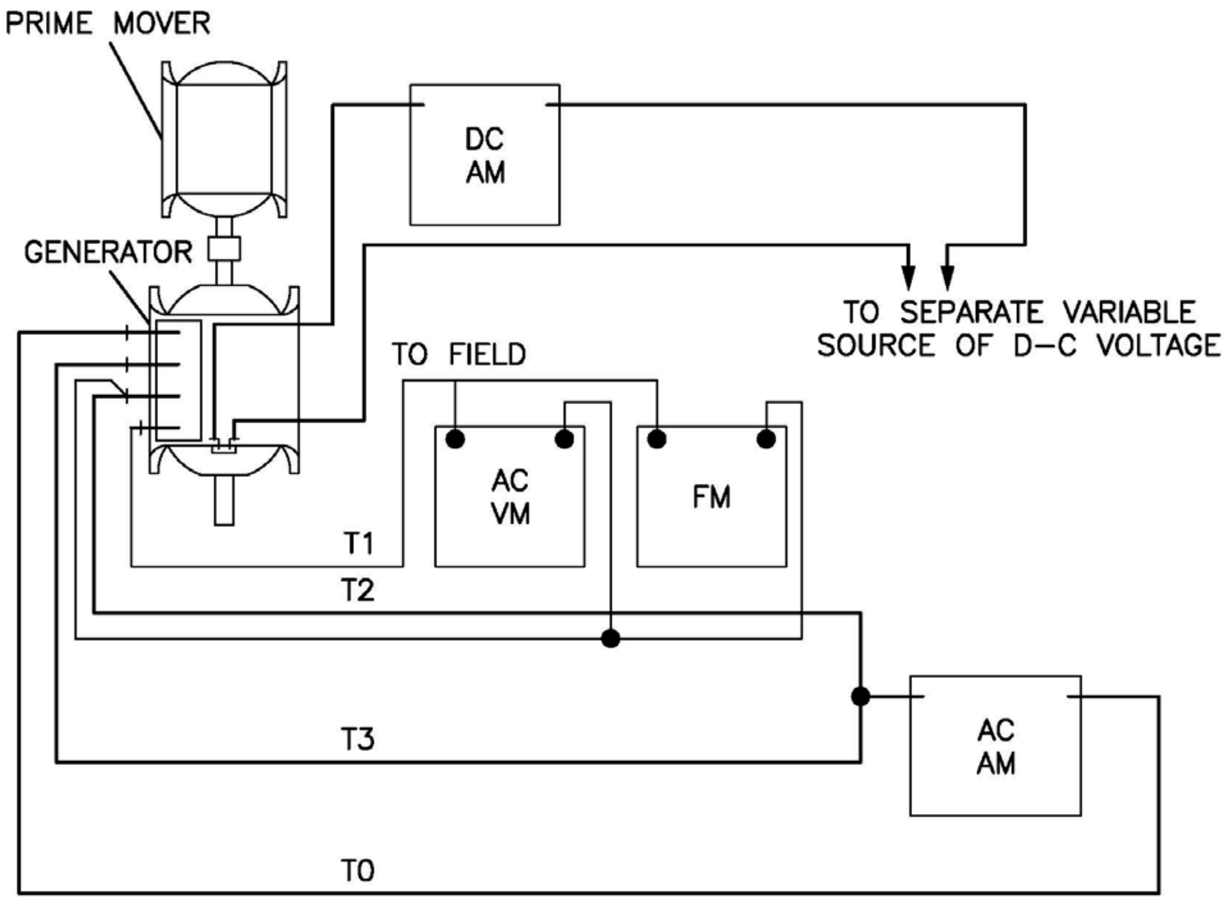



FIGURE 423.1-I  Apparatus hook-up for zero-sequence reactance test.

| | | |
|---|---|---|
| **DESCRIPTION:** 5KW, 60HZ<br>120/208V, 3-PHASE<br>GENERATOR ONLY<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-5.0-MD<br><br>**SERIAL NO.** 3716<br><br>**REF.** MIL-STD-705/423.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>ZERO SEQUENCE REACTANCE TEST | **TEST NO.** 12<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** JANUARY 25, 1971<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 431 | | 5965 | | 8711 | | | 5954 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | TERMINAL VOLTAGE | | NEUTRAL CURRENT | | SPEED | | EXCITER FIELD | | | | | | | | | |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | | RPM | | AMPS | | | | | | | | |
| **SYM** | | | | X20 | X1 | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 324 | 0815 | | 30.0 | 2.60 | 52.0 | | 36.00 | | 1.71 | | | | | | | | |

$$X_0 = \frac{E_a\ I_{RP}}{I_N\ V_{RP}}\ X\ 100 = \frac{30.0\ X\ 17.3\ X\ 100}{52\ X\ 208} = 4.8\%$$

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

| | |
|---|---|
| **NOTES** | NEUTRAL CURRENT MEASURED USING C. T. NO. 1305 |
| | EXCITER LEAD CURRENT MEASURED USING 2A, 50mV SHUNT NO. 1041 |

FIGURE 423.1-II Typical test record for zero sequence reactance test.

# METHOD 424.1b

## QUADRATURE-AXIS SYNCHRONOUS REACTANCE TEST

**NOTE**: Method 424.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

424.1.1 General. Quadrature-axis synchronous reactance is used by design engineers to determine the performance of generators under various load conditions.

424.1.2 Apparatus. Instrumentation for measuring generator terminal voltage, line current and field voltage shall be as described and illustrated in MIL-HDBK-705. In addition an oscillograph with sufficient galvanometers having a flat frequency response (flat within ±5 percent) from dc to 3,000 Hz, a non-inductive shunt, a variable voltage ac power supply with sufficient power to deliver rated current to the generator at generator rated frequency, a variable speed prime mover and a tachometer (for generator speed) shall be required. Electrical instrumentation for this test shall have an accuracy of ±0.5 percent or better.

424.1.3 Procedure.

424.1.3.1. Preparation for test.

a. Mechanically connect the generator to the prime mover.

b. Connect the apparatus in accordance with FIGURE 424.1-I or FIGURE 424.1-II whichever is applicable.

c. Open circuit the generator field by disconnecting the exciter leads to the field (for brushless machines this method will require slip rings and pilot brushes).

424.1.3.2. Test.

a. Start the prime mover and operate the generator in its normal rotation at rated speed.

b. Apply the variable voltage, ac power supply to the generator load terminals at a voltage value well below rated (zero voltage if possible). Slowly increase the applied voltage to the value required to circulate rated current through the generator windings.

c. Record all instrument readings.

d. Adjust the oscillograph elements which record the generator phase voltage trace, the voltage across the open field trace, and the armature current trace to 2-inch amplitudes. Then take an oscillogram for calibration purposes.

e. Gradually reduce the generator speed approximately 5 percent but not more than 5 percent.

f. Take an oscillogram of not less than 5 seconds at sufficient film speed to clearly show the individual peaks of the voltage and current waves.

g. Gradually increase the generator speed to rated.

h. Record all instrument readings and take another oscillogram for calibration purposes.

CAUTION: Gradually reduce the stator current to zero before the prime mover is brought to rest.

424.1.3.3. Computations. The determination of the quadrature-axis synchronous reactance is made from an interpretation of the oscillogram obtained in 424.1.3.2, step f above when the generator was being driven at a reduced speed. Under these conditions, the quadrature-axis synchronous reactance is in effect when the impedance is at a minimum (i.e., when the ratio of rms armature voltage to rms armature current is at a minimum). The direct-axis synchronous reactance is in effect when the ratio of rms armature voltage to rms armature current is at a maximum.

a. From the oscillogram taken in 424.1.3.2, step f, determine the rms values of line-to-line voltage and the rms values of line current at each peak. Tabulate these values against time in cycles, as shown in the sample tabulation (FIGURE 424.1-V). Each value of line-to-line voltage shall be expressed as a decimal fraction of rated line-to-line voltage. Each value of line current also shall be expressed as a decimal fraction of rated line current (see procedure 4, FIGURE 424.1-III).

b. Divide each value of rms voltage (expressed as a decimal), by the corresponding rms current (expressed as a decimal). These values shall be tabulated and used as a basis for plotting a curve (FIGURE 424.1-V and FIGURE 424.1-VI).

c. These ratios shall be plotted versus time in cycles (FIGURE 424.1-VI).

d. The approximate per unit direct-axis synchronous reactance is the maximum value of the ratio obtained in step b above.

e. The approximate per unit quadrature-axis synchronous reactance is the minimum value of the ratio obtained in step b above.

f. The ohmic values of direct-axis and quadrature-axis synchronous reactance are the unit values obtained in steps d and e above, multiplied by base ohms. The base ohms are determined by dividing rated phase voltage by rated phase current.

424.1.4 Results. Compare the value of quadrature-axis synchronous reactance obtained in 424.1.3 with the procurement document requirements.

424.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection(s) and frequency(ies) at which this method shall be performed.

b. The maximum, minimum or range of allowable quadrature-axis synchronous reactance, if applicable.

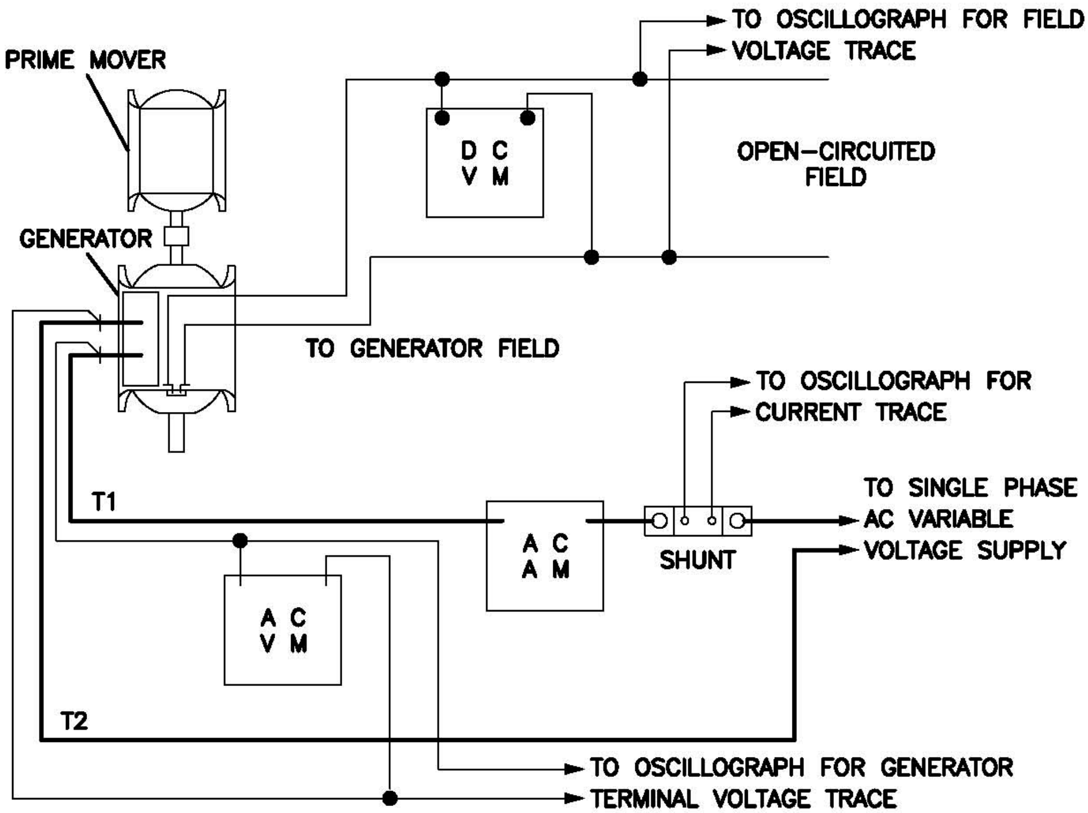



FIGURE 424.1-I Apparatus hookup for determination of quadrature-axis synchronous reactance of single-phase generators.

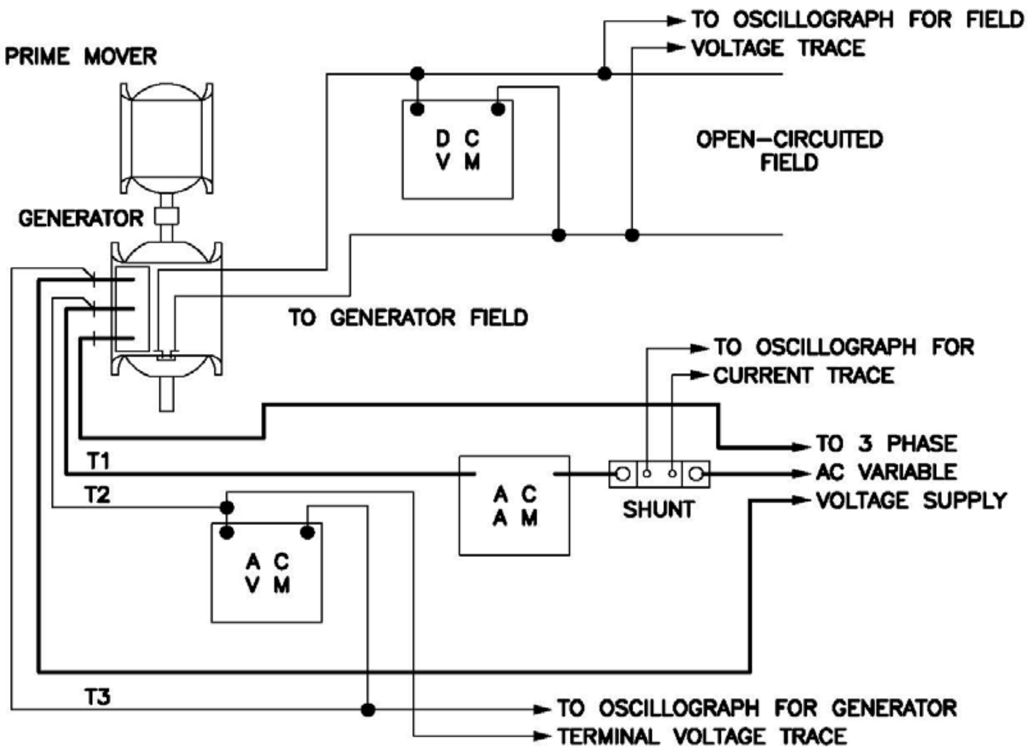
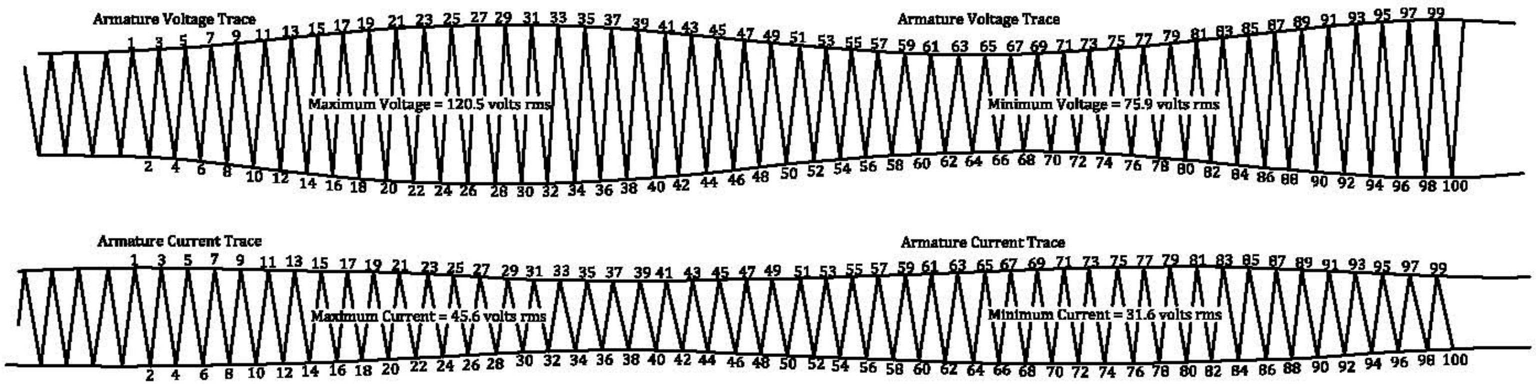



FIGURE 424.1-II Apparatus hookup for determination of quadrature-axis synchronous reactance of three-phase generators.




Procedure

1. Wave form traced from oscillogram
2. Lines defining envelopes were drawn
3. Amplitude of waves measured in inches and converted to RMS values of voltage and current
4. RMS values converted to Per Unit Values
5. Volts per unit divided by per unit current
6. Curve plotted against time in cycles

3. PEAK 1:

CURRENT = 31.7 mm

VOLTAGE = 34.8 mm

31.7 x 1.41 AMP/mm = 44.9 AMP

34.8 x 2.26 VOLT/mm = 78.5 VOLTS

NOTE THAT: $\frac{\text{VOLTS}}{\text{RATED VOLTS}}$ = VOLTS PER UNIT (VPU)

AND $\frac{\text{AMPERES}}{\text{RATED AMPERES}}$ = AMPERES PER UNIT (IPU)

4. CYCLE 1:

$\frac{78.5}{1200}$ = 0.655 PER UNIT VOLTS

$\frac{44.9}{522}$ = 0.860 PER UNIT AMPS

5. CYCL 1:

$\frac{\text{VP.U}}{\text{IP.U}} = \frac{0.655}{0.860}$ = 0.762 P.U

FIGURE 424.1-III Typical oscillogram obtained during quadrature-axis synchronous reactance test.

**DESCRIPTION:** 5KW, 60HZ
120V, SINGLE PHASE
GENERATOR ONLY

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-5.0-MD

**SERIAL NO.** 42968

**REF.** MIL-STD-705/424.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

QUADRATURE AXIS SYNCHRONOUS REACTANCE TEST

**TEST NO.** 19

**SHEET:** 1 OF 1

**DATE:** FEBRUARY 8, 1971

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 117 | | 216 | | 159 | | 618 | | | | | | | | | 1077 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | FIELD VOLTAGE | | SPEED | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | | VOLTS | | RPM | | | | | | | | |
| **SYM** | | | | X20 | X1 | | | | | | | | | | | | °F |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1000 | STARTED PRIME MOVER | | | | | | | 3600 | | | | | | | | |
| | 1010 | | 18.0 | 2.60 | 52.0 | | 7.0 | | 3600 | EXPOSURE #1 | | | | | | | 77 |
| | 1012 | | | | | | | | 3600 | EXPOSURE #2 10 SEC | | | | | | | |
| | 1016 | | 18.0 | 2.60 | 52.0 | | 7.0 | | 3600 | EXPOSURE #3 | | | | | | | |
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SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

**NOTES** LINE CURRENT MEASURED USING C.T. NO. 1305

FIGURE 424.1-IV Typical test record for quadrature axis synchronous reactance test.

TABULATED RESULTS

| TIME cycles | VOLTAGE rms volts | CURRENT rms amps | VOLTAGE p u | CURRENT p u | $V_{pu}/I_{pu}$ |
|---|---|---|---|---|---|
| 1 | 78.5 | 44.9 | 0.655 | 0.860 | 0.762 |
| 2 | 80.3 | 45.0 | .667 | .869 | .768 |
| 3 | 82.6 | 45.2 | .688 | .871 | .790 |
| 4 | 86.7 | 45.6 | .721 | .880 | .820 |
| 5 | 91.6 | 45.4 | .763 | .877 | .870 |
| 6 | 63.0 | 44.8 | .800 | .867 | .923 |
| 7 | 101.2 | 44.5 | .843 | .860 | .980 |
| 8 | 105.6 | 43.8 | .880 | .846 | 1.040 |
| 9 | 109.4 | 42.5 | .912 | .821 | 1.110 |
| 10 | 112.6 | 41.3 | .938 | .799 | 1.175 |
| 11 | 115.2 | 40.0 | .960 | .773 | 1.240 |
| 12 | 117.5 | 39.4 | .978 | .741 | 1.320 |
| 13 | 119.6 | 37.2 | .997 | .718 | 1.390 |
| 14 | 120.5 | 35.7 | 1.004 | .690 | 1.456 |
| 15 | 120.2 | 34.3 | 1.002 | .662 | 1.514 |
| 16 | 120.0 | 33.4 | 1.000 | .645 | 1.550 |
| 17 | 118.6 | 32.9 | .988 | .636 | 1.553 |
| 18 | 116.2 | 32.4 | .969 | .626 | 1.547 |
| 19 | 113.0 | 32.0 | .941 | .618 | 1.522 |
| 20 | 108.2 | 31.6 | .901 | .610 | 1.478 |
| 21 | 103.0 | 32.0 | .858 | .618 | 1.390 |
| 22 | 98.6 | 32.7 | .822 | .631 | 1.302 |
| 23 | 94.8 | 33.8 | .790 | .653 | 1.210 |
| 24 | 90.5 | 34.6 | .754 | .668 | 1.127 |
| 25 | 89.3 | 35.8 | .744 | .691 | 1.075 |
| 26 | 85.8 | 37.2 | .715 | .718 | .996 |
| 27 | 82.0 | 38.6 | .683 | .746 | .915 |
| 28 | 79.1 | 39.7 | .659 | .767 | .859 |
| 29 | 77.7 | 40.6 | .648 | .785 | .827 |
| 30 | 76.5 | 41.5 | .637 | .802 | .795 |
| 31 | 75.9 | 42.9 | .632 | .829 | .763 |
| 32 | 76.2 | 43.6 | .634 | .841 | .753 |
| 33 | 76.2 | 44.5 | .634 | .860 | .737 |
| 34 | 77.1 | 44.8 | .642 | .867 | .740 |
| 35 | 78.5 | 45.2 | .654 | .871 | .750 |
| 36 | 81.5 | 45.4 | .679 | .877 | .775 |

SIMULATED DATA
FOR ILLUSTRATIVE
PUROSE ONLY

FIGURE 424.1-V Typical results tabulation for quadrature-axis synchronous reactance test.

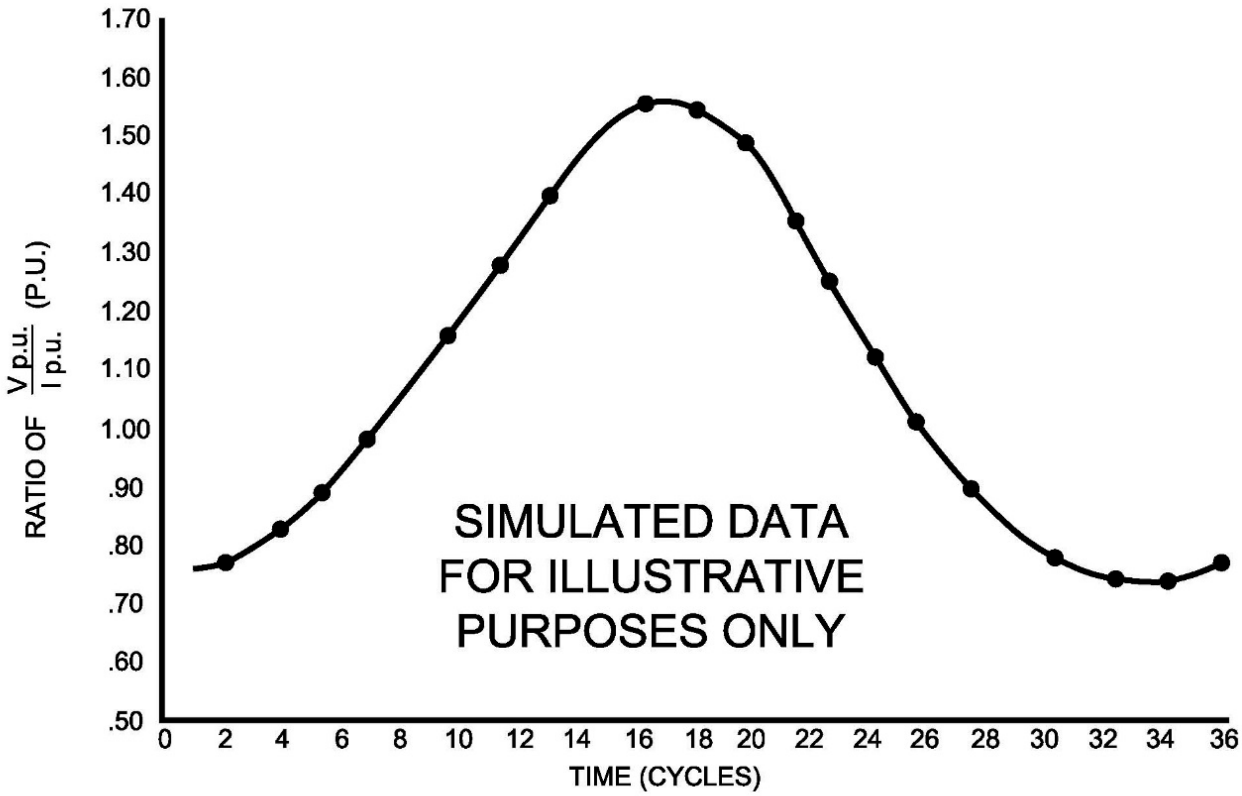


FIGURE 424.1-VI Reactance versus time curve.

METHOD 425.1c

DIRECT-AXIS TRANSIENT REACTANCE TEST

425.1.1 General. The direct-axis transient reactance is used by design engineers to determine the ability of the generator to absorb sudden load applications without having the voltage drop below acceptable levels for using equipment. This reactance gives an indication of the motor starting capabilities of the generator.

425.1.2 Apparatus. Use instrumentation for measuring load conditions, field voltage and current as described and illustrated in the 100 series methods as applicable. In addition, use an oscillograph with sufficient galvanometers having a flat frequency response (flat within ±5 percent) from DC to 3,000 Hz, a non-inductive shunt, a timing wave source, a short circuiting switch, a separate variable DC source for generator excitation and a prime mover capable of maintaining the generator speed within ±1 percent of rated speed under all load conditions of this Method. Electrical instrumentation for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

425.1.3 Procedure.

425.1.3.1. Preparation for test.

a. Mechanically connect the prime mover to the generator and provide the external excitation supply to the generator.

b. Connect the instrumentation and shorting switch to the generator in accordance with FIGURE 425.1-1 for the voltage connection and frequency specified in the procurement document.

**NOTE**: Care shall be taken to reduce the impedance of the current-carrying leads and contacts to a minimum. The leads shall be as short as possible and the conductors for the various phases as close together as practicable to reduce the inductance. These precautions are especially important when dealing with frequencies above 60 Hz.

c. Operate the generator at rated speed and adjust the field current to produce rated voltage at the generator terminals at no load.

d. Adjust the oscillograph such that the no-load voltage trace has a minimum amplitude of 2 inches peak-to-peak. Close the shorting switch and adjust the oscillograph such that the sustained short-circuit current trace has a minimum amplitude of 3/4 inch peak-to-peak.

e. Adjust the speed of the oscillograph film drive such that successive peaks are separated by a minimum of 1/8 inch on the oscillogram.

f. After these adjustments have been made, open the shorting switch.

425.1.3.2. Test.

a. Start and operate the prime mover such that the generator is at rated speed. Adjust the external excitation supply to produce rated voltage at the generator terminals with no load.

b. Record all instrument readings per METHOD 203.1 (see FIGURE 425.1-2).

c. Start the oscillograph. Allow sufficient time to record the zero position of the current trace, the open circuit voltage, and the timing wave.

d. Close the short-circuiting switch. Allow the oscillograph to record the transient and sustained short-circuit current and voltage.

e. Record all instrument readings when sustained short-circuit conditions are achieved.

f. Repeat steps a through e two additional times.

**NOTE**: For a polyphase generator, it is permissible to record oscillographically the short-circuit current in one phase only.

425.1.4 Results.

a. Working directly on the oscillogram, start with the first peak in the current wave following the application of the short-circuit, and number this peak "1" (see FIGURE 425.1-3). Number subsequent peaks consecutively until steady-state conditions occur.

b. Draw a curve through the even numbered peaks and another through the odd numbered peaks; these two curves are the "envelope".

c. Construct straight lines from each peak to a point on the opposite half of the envelope which is 1/2 the horizontal distance between the preceding and the following peaks on the opposite side of the zero axis.

d. Starting at the first peak that can be identified (either peak no. 1 or peak no. 2), measure (in millimeters or other comparable units) the distance between envelope lines along the lines just constructed. Prepare a table of these distances (see FIGURE 425.1-4).

e. Measure the perpendicular distance between envelope lines at steady-state and enter this into the table prepared in step d above. Determine steady-state by the envelope lines (they are parallel at steady-state).

f. Subtract the steady-state distance from each of the other distances to obtain the fourth column of the table.

g. Using semi-log graph paper with the linear axis labeled "peaks" and the log axis labeled "millimeters" (or the unit used in measuring the distances in steps d and e above), plot each of the distances obtained in the fourth column.

h. Draw a smooth curve through the points ignoring obvious measurement errors, "Curve A" in FIGURE 425.1-5.

i. Extend the straight line portion of "Curve A" to the edge of the paper, "Curve B" in FIGURE 425.1-5.

j. On the oscillogram measure the distance along the zero axis between the "t = 0" line (the point at which the short circuit was applied) and the line drawn from the no. 2 peak. Enter this distance on the work sheet. In the example, the distance was found to be 7.0 millimeters.

k. Measure the distance along the zero axis between the lines drawn from no. 2 and no. 4 peaks. Enter this distance on the work sheet. In the example, the distance was found to be 11.5 millimeters.

l. Divide the measurement obtained in step j by the measurement obtained in step k to obtain the ratio between the two distances. In the example, this ratio is 0.61.

m. On the graph, plot a point to the left of the no. 2 peak position, representing the ratio obtained in step l multiplied by the distance between 2 and 0 on the semi-log paper. In FIGURE 425.1-5 this distance is 6.1 squares to the left of the no. 2 peak position. Draw a perpendicular line through this point and extending through "Curve B"; this line represents t = 0.

n. Determine the reading at the point where "Curve B" intersects the t = 0 line. In the example, this reading is 18.5 millimeters. Substitute this value for $i_{t=0}$ in the following formula:

$$X'_d = \frac{I_{RATED}}{(i_{t=0} + i_{ss})\frac{I_{ss}}{i_{ss}}}$$

Where:

$i_{ss}$ is the distance perpendicular to the zero axis of the oscillogram between peaks at steady-state. In the example, $i_{ss}$=25 millimeters.

$I_{ss}$ is the ammeter reading obtained from the data sheet. In the example, $I_{ss}$=64.5 amperes.

$I_{RATED}$ is the rated current of the generator phase under test. In the example, $I_{RATED}$= 17.34 amperes.

$X'_d$ is the direct axis transient reactance. In the example, $X'_d$= 0.154 per unit or 15.4 percent.

o. Repeat steps a through n above for each oscillogram taken in 425.1.3.2. Take the value of the direct axis transient reactance as the average of the several computed values.

p. Compare the computed value of the direct axis transient reactance with the procurement document requirements.

425.1.5 Procurement document requirements.

a. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

b. Maximum allowable direct axis transient reactance ($X'_d$), at rated voltage expressed in per unit or percent.

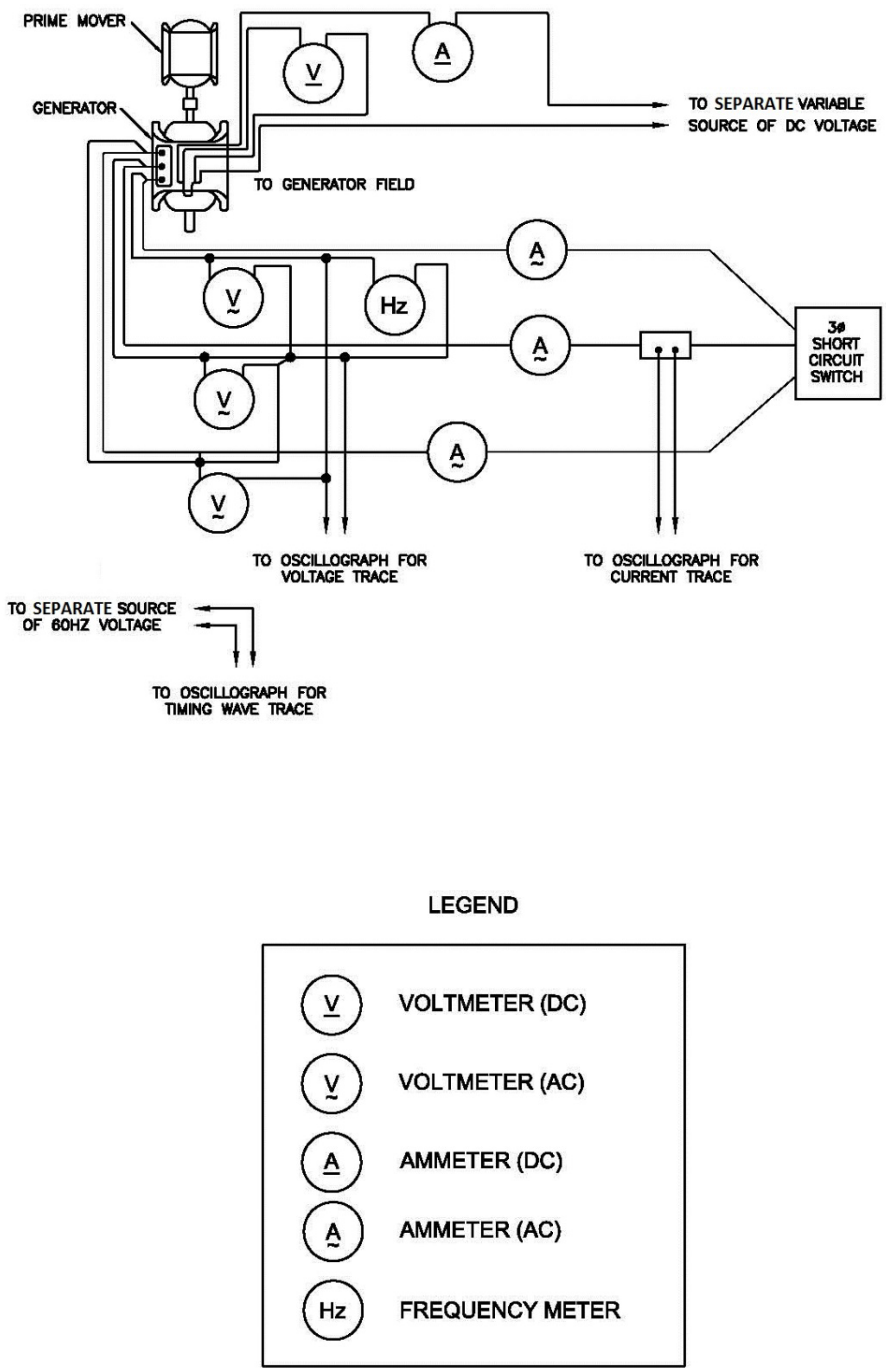


FIGURE 425.1-1 Typical apparatus hookup for direct axis transient reactance test.

**DESCRIPTION:** 3 KW, 400 HZ
120/280V, 3 PHASE
POWER SYSTEM

**MFGR.** ENGENSETS, INC.

**MODEL NO.** SF-3.0-MD

**SERIAL NO.** 1667

**REF.** MIL-STD-705/425.1

**PHILADELPHIA REGION**
**DEFENSE CONRACT ADMINISTRATION SERVICE**

DIRECT-AXIS TRANSIENT REACTANCE TEST

**TEST NO.** 16

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L WRIGHT

**PROJ. ENGR.** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | | 117 | | | | 337 | | | | 511 | | | 131 | 381 | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | | TERMINAL VOLTAGE | | | | LINE CURRENT | | | | FREQUENCY | | | EXCITER FIELD | | | AVG AMB TEMP |
| | | | $L_1 - L_2$ | $L_2 - L_3$ | $L_3 - L_1$ | | $L_1$ | $L_2$ | $L_3$ | | | | | | | | |
| **UNITS** | HRS | | VOLTS | VOLTS | VOLTS | | AMPS | AMPS | AMPS | | | HZ | | VOLTS | AMPS | | °F |
| **SYM** | | | | | | | X 20 | X 20 | X 20 | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0830 | | 205 | 206 | 206 | | 0 | 0 | 0 | | | 418 | | 22.1 | .23 | | 73 |
| | | | 0 | 0 | 0 | | 3.21 | 3.22 | 3.20 | | | | | 22.1 | .23 | | |
| | | | | | | | | | | | | | | | | | |
| | 0900 | | 208 | 208 | 208 | | 0 | 0 | 0 | | | 416 | | 22.3 | .25 | | 72 |
| | | | 0 | 0 | 0 | | 3.22 | 3.22 | 3.22 | | | | | 22.3 | .25 | | |
| | | | | | | | | | | | | | | | | | |
| | 0930 | | 208 | 208 | 208 | | 0 | 0 | 0 | | | 417 | | 22.3 | .25 | | 73 |
| | | | 0 | 0 | 0 | | 3.22 | 3.22 | 3.22 | | | | | 22.3 | .25 | | |
| | | | | | | | | | | | | | | | | | |
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SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSE ONLY

**NOTES**
LINE CURRENT MEASURED USING C.T. $L_1$ - #1306; $L_2$ - #1307; $L_3$ - #1308
EXCITER FIELD CURRENT MEASURED USING A 0.5A , 50mV SHUNT #1674

FIGURE 425.1-2 Typical test record for direct-axis transient reactance test.

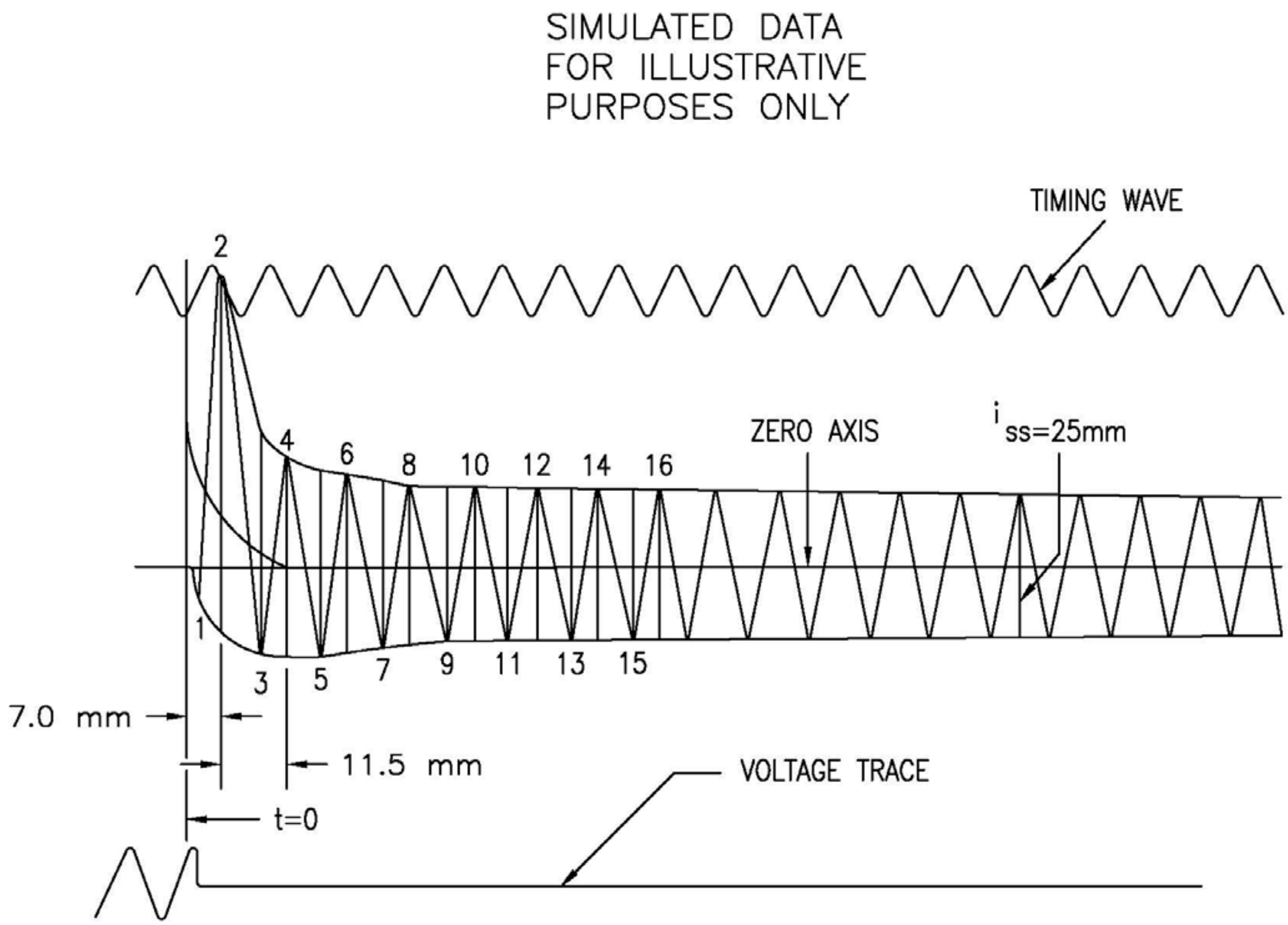


FIGURE 425.1-3 Sample oscillogram for direct-axis transient reactance test.

| PEAK NO. | LENGTH mm | $i_{SS}$ LENGTH mm | COL (2) - COL (3) |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| 1 | | 25 | |
| 2 | 63.5 | 25 | 38.5 |
| 3 | 40.5 | 25 | 15.5 |
| 4 | 35 | 25 | 10 |
| 5 | 33 | 25 | 8 |
| 6 | 31.5 | 25 | 6.5 |
| 7 | 30 | 25 | 5 |
| 8 | 29.5 | 25 | 4.5 |
| 9 | 28.5 | 25 | 3.5 |
| 10 | 28 | 25 | 3 |
| 11 | 27.4 | 25 | 2.4 |
| 12 | 27 | 25 | 2 |
| 13 | 26.5 | 25 | 1.5 |
| 14 | 26.5 | 25 | 1.5 |
| 15 | 26.5 | 25 | 1.5 |
| 16 | 26.5 | 25 | 1.5 |

$$X'_d = \frac{I_{RATED}}{(i_{t=0} + i_{SS})\frac{I_{SS}}{i_{SS}}}$$

t = O TO PEAK 2 = 7.0 mm
PEAK 2 TO PEAK 4 = 11.5 mm

$$\frac{7.0}{11.5} = 0.61$$

$i_{t=0}$ = 18.5 mm
$i_{SS}$ = 25 mm
$I_{SS}$ = 64.5 AMPERES
$I_{RATED}$ = 17.34 AMPERES

THEREFORE

$$X'_d = \frac{17.34}{(18.5+25)\frac{64.5}{25}}$$

$$X'_d = \frac{17.34}{43.5(\frac{64.5}{25})}$$

$$X'_d = \frac{17.34}{43.5\,(2.58)}$$

$$X'_d = \frac{17.34}{112.23}$$

$X'_d$ = 0.154 REACTANCE OR 15.4%

SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSE ONLY

FIGURE 425.1-4 Sample worksheet for direct-axis transient reactance test.

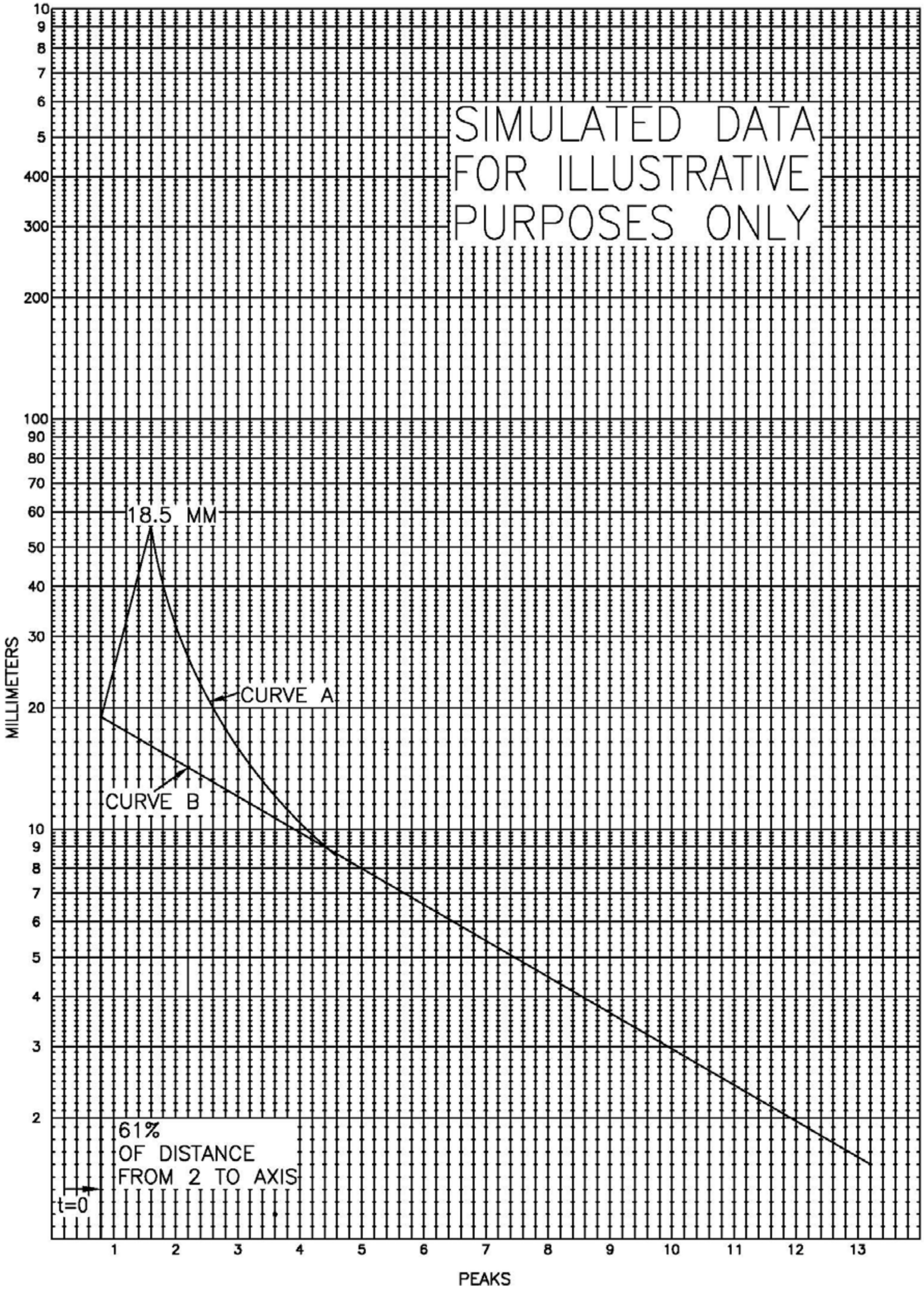


FIGURE 425.1-5 Sample curve used in the determination of direct-axis transient reactance.

# METHOD 426.1c

## DIRECT-AXIS SUBTRANSIENT REACTANCE TEST

426.1.1 General. The direct-axis subtransient reactance is used by design engineers to determine the necessary interrupting capacity of the power system circuit interrupter.

426.1.2 Apparatus. Use instrumentation for measuring load conditions, field voltage and current as described and illustrated in the 100 series methods as applicable. In addition, use an oscilloscope with sufficient galvanometers having a flat frequency response (flat within +5 percent) from DC to 3,000 Hz, a non-inductive shunt, a timing wave source, a short circuiting switch, a separate, variable DC source for generator excitation and a prime mover capable of maintaining the generator speed within ±1 percent of rated speed under all load conditions of this Method. Electrical instrumentation for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

426.1.3 Procedure.

a. Perform METHOD 425.1, Direct-Axis Transient Reactance Test.

b. On the same graph as plotted for METHOD 425.1, plot an additional line as shown in FIGURE 426.1-1. Plot the line as follows:

   1. Ascertain the scale distance between the straight line (Curve "B") and the curved line (Curve "A") for at least three peak positions.

   2. Plot these distances on the respective peak lines. In the example, Curve "A" is 24 mm from Curve "B" on the No. 2 peak perpendicular. Similarly, at the 2.6 peak, the scale distance between the two curves is 7.5 mm. At the No. 3 peak, the distance is 3.5 mm.

   3. Draw a straight line through these points. In the example, this line is identified as Curve "C".

c. Read the value in mm (or the unit used in measuring the distances in step b above) where the Curve "C" crosses the t = 0 line. In the example, this crossing is at 264 mm.

d. Using the following formula, compute the direct-axis subtransient reactance, $X''_d$.

$$X''_d\,(in\,percent) = \frac{I_{RATED}}{(i'_{t=0} + i_{t=0} + i_{ss})\frac{I_{ss}}{i_{ss}}} * 100$$

Where:

$i'_{t=0}$ is the point where Curve "C" crosses the t=0 line (in the example $i'_{t=0}$=264 mm).

$i_{t=0}$ is the point where Curve "B" crosses the t=0 line.

$i_{ss}$ is the distance perpendicular to the zero axis of the oscillogram between peaks at steady-state.

$I_{ss}$ is the ammeter reading obtained from the data sheet taken in METHOD 425.1.

$I_{RATED}$ is the rated current of the generator under test.

e. Apply the above procedure to the short-circuit current in all phases of a polyphase generator when they have been recorded oscillographically, or to the three individual oscillograms taken on one phase. Take the value of $X''_d$ for the generator as the average of the several computed values.

426.1.4 Results. Compare the average value of the subtransient reactance ($X''_d$) with the procurement document requirements.

426.1.5 Procurement document requirements.

a. Maximum, minimum or range of allowable values of the direct-axis subtransient reactance ($X''_d$), at rated voltage, expressed as a percent.

b. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

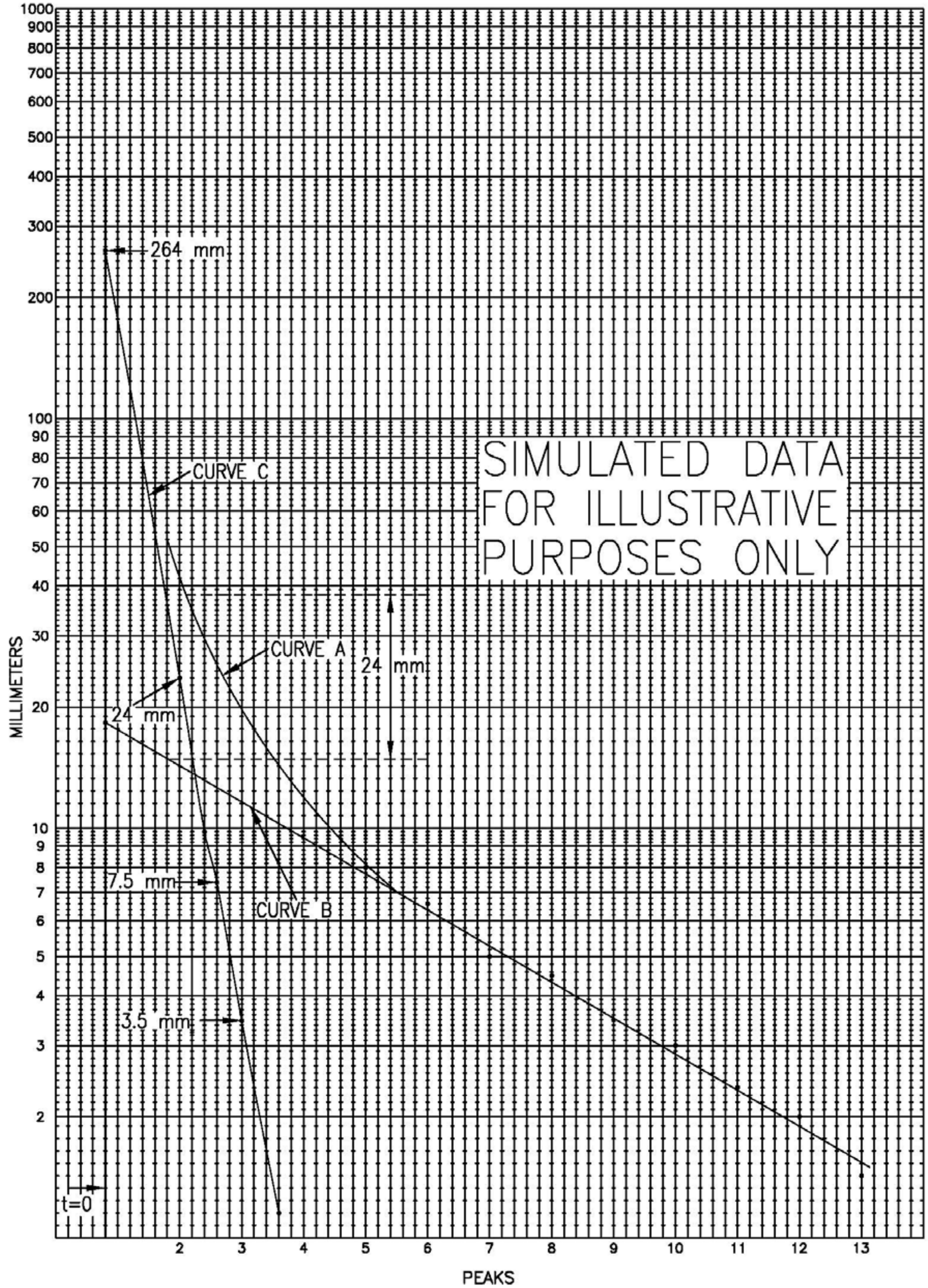


FIGURE 426.1-1 Sample curve used in the determination of direct-axis subtransient reactance.

METHOD 427.1c

DIRECT-AXIS TRANSIENT SHORT-CIRCUIT TIME CONSTANT TEST

427.1.1 General. The direct-axis transient short-circuit time constant is used by design engineers to aid in the determination of the performance of a generator under various load conditions.

427.1.2 Apparatus. Use instrumentation for measuring load conditions, field voltage and current as described and illustrated in the 100 series methods as applicable. In addition, use an oscilloscope with sufficient galvanometers having a flat frequency response (flat within $\pm$5 percent) from DC to 3,000 Hz, a non-inductive shunt, a timing wave source, a short circuiting switch, a separate, variable DC source for generator excitation and a prime mover capable of maintaining the generator speed within $\pm$1 percent of rated speed under all load conditions of this Method. Electrical instrumentation for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

427.1.3 Procedure.

a. Perform METHOD 425.1, Direct-Axis Transient Reactance Test.

b. On the same graph as plotted for METHOD 425.1:

1. Determine the point at which Curve "B" crosses the t = 0 line. In the example; this has been previously determined to be 18.5 mm.

2. Multiply the quantity obtained in step 1 above by 0.368. In example: 18.5 x 0.368 = 6.8 mm.

3. Find the point of Curve "B" at which the quantity obtained in step 2 above is located.

4. Determine the peak at this point. In the example, this is 5.7 peaks (FIGURE 427.1-1).

5. Subtract "1.0" from the number obtained in step 4 above. In example: 5.7 - 1.0 = 4.7.

6. To the number obtained in step 5 above, add the time (peaks) from t = 0 to t = 1. In the example, this time is 0.2 peaks. 4.7 + 0.2 = 4.9 peaks.

7. Multiply the number of peaks obtained in step 6 above by the time interval between peaks, which is "1" divided by twice the frequency. In the example, the frequency is 60 Hz. The computation, then, becomes

$4.9 \times \frac{1}{120} = 0.041$ second, the direct-axis transient short-circuit time constant.

c. Repeat step b above for each of the three graphs plotted for METHOD 425.1. Take the value for the direct-axis transient short-circuit time constant as the average of the several computed values.

427.1.4 Results. Compare the average value of the direct-axis transient short-circuit time constant with the procurement document requirements.

427.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The allowable range of direct-axis transient short-circuit time constant in seconds, if applicable.

b. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

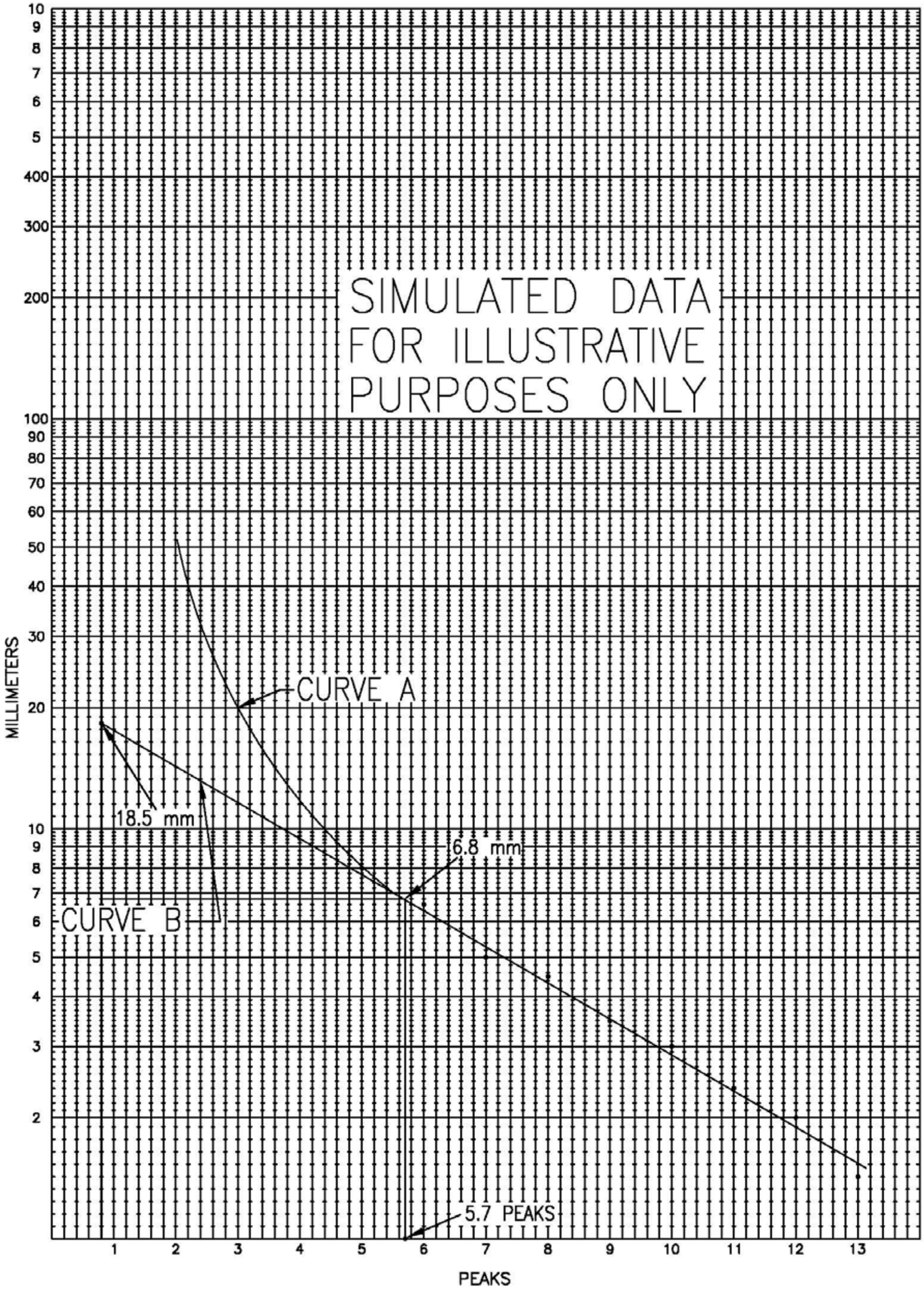


FIGURE 427.1-1 Sample curve used in the determination of direct-axis transient short-circuit time constant.

METHOD 428.1c

DIRECT-AXIS SUBTRANSIENT SHORT-CIRCUIT TIME CONSTANT TEST

428.1.1 General. The direct-axis subtransient short-circuit time constant is used by design engineers to aid in the determination of the performance of a generator under various load conditions.

428.1.2 Apparatus. Use instrumentation for measuring load conditions, field voltage and current as described and illustrated in the 100 series methods as applicable. In addition, use an oscilloscope with sufficient galvanometers having a flat frequency response (flat within ±5 percent) from DC to 3,000 Hz, a non-inductive shunt, a timing wave source, a short circuiting switch, a separate, variable DC source for generator excitation and a prime mover capable of maintaining the generator speed within ±1 percent of rated speed under all load conditions of this Method. Electrical instrumentation for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

428.1.3 Procedure.

a. Perform METHOD 426.1, Direct-Axis Subtransient Reactance Test.

b. On the same graph as plotted for METHOD 426.1:

1. Determine the point at which Curve "C" crosses the t = 0 line. In the example, this has been previously determined to be 264 mm.

2. Multiply the quantity obtained in step 1 above by 0.368. In the example: 264 x 0.368 = 97.15.

3. Find the point on Curve "C" at which the quantity obtained in step 2 above is located.

4. Determine the peak at this point. In the example, this is 1.3 peaks (FIGURE 428.1-1).

5. Subtract "1.0" from the number obtained in step 4 above. In the example, 1.3 - 1.0 = 0.3.

6. To the number obtained in step 5 above, add the time (peaks) from t = 0 to t = 1. In the example, this time is 0.2 peak. 0.3 + 0.2 = 0.5 peak.

7. Multiply the number of peaks obtained in step 6 above by the time interval between peaks, which is "1" divided by twice the frequency. In the example, the frequency is 60 Hz. The computation, then, becomes

$0.5 \times \frac{1}{120}$ = .004 second, the direct-axis subtransient short-circuit time constant.

c. Repeat step b above for each of the three graphs plotted for METHOD 426.1. Take the value for the direct-axis subtransient short-circuit time constant as the average of the several computed values.

428.1.4 Results. Compare the average value of the direct-axis subtransient short-circuit time constant with the procurement document requirements.

428.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The allowable range of direct-axis subtransient short-circuit time constant in seconds, if applicable.

b. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

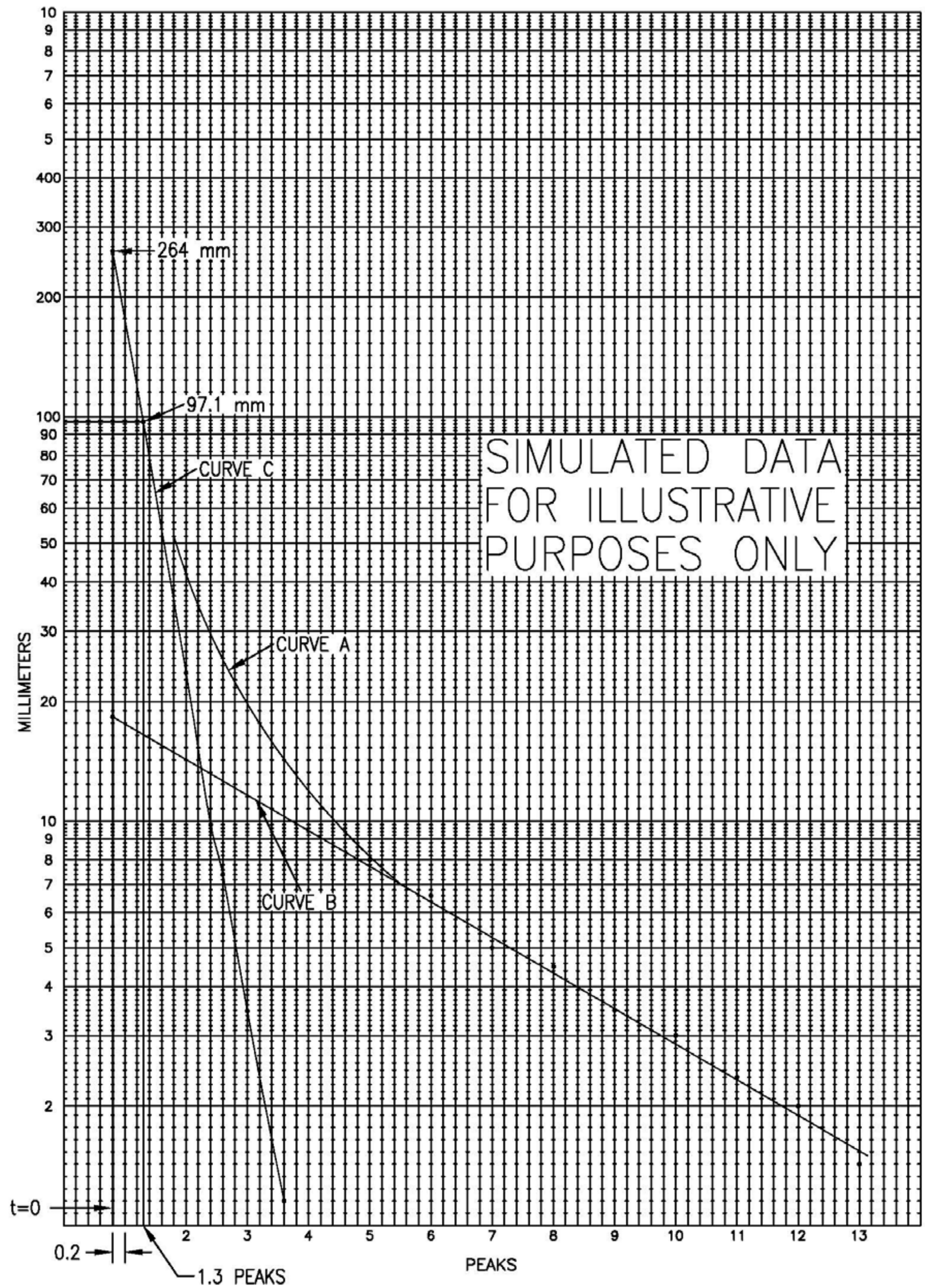


FIGURE 428.1-1 Sample curve used in the determination of direct-axis subtransient short-circuit time constant.

METHOD 430.1a

DIRECT-AXIS TRANSIENT OPEN-CIRCUIT TIME CONSTANT TEST

**NOTE**: Method 430.1a was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

430.1.1 General. The direct-axis transient open-circuit time constant is used by design engineers to aid in the determination of the performance of a generator under various load conditions.

430.1.2 Apparatus. Instrumentation for measuring terminal voltage, generator speed, and field voltage and current shall be as described and illustrated in MIL-HDBK-705. In addition a short circuiting switch, for the generator field; an oscillograph with sufficient galvanometers (3,000 Hz response); and a prime mover shall be required.

430.1.3 Procedure.

430.1.3.1 Preparation for test.

a. Mechanically connect the generator to the prime mover and provide the external excitation supply to the generator through a resistor of sufficient size to prevent injury to the supply circuit when the field is short circuited.

b. Connect the instrumentation and field shorting switch in accordance with FIGURE 430.1-I for a voltage connection and frequency specified in the procurement document.

430.1.3.2 Test.

a. Start and operate the prime mover such that the generator is at rated voltage, rated speed and no load.

b. Adjust the amplitude of the generator terminal voltage trace to at least 2 inches.

c. Adjust the amplitude of the generator field voltage trace to at least 3/4 inch and set up a field voltage zero trace.

d. Set up a timing line trace.

e. Adjust oscillograph film speed to give at least 1/8 inch separation between successive peaks.

f. Start the oscillograph, with the generator operating at rated voltage, rated speed and no load, and operate for at least 1/4-second to record the initial steady-state traces of the terminal voltage and field voltage. Record all instrument readings (see FIGURE 430.1-II).

g. Close the field short-circuiting switch and keep the oscillograph in operation until the generator voltage decays to its residual value. Record this value on the data sheet.

430.1.4 Results.

430.1.4.1 Instructions.

a. Draw a voltage envelope on the oscillogram. Construct a perpendicular at t = 0 (a typical curve is shown inSIMULATED DATA **FOR ILLUSTRATIVE PURPOSES ONLY**
b. FIGURE 430.1-III).

c. Measure the height of the initial envelope (steady-state before shorting field).

d. Measure the height of the final envelope (steady-state after shorting field).

e. Subtract final measurement from initial measurement and multiply by 0.368.

f. To the value obtained in step d above add the measurement taken in step c above.

g. Slide the scale along the curve until the envelope height is the value obtained in step e above. At this point construct a perpendicular to the timing wave.

h. From the point of the timing wave obtained in step f above, determine length of time away from t = 0. This is the direct-axis transient open-circuit time constant.

Compare the results with the procurement document requirements.

430.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable direct-axis transient open-circuit time constant in seconds.

b. Voltage connection(s) and frequency(ies) at which this method is to be performed.

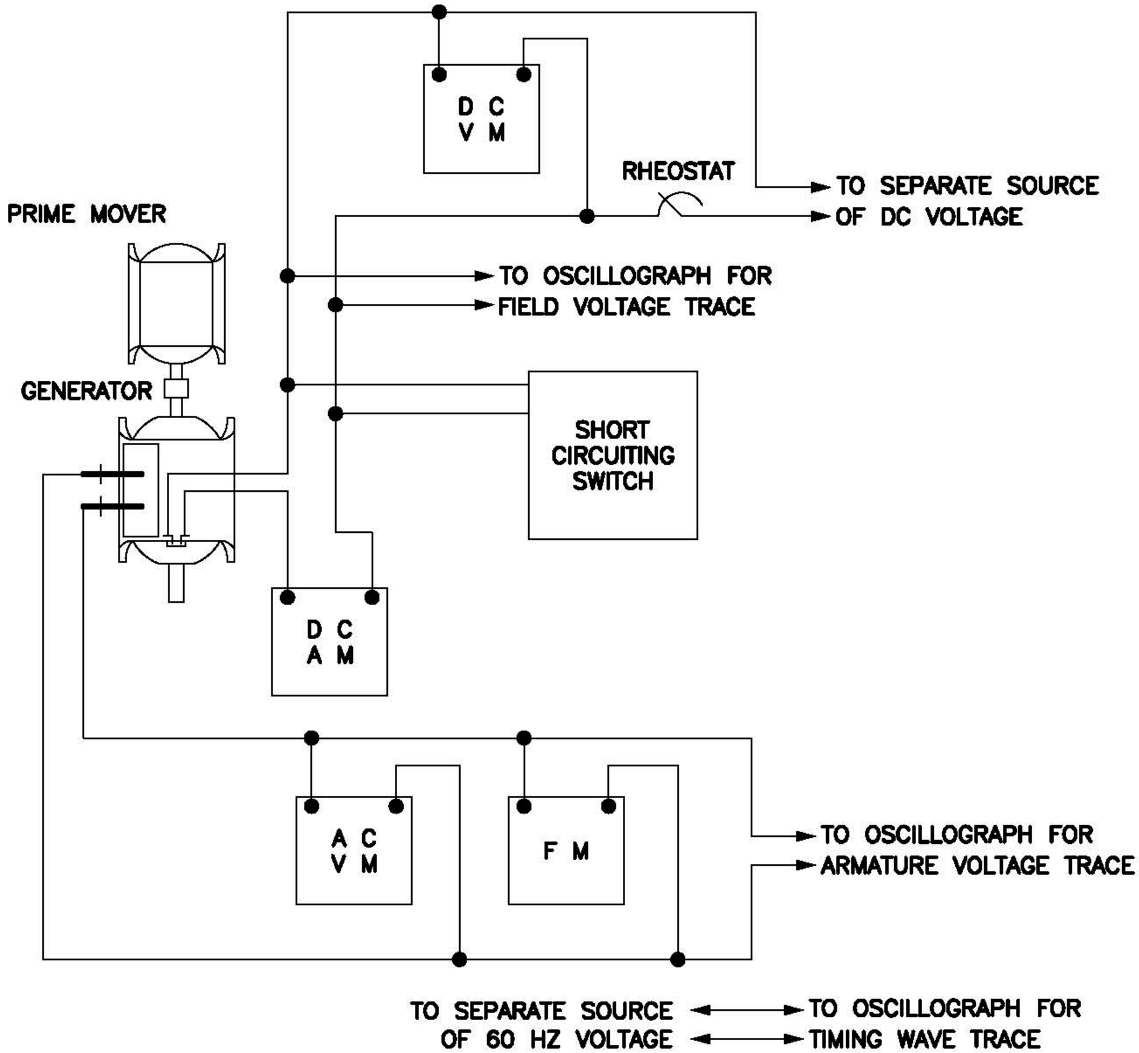


FIGURE 430.1-I Typical apparatus hookup for direct-axis transient open-circuit time constant test.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60HZ<br>120V, SINGLE PHASE<br>GENERATOR ONLY<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 10717<br><br>**REF.** MIL-STD-705/430.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>DIRECT AXIS TRANSIENT OPEN CIRCUIT<br>TIME CONSTANT TEST | **TEST NO.** 11<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** FEBRUARY 1, 1971<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 107 | | 612 | | | 118 | 306 | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | TERMINAL VOLTAGE | | FREQUENCY | | | GENERATOR FIELD | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | | HZ | | VOLTS | AMPS | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | °F |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0715 | | 120.0 | | 60.0 | | 0.28 | 9.5 | BEFORE SHORTING | | | | | | | | 84 |
| | | | 21.2 | | --- | | 0 | 0 | AFTER SHORTING | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | FROM 0-GRAPH - DIRECT AXIS TRANSCIENT OPEN-CIRCUIT TIME CONTANT = 0.70 SEC | | | | | | | | | | | | | | | |
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SIMULATED DATA
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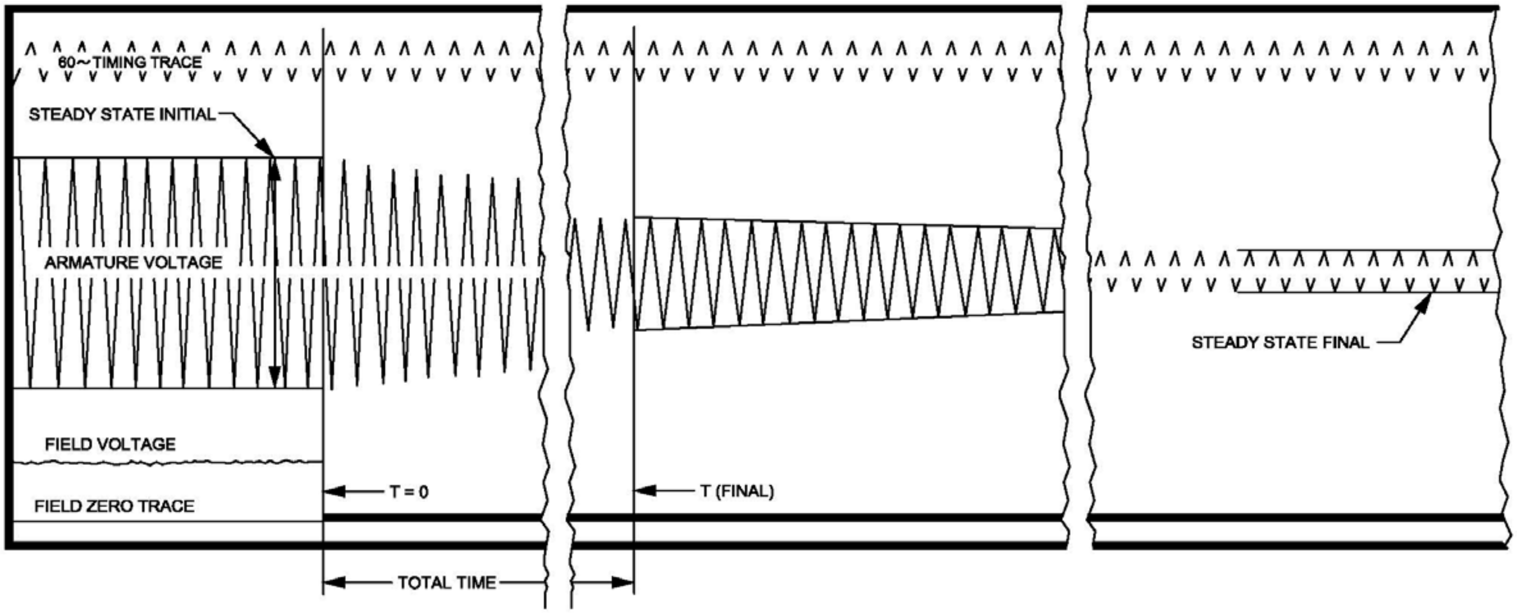
| **NOTES** | |
|---|---|
| | GENERATOR FIELD CURRENT MEASURED USING 10A, 50mV SHUNT NO. 2110 |
| | |
| | |

FIGURE 430.1-II Typical test record for direct axis open circuit time constant test.

**SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY**




CALCULATION

| ITEM | UNIT |
|---|---|
| A. ERECT PERPENDICULAR T = 0 | |
| B. STEADY STATE INITIAL | 44.0 |
| C. STEADY STATE FINAL | 7.8 |
| D. B-C | 44.0-7.8 = 36.2 |
| E. D X 0.368 | 36.2 X 0.368 = 13.3 |
| F. C + E | 7.8 + 13.3 = 21.1 |
| | |

CALCULATION

| ITEM | UNIT |
|---|---|
| G. SLIDE SCALE ALONG ENVELOPE UNTIL WIDTH IS THE VALUE FOUND IN F. ABOVE. ERECT PERPENDICULAR TO TIMING WAVE | |
| H. COMPUTE TOTAL TIME FROM TIMING TRACE | $\frac{\text{42 CYCLES}}{60}$ = 0.70 SECONDS |

FIGURE 430.1-III Typical oscillogram, Direct-Axis transient open-circuit time constant test.

METHOD 432.1c

SHORT-CIRCUIT TIME CONSTANT OF ARMATURE WINDING TEST

432.1.1 General. The short-circuit time constant of armature winding is used by design engineers as a criterion for the requirements of auxiliary equipment intended to protect the load and generator from extreme conditions.

432.1.2 Apparatus. Use instrumentation for measuring load conditions, field voltage and current shall be as described and illustrated in the 100 series methods as applicable. In addition, use an oscilloscope with sufficient galvanometers having a flat frequency response (flat within ±5 percent) from DC to 3,000 Hz, a non-inductive shunt, a timing wave source, a short circuiting switch, a separate, variable DC source for generator excitation and a prime mover capable of maintaining the generator speed within ±1 percent of rated speed under all load conditions of this Method. Electrical instrumentation for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

432.1.3 Procedure.

a. Perform METHOD 425.1, Direct-Axis Transient Reactance Test.

b. On an oscillogram obtained in step a above (see SIMULATED DATA

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c. FIGURE 432.1-1), beginning at the number two peak, determine the distance in millimeters between the zero axis and each current envelope line, at each peak, as far as steady-state. Tabulate these distances.

d. Determine the difference between the values obtained at each peak and tabulate these differences. Tabulate the data as follows: column 1 shall contain the peak number; column 2 shall contain the distance between the zero axis and the upper envelope line; column 3 shall contain the distance between the zero axis and the lower envelope line; and column 4 shall contain the differences between the values in columns 3 and 4. These differences represent the asymmetrical component.

e. Plot a curve on semi-log paper of the asymmetrical component versus peak number. Plot the asymmetrical component values on the logarithmic axis and the peak numbers on the linear axis. Add this curve to the graph obtained in step a above and extended to cross the t = 0 line. The curve is shown in FIGURE 432.1-2, and is labeled "D".

f. Determine the point at which the curve crosses the t = 0 line. In the example shown in FIGURE 432.1-2, this value is 27.

g. Multiply the quantity obtained in step e above by 0.368. In the example: 27 x 0.368 = 9.9.

h. Find the point on the curve at which the value obtained in step f above falls.

i. Determine the peak value at the point determined in step g above. In the example, this point is 2.2 peaks.

j. Subtract "1.0" from the peak value obtained in step g above. In the example: 2.2 - 1.0 = 1.2.

k. To the value obtained in step i above, add the peak value from t = 0 to t = 1. In the example, this time is 0.2 peak. Therefore: 1.2 + 0.2 = 1.4.

l. Multiply the peak value obtained in step j above by the time interval between peaks, which is "1.0" divided by twice the frequency. In the example, the frequency is 60 Hz. The short-circuit time constant for armature winding in the example is $1.4 \times \frac{1}{120} = 0.01167$ seconds.

m. Repeat steps b through k above for each oscillogram taken during step a above. Take the short-circuit time constant for armature winding as the average of the several values.

432.1.4 Results. Compare the short-circuit time constant of armature winding with the procurement document requirements.

432.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The maximum allowable short-circuit time constant for armature winding, if applicable.

b. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

**SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSES ONLY**

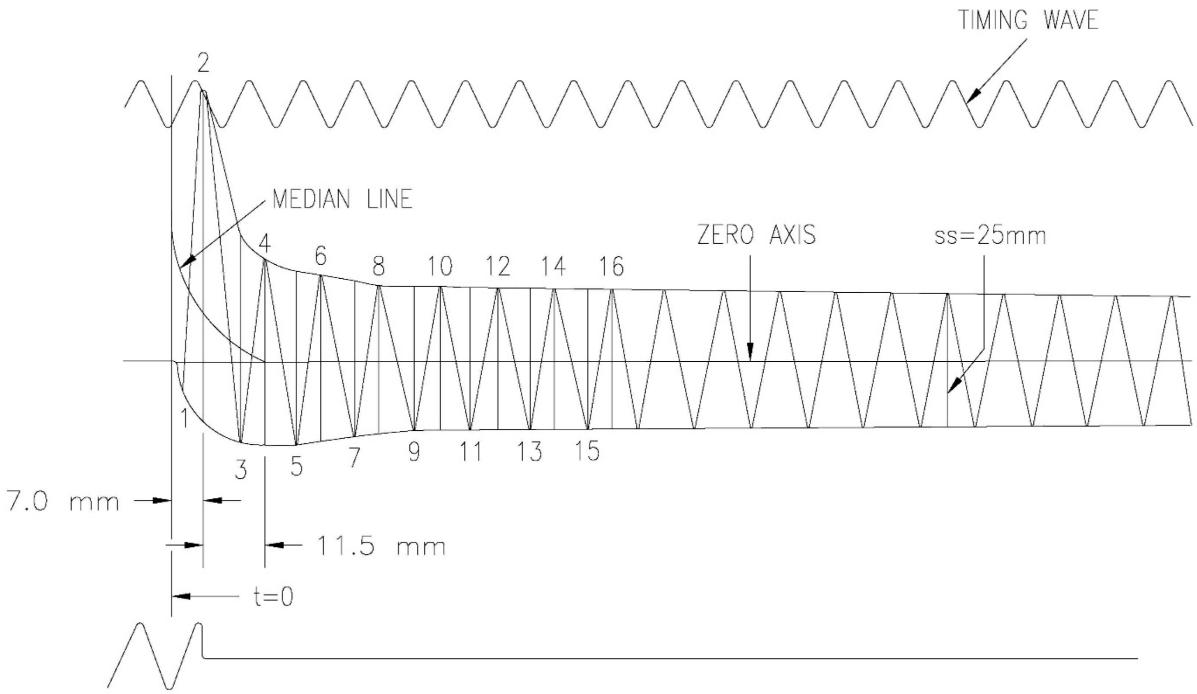


FIGURE 432.1-1 Sample oscillogram, showing median line.

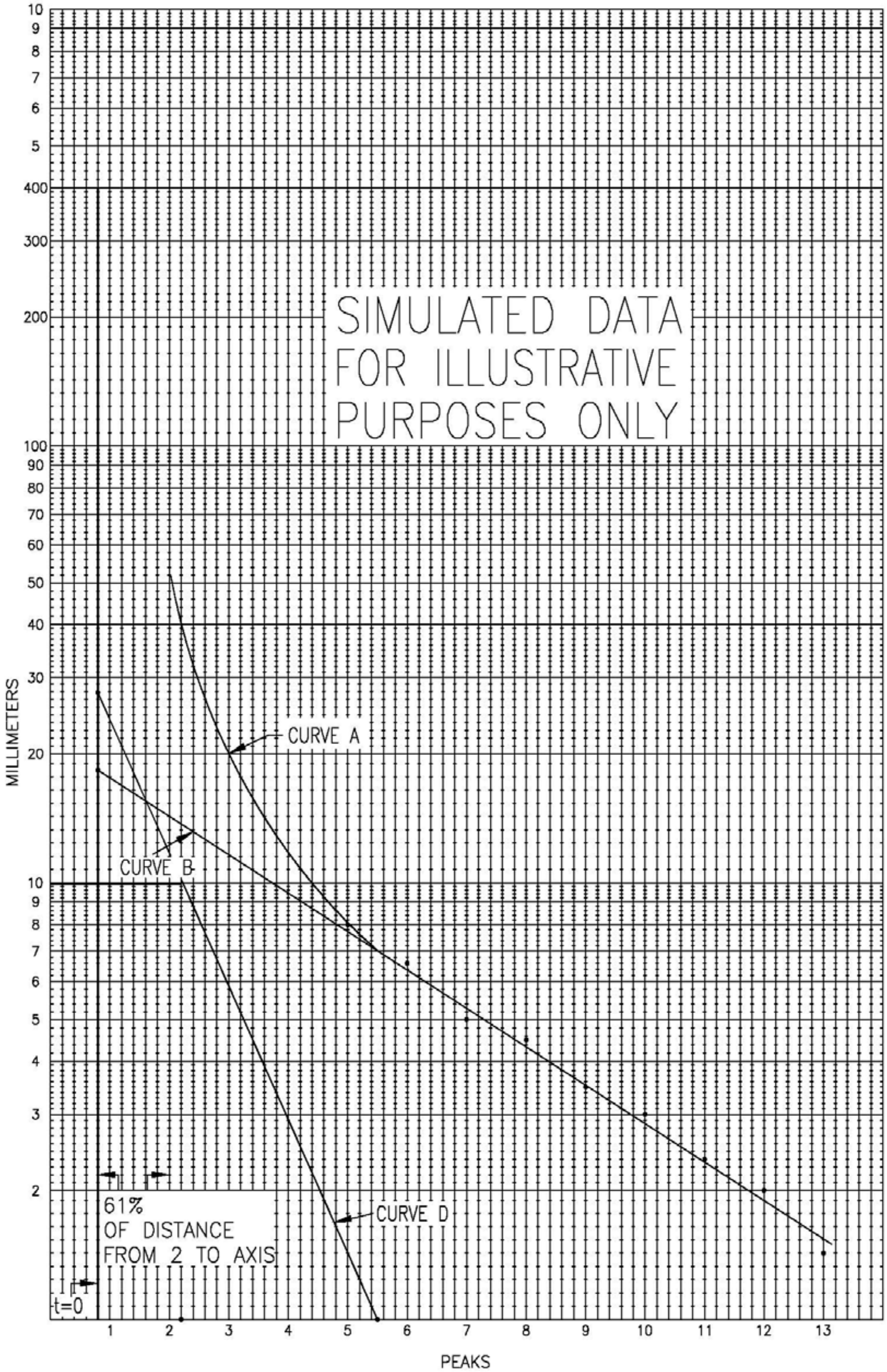


FIGURE 432.1-2 Sample curve used in determining the short-circuit time constant of armature winding.

# METHOD 503.1d

## START AND STOP TEST

503.1.1 General. The adequacy of the starting and operating instructions on the power system is essential to safe operation of the power system. Any abnormal start and stop conditions may endanger personnel or equipment. The start time is the period of time from initiating start procedures until the power system has achieved rated voltage and frequency (speed) without the further use of starting aids. A power system is considered to have stopped when all rotating members are at zero rpm, with the exception of the turbocharger, if used.

503.1.2 Apparatus. Use a stopwatch/timer. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

503.1.3 Procedure. Using the items provided as part of the power system, perform the following operations:

a. Start the power system by following the operating instructions on the power system. Use the stopwatch/timer to determine the time required to start the power system as defined in 503.1.1 and record readings per METHOD 203.1 (see FIGURE 503.1-1).

b. Operate the power system at rated voltage, rated frequency (speed), and no load for 5 minutes with the circuit interrupter closed.

c. Stop the power system by following the operating instructions on the power system. Use the stopwatch/timer to determine the time required to stop the power system as defined in 503.1.1.

d. Repeat steps a through c two additional times.

e. Repeat steps a through d utilizing any alternate starting methods provided for in the operator's manual or power system design (e.g. rope start) but not including remote starting.

503.1.4 Results. Indicate on the data sheet how the power system performed during this test, including the time to start, the operating time, the voltage and operating speed during each period of operation, and the manner and time of power system shutdown. Compare these results with the procurement document requirements.

503.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection and frequency at which this Method is to be performed.

b. Time limit to start the power system.

c. Time limit to stop the power system, if applicable.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60 HZ<br>120V SINGLE PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/503.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>START AND STOP TEST | **TEST NO.** 6<br><br>**SHEET:** 1 OF 2<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **INST→** | | | | | | | | | | | | | | | | | |
| **READ NO ↓** | TIME | | | | | | | | | | | | | | | | |
| **UNITS** | HRS | | | | | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 0910 | STARTED POWER SYSTEM IN 15 SEC USING NORMAL START PROCEDURE. CLOSED CIRCUIT BREAKER | | | | | | | | | | | | | | | |
| | | POWER SYSTEM OPERATING AT 120V & 60HZ | | | | | | | | | | | | | | | |
| | 0915 | SHUTDOWN POWER SYSTEM. POWER SYSTEM SLOWED BUT CONTINUED TO RUN ERRATICALLY FOR 48 SEC | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 0920 | STARTED POWER SYSTEM IN 10 SEC USING NORMAL START PROCEDURE. CLOSED CIRCUIT BREAKER | | | | | | | | | | | | | | | |
| | | POWER SYSTEM OPERATING AT 120V & 60HZ | | | | | | | | | | | | | | | |
| | 0925 | SHUTDOWN POWER SYSTEM. POWER SYSTEM SLOWED BUT CONTINUED TO RUN ERRATICALLY FOR 36 SEC | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 0930 | STARTED POWER SYSTEM IN 5 SEC USING NORMAL START PROCEDURE. CLOSED CIRCUIT BREAKER | | | | | | | | | | | | | | | |
| | | POWER SYSTEM OPERATING AT 120V & 60HZ | | | | | | | | | | | | | | | |
| | 0935 | SHUTDOWN POWER SYSTEM IN 5 SEC – NO ERRATIC OPERATION NOTICED | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 0940 | STARTED POWER SYSTEM IN 9 SEC USING EMERGENCY START PROCEDURE. CLOSED CIRCUIT | | | | | | | | | | | | | | | |
| | | BREAKER POWER SYSTEM OPERATING AT 120V & 60HZ | | | | | | | | | | | | | | | |
| | 0945 | SHUTDOWN POWER SYSTEM IN 3 SEC – NO ERRATIC OPERATION | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | 0950 | STARTED POWER SYSTEM IN 7 SEC USING EMERGENCY START PROCEDURE. CLOSED CIRCUIT | | | | | | | | | | | | | | | |
| | | BREAKER POWER SYSTEM OPERATING AT 120V & 60HZ | | | | | | | | | | | | | | | |
| | 0955 | SHUTDOWN POWER SYSTEM IN 3 SEC – NO ERRATIC OPERATION | | | | | | | | | | | | | | | |
| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 503.1-1 Portion of a typical test record for start and stop test.

METHOD 503.2d

START AND STOP TEST
(REMOTE CONTROL)

503.2.1 General. The adequacy of the remote control starting and operating instructions on the power system is essential to safe operation of the power system. Any abnormal start and stop conditions may endanger personnel or equipment. Some power systems have “local” and “remote” or similarly named settings. When the power system is in the “local” setting, any use of the remote control should have no effect on the power system. The start time is the period of time from initiating start procedures until the power system has achieved rated voltage and frequency (speed) without the further use of starting aids. A power system is considered to have stopped when all the rotating members are at zero rpm, with the exception of the turbocharger, if used.

503.2.2 Apparatus. Use a stopwatch/timer. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

503.2.3 Procedure.

503.2.3.1 Preparation for test. Connect and enable the remote control system per the technical manual or power system requirements.

503.2.3.2 Test.

a. Using the remote control, start the power system by following the remote control operating instructions on the power system or in the technical manual and record readings per METHOD 203.1 (see FIGURE 503.2-1). Use the stopwatch/timer to determine the time required to start the power system as defined in 503.2.1.

b. Operate the power system at rated voltage, rated frequency, and no load for 5 minutes.

c. Using the remote control, stop the power system by following the operating instructions on the power system or in the technical manual. Use the stopwatch/timer to determine the time required to stop the power system as defined in 503.2.1.

d. Repeat steps a through c above two additional times.

e. If applicable, with the power system set to “local” (or equivalent), attempt to start the power system with the remote control. Record whether the power system started.

503.2.4 Results. Indicate on the data sheet how the power system performed during this test, including the time to start, the operating time, the voltage and operating speed during each period of operation, the manner and time of power system shutdown, and if the power system started from the remote control with the switch in the "local" (or equivalent) position. Compare these results with the procurement document requirements.

503.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection and frequency at which this Method is to be performed.

b. The time limit for remote starting, if different than the time limit for starting at the power system.

c. The time limit for remote stopping, if applicable.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120V, SINGLE PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/503.2 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>START AND STOP TEST<br>(REMOTE CONTROL) | **TEST NO.** 7<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY, 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST.→** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | | | | | | | | | | | | | | | | |
| **UNITS** | HRS | | | | | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1015 | STARTED POWER SYSTEM IN 8 SEC USING REMOTE START PROCEDURE. POWER SYSTEM OPERATING AT 120 V, 60 HZ | | | | | | | | | | | | | | | |
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| | 1020 | SHUTDOWN POWER SYSTEM IN 3 SEC USING REMOTE STOP PROCEDURE | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1022 | STARTED POWER SYSTEM IN 6 SEC USING REMOTE START PROCEDURE. POWER SYSTEM OPERATING AT 120 V, 60 HZ | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1027 | SHUTDOWN POWER SYSTEM IN 3 SEC USING REMOTE STOP PROCEDURE | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1030 | STARTED POWER SYSTEM IN 7 SEC USING REMOTE START PROCEDURE. POWER SYSTEM OPERATING AT 120 V, 60 HZ | | | | | | | | | | | | | | | |
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| | 1035 | SHUTDOWN POWER SYSTEM IN 3 SEC USING REMOTE STOP PROCEDURE | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1038 | PUT "REMOTE-LOCAL" SWITCH IN "LOCAL" – ATTEMPTED TO START POWER SYSTEM USING REMOTE SWITCH. POWER SYSTEM | | | | | | | | | | | | | | | |
| | | CRANKED BUT WOULD NOT START AFTER 30 SEC OF CRANKING. | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 503.2-1 Typical test record for start and stop test (remote control).

# METHOD 503.3b

## REMOTE OPERATION AND MONITORING TEST

503.3.1 General. The remote control must be capable of starting, operating, and monitoring the power system.

503.3.2 Apparatus. Use instrumentation for measuring load conditions, field voltage and current, and ambient temperature as described and illustrated in METHOD 205.1. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

503.3.3 Procedure.

503.3.3.1 Preparation for test.

a. Connect and enable the remote control system per the technical manual or power system requirements.

b. Connect the load and field instrumentation in accordance with the applicable figure of 205.1.10 for one voltage connection and frequency specified in the procurement document.

503.3.3.2 Test.

a. Perform METHOD 503.2, Start and Stop Test (Remote Control).

b. Using the remote control, if applicable, perform METHOD 511.1, Regulator Range Test.

c. Using the remote control, if applicable, perform METHOD 511.2, Frequency Adjustment Range Test.

d. Using the remote control, if applicable, perform METHOD 513.2, Indicating Instrument Test (Electrical).

e. Using the remote control, if applicable, perform any additional method(s) specified in the procurement document.

f. Repeat steps a through e above at any other voltage connection and frequency specified in the procurement document.

g. Shutdown the power system using the remote control.

503.3.4 Results. Compare the results with the procurement document requirements.

503.3.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

b. Any methods to be performed not specified herein.

c. Maximum and minimum voltages between which the power system shall perform.

d. The maximum allowable voltage regulation (droop).

e. Maximum frequency adjustment(s).

f. Minimum frequency adjustment(s).

g. The accuracy of each instrument contained in the remote control system.

| DESCRIPTION | | TEST RECORD |
|---|---|---|
| **DESCRIPTION:** 15KW, 60 HZ<br>120/208V 3-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-15.0-MD<br><br>**SERIAL NO.** 1186<br><br>**REF.** MIL-STD-705/503.3 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>REMOTE OPERATION AND MONITORING TEST | **TEST NO.** 13<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | | | | | | | | | | | | | | | | |
| **UNITS** | HRS | | | | | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 1000 | STARTED POWER SYSTEM– APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1010 | PERFORMED METHOD 511.1 | | | | | | | | | | | | | | | |
| | 1030 | PERFORMED METHOD 511.2 | | | | | | | | | | | | | | | |
| | 1050 | PERFORMED METHOD 513.2 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1120 | SHUTDOWN POWER SYSTEM - FROM REMOTE CUBICLE | | | | | | | | | | | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY

FIGURE 503.3-1 Portion of a typical test record for remote operation and monitoring test.

# METHOD 504.2b

## TORSIOGRAPHING TEST

504.2.1 General. Torsional vibration means the repeated twisting of a shaft, back and forth, about its axis.

If the shaft of an engine is twisted and then released, it will vibrate back and forth at a number of vibrations per second (natural frequency) which will be determined by the stiffness of the shaft and the type of weights attached to various parts of the shaft. If the shaft is left alone, these vibrations will gradually die out, but if a vibrating force is applied which rises and falls at a time rate close to the natural frequency, torsional vibration will build up and may eventually destroy the shaft. Therefore, since the turning effort of an engine varies during each revolution, it is possible to run the engine at a speed at which the frequency of the turning effort variations coincides with the natural frequency of the shaft system, thus causing torsional vibrations to build up.

Torsional vibration is different from other forms of vibration in that there may be no visible or audible indications that dangerous vibrations are present. Furthermore, an engine-generator set with dangerous torsional vibrations may not show any defects during inspection, yet shaft failure may occur after many hours of operation. It is necessary to use special instrumentation and compare the instrument readings with certain calculated values in order to make sure the engine-generator set is not subjected to injurious torsional vibrations. The instrumentation used shall not require attachment of masses of such a magnitude to the shaft that they appreciably affect the characteristics of the system.

The instrumentation used in torsional vibration studies is designed to measure changes in speed, not speed itself, and the frequency of these changes in speed. This can be done either mechanically or electrically.

504.2.2 Apparatus. Use load instrumentation as described and illustrated in the 100 series methods as applicable. In addition, use a suitable torsiograph instrument.

504.2.3 Procedure.

504.2.3.1. Preparation for test.

a. Obtain the contractor's mathematical analyses, indicating probable compliance with the limits of the equipment specification. The mathematical analyses shall include:

    1. A description of the system relating information pertinent to analyses such as operating speed range and identification plate data.

2. A mass-elastic assembly drawing, showing the arrangement of the units in the generator set and dimensions of shafting, including minimum diameters (or section moduli) of all shafting in the system.

3. A labeled line diagram of the mass elastic system indicating values of masses, stiffness, equivalent lengths, and equivalent diameters including basic assumptions where applicable. See FIGURE 504.2-1.

4. Sample calculations showing procedure used to obtain relative stress.

5. Holzer tables for the natural frequencies of all significant modes of vibration. Table shall include calculation of equivalent stresses in each shaft length for a one degree deflection (twist) at mass no. 1.

b. Connect the load and instrumentation in accordance with the applicable figure of 205.1.10.

c. Install the torsiograph instrument on one end of the shaft of the generator set per the instrument manufacturer's instructions.

504.2.3.2. Test.

a. Start and operate the set at rated voltage, rated frequency (speed) and rated load. Record all instrument readings including the torsiograph output.

b. Reduce the load to zero and record all instrument readings.

c. Repeat steps a and b above for the maximum and minimum frequencies specified in the procurement document.

d. Repeat steps a and c above for any other load condition specified in the procurement document.

e. Repeat steps a through d above for any other rated frequency specified in the procurement document.

504.2.4 Results.

a. Recalculate the Holzer table(s) supplied by the contractor to insure that no mathematical errors exist (see FIGURE 504.2-2).

b. Reduce the data taken from the torsiograph instrumentation per the manufacturer's instructions to determine both the frequency of vibration and the amount of twist in degrees for each condition specified in the procurement document.

c. Using the frequency of the torsional vibration found in step b above determine the applicable Holzer table to use, e.g., use the first mode Holzer table for any vibrational frequency below the first mode natural frequency; use the second mode Holzer table for any vibrational frequency above the first mode natural frequency but below the second mode natural frequency, etc.

d. From the applicable Holzer table determine the maximum shaft stress for a one degree deflection at mass no. 1. This will be the largest number in the summation column.

e. To determine the actual shaft stress multiply the maximum shaft stress by the actual deflection at mass no. 1 as found in step b above.

f. Repeat steps c through e above for each load and frequency condition specified in the procurement document.

g. Tabulate the data and results into a table. See FIGURE 504.2-3.

h. Have this data analyzed by a competent impartial agency.

504.2.5 Procurement document requirements. The following details must be specified in the individual procurement document.

a. Rated frequency(ies) at which this Method shall be performed.

b. Maximum and minimum frequencies between which specified torsional stresses shall not be exceeded, in percent of rated frequency.

c. Load conditions at which this test shall be performed if other than rated load and no load.

d. Maximum allowable torsional stress in the shaft in pounds per square inch.

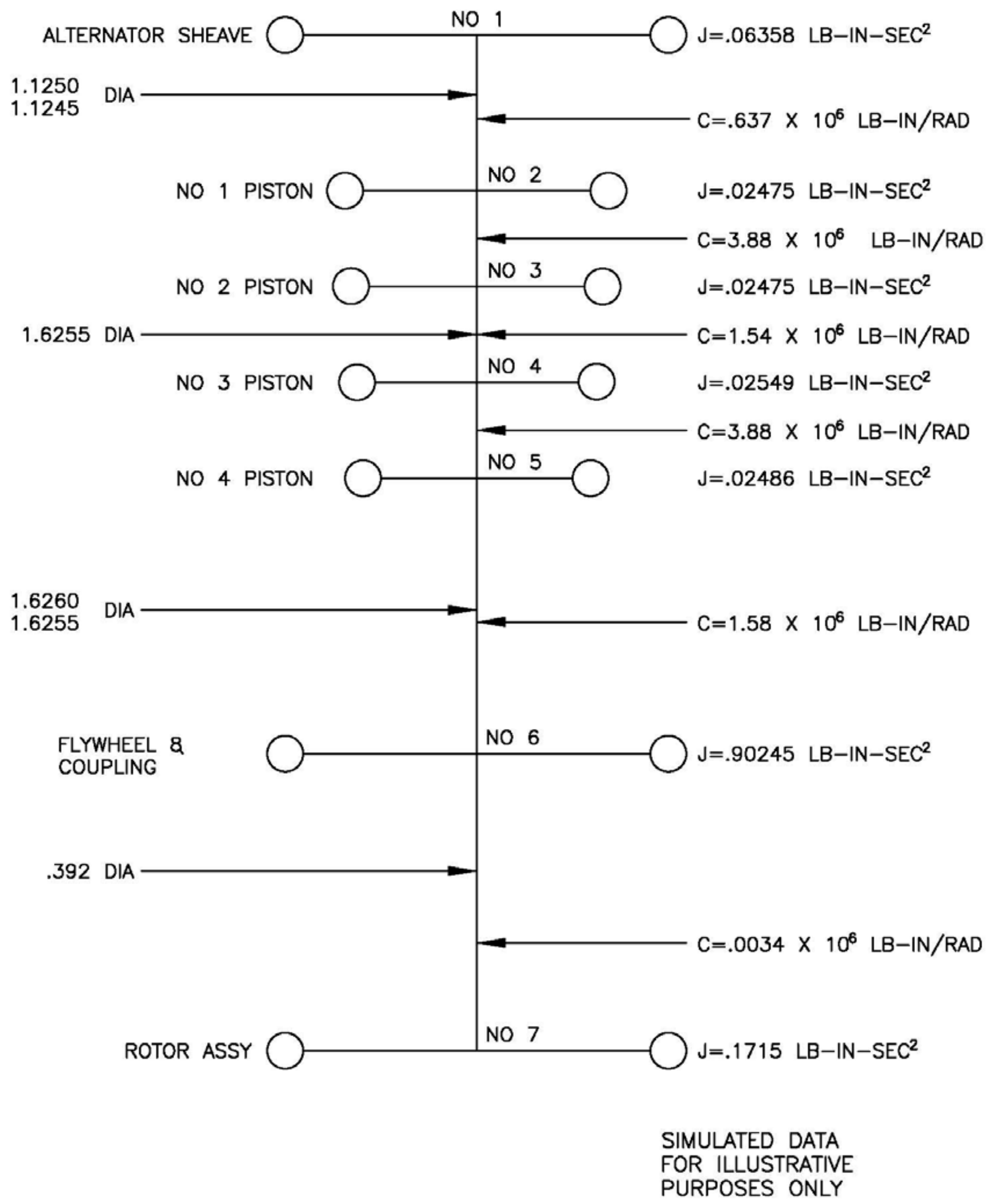


FIGURE 504.2-1 Typical mass-elastic system.

$w^2 = 4.147567463 \times 10^6$
$w = 2.036557749 \times 10^3$
$f = 324.1285066$ Hz

| STATION | J | $Jw^2/10^6$ | β | $Jw^2\beta/10^6$ | $\sum Jw^2\beta/10^6$ | $C/10^6$ | $\sum Jw^2\beta/C$ |
|---|---|---|---|---|---|---|---|
| 1 | 0.06358 | 0.2637023393 | 1.0000000000 | 0.2637023393 | 0.2637023393 | 0.637 | 0.4139754149 |
| 2 | 0.02476 | 0.1026937704 | 0.5860245851 | 0.0601810742 | 0.3238834135 | 3.88 | 0.834751066 |
| 3 | 0.02549 | 0.1057214946 | 0.5025494785 | 0.0531302820 | 0.3770136955 | 1.54 | 0.2448140880 |
| 4 | 0.02549 | 0.10575214946 | 0.2577353905 | 0.0282481707 | 0.4042618662 | 3.88 | 0.1041912026 |
| 5 | 0.02486 | 1.1031085271 | 0.1535441879 | 0.0158317151 | 0.4200935813 | 1.58 | 0.2658820135 |
| 6 | 0.90245 | 3.742972257 | -0.1123378256 | -0.4204773646 | -0.0003837833 | 0.0034 | -0.1128774412 |
| 7 | 0.17150 | 0.7113078199 | +0.0003838328 | +0.0003838328 | +0.0000000495 | -- | -- |

= 1.0000000000 at Sta. 1

β = (Sta . 1β - Sta. 1 $\sum Jw^2\beta/c$) at Sta. 2 etc.

SIMULATED DATA FOR
ILLUSTRATIVE
PURPOSES ONLY

FIGURE 504.2-2 Typical Holzer Table.

RESULTS

| ENGINE SPEED RPM | LOAD % | VIBRATION PERIOD ms X 1/3 | VIBRATION FREQUENCY Hz (CAL) | VIBRATION w RAD/SEC (CAL) | VIBRATION LEVEL V(P-P) | ANGULAR DISPLACEMENT DEGREE (CAL) | TORSIONAL STRESS PSI (CAL) |
|---|---|---|---|---|---|---|---|
| 3200 | 0 | 10.2 | 294 | 1848 | 1.2 | 0.0361 | 595 |
| 3200 | 100 | 10.2 | 294 | 1848 | 1.7 | 0.0512 | 843 |
| 3300 | 0 | 10.2 | 294 | 1848 | 0.84 | 0.0254 | 419 |
| 3300 | 100 | 9.9 | 303 | 1903 | 1.7 | 0.0496 | 818 |
| 3400 | 0 | 10.8 | 278 | 1745 | 1.0 | 0.0318 | 524 |
| 3400 | 100 | 10.2 | 294 | 1848 | 1.9 | 0.0572 | 943 |
| 3500 | 0 | 10.2 | 294 | 1848 | 1.8 | 0.0541 | 892 |
| 3500 | 100 | 9.9 | 303 | 1903 | 2.6 | 0.0758 | 1249 |
| 3600 | 0 | 9.6 | 311 | 1952 | 1.7 | 0.0483 | 796 |
| 3600 | 100 | 9.5 | 316 | 1985 | 2.2 | 0.0616 | 1015 |
| 3700 | 0 | 9.9 | 303 | 1903 | 1.3 | 0.0380 | 626 |
| 3700 | 100 | 9.9 | 303 | 1903 | 1.9 | 0.0554 | 913 |
| 3800 | 0 | 10.4 | 288 | 1808 | 1.4 | 0.0431 | 710 |
| 3800 | 100 | 9.9 | 303 | 1903 | 1.9 | 0.0554 | 913 |
| 3900 | 0 | 11.1 | 270 | 1695 | 1.5 | 0.0492 | 811 |
| 3900 | 100 | 9.9 | 303 | 1903 | 2.6 | 0.0758 | 1249 |
| 4000 | 0 | 9.9 | 303 | 1903 | 1.6 | 0.0467 | 770 |
| 4000 | 100 | 11.2 | 268 | 1682 | 2.3 | 0.0758 | 1249 |

SIMULATED DATA
FOR ILLUSTRATIVE
DATA ONLY

FIGURE 504.2-3 Typical results tabulation.

METHOD 505.1c

OVERSPEED TEST (POWER SYSTEM)

505.1.1 General. Since possible surging speeds during operation may injure personnel or destroy the equipment, there must be assurance that rotating parts are in balance.

505.1.2 Apparatus. Use a frequency meter or tachometer, as described and illustrated in METHOD 104.1 or METHOD 109.1. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

505.1.3 Procedure.

505.1.3.1. Preparation for test.

a. Connect the frequency meter or tachometer as described and illustrated in 205.1.9, or utilize the tachometer in accordance with the manufacturer's instructions.

b. Disconnect, or otherwise render inoperative, any overspeed protection devices, if necessary.

505.1.3.2. Test.

a. Start and operate the power system at rated voltage, rated frequency (speed) and at no load.

b. By operating the throttle lever, or by any other satisfactory means, bring the speed up slowly from rated speed to the overspeed specified in the procurement document.

c. With the generator operating without load, adjust the terminal voltage, if possible, to approximately rated value. The voltmeter on the power system control panel is adequate to indicate the voltage for this Method.

d. Maintain the overspeed for the specified time duration and record the time of overspeed operation per METHOD 203.1 (see FIGURE 505.1-1).

e. Record any evidence of abnormal noise, destruction, damage or noticeable change in any part. Disassemble and inspect as necessary to determine the cause of any abnormal noise, destruction, damage or noticeable change in any part. Record findings.

f. After completion of this test, reconnect any overspeed protection devices, if necessary.

505.1.4 Results. Any evidence of abnormal noise, destruction, damage or noticeable change in any part shall constitute failure of this Method. Faliure of the power system to operate for the required time at overspeed (see 505.1.5) shall also constitute failure of this Method.

505.1.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. The overspeed at which this Method is to be performed.

b. The time duration that the power system is required to operate at the overspeed condition.

**DESCRIPTION:** 15KW, 60 HZ
120/208V 3-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-15.0-MD

**SERIAL NO.** 16037

**REF.** MIL-STD-705/505.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

OVERSPEED TEST
(POWER SYSTEM)

**TEST NO.** 36

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | SET | | | 3686 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | OUTPUT VOLTAGE | | | SPEED | | | | | | | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | RPM | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 0923 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| | 0923 | 120 | 120 | 119 | 1800 | | | | | | | | | | | | |
| | 0924 | 120 | 120 | 119 | 2350 | | | | | | | | | | | | |
| | 0930 | | | | | POWER SYSTEM VIBRATED EXCESSIVELY | | | | | | | | | | | |
| | 0939 | 120 | 120 | 119 | 2350 | | | | | | | | | | | | |
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SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSES ONLY

**NOTES** REMOVAL OF THE GENERATOR ASSEMBLY REVEALED ROTOR BALANCE WEIGHT THROWN OFF.

FIGURE 505.1-1 Typical test record for overspeed test.

METHOD 505.2c

OVERSPEED PROTECTIVE DEVICE TEST

505.2.1 General. To assure that adequate protection is afforded the power system against overspeeding, the overspeed protective device must operate properly.

505.2.2 Apparatus. Use a frequency meter or tachometer as described and illustrated in METHOD 104.1 or METHOD 109.1. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

505.2.3 Procedure.

505.2.3.1 Preparation for test. Connect the frequency meter in accordance with 205.1.9, or utilize the tachometer in accordance with the manufacturer's instructions. If the power system is provided with an electronic governor or throttle stops, deactivate these devices if necessary.

505.2.3.2 Test.

a. Start and operate the power system at rated speed (frequency), rated voltage and no load.

b. Slowly increase the engine speed until the overspeed protective device actuates. Record the speed of the power system at this point, and the malfunction indicator light indication per METHOD 203.1, if applicable (see FIGURE 505.2-1).

**CAUTION: Do not operate the power system in excess of 125 percent of rated speed or as otherwise limited in the procurement document.**

c. If the power system is equipped with a manual reset provision for the overspeed protective device, attempt to start the power system. Record if starting is achieved. If the power system did not start, reset the overspeed protective device.

d. Repeat steps a through c above two additional times.

505.2.4 Results. Compare the speed at which the overspeed protective device actuated with the limits specified in the procurement document.

505.2.5 Procurement document requirements. The following details must be specified in the individual procurement document:

a. Speed conditions at which the overspeed protective device shall actuate.

b. Overspeed malfunction indicator requirements, if applicable.

c. Manual reset requirements, if applicable.

**DESCRIPTION:** 15KW, 60 HZ
120/208V 3-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-15.0-MD

**SERIAL NO.** 1716

**REF.** MIL-STD-705/505.2

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

OVERSPEED PROTECTIVE DEVICE TEST

**TEST NO.** 24

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER**: L. SEE

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **INST→** | | | | 316 | | | | | | | | | | | | | |
| **READ NO↓** | TIME | | | FREQUENCY | | | | | | | | | | | | | |
| **UNITS** | | | | | Hz | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 1410 | STARTED POWER SYSTEM | | | 60.0 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1415 | | | | 67.2 | OVERSPEED PROTECTIVE DEVICE ACTUATED | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1420 | ATTEMPTED TO RESTART POWER SYSTEM – IT WOULD NOT CRANK – RESET OVERSPEED SWITCH | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1425 | STARTED POWER SYSTEM | | | 60.0 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1428 | | | | 67.0 | OVERSPEED PROTECTIVE DEVICE ACTUATED | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1430 | ATTEMPTED TO RESTART POWER SYSTEM – IT WOULD NOT CRANK – RESET OVERSPEED SWITCH | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1435 | STARTED POWER SYSTEM | | | 60.0 | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY | | | |
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| | 1440 | | | | 67.1 | OVERSPEED PROTECTIVE DEVICE ACTUATED | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1442 | ATTEMPTED TO RESTART POWER SYSTEM – IT WOULD NOT CRANK – RESET OVERSPEED SWITCH | | | | | | | | | | | | | | | |
| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 505.2-1 Typical test record for overspeed protective device test.

# METHOD 505.3d

## OVERSPEED TEST
## (GENERATOR ONLY)

505.3.1 General. Unbalanced rotating assemblies during possible surging speeds may injure personnel, or damage or destroy the equipment; there must be assurance that rotating parts are properly balanced.

505.3.2 Apparatus. Use a voltmeter and frequency meter or tachometer as described and illustrated in METHOD 101.1 and METHOD 104.1 or METHOD 109.1. Use a variable speed prime mover capable of driving the generator at the specified overspeed at no load, and an external DC source for excitation. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

505.3.3 Procedure.

505.3.3.1 Preparation for test.

a. Mechanically connect the generator to the prime mover and connect the external excitation supply to the generator.

b. Connect the voltmeter to any suitable terminals of the generator as described and illustrated in 205.1.4.

c. Connect the frequency meter as described and illustrated in 205.1.9, or utilize the tachometer in accordance with the manufacturer's instructions.

505.3.3.2 Test.

a. Start and operate the prime mover so that the generator is operating at rated frequency (speed), and adjust the external excitation supply to produce rated voltage.

b. By operating the prime mover controls, increase the speed of the generator slowly from rated to the specified overspeed.

c. With the generator operating without load, adjust the coil voltage to approximately rated voltage, if necessary.

d. Maintain the overspeed condition for 15 minutes or for the time interval specified in the procurement document. Record any evidence of abnormal noise, destruction, damage or noticeable change in any part per METHOD 203.1 (see FIGURE 505.3-1).

e. Stop the prime mover and generator, and visually inspect the generator for evidence of destruction, damage or noticeable change to any part. Record findings.

505.3.4 Results. Any evidence of abnormal noise, destruction, damage or noticeable change in any part shall constitute failure of this Method. Failure of the generator to operate for the required time (see 505.3.5) shall also constitute failure of this Method.

505.3.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The speed at which this Method shall be performed.

b. The time duration that the generator is required to operate at the overspeed condition, if other than 15 minutes.

| | | |
|---|---|---|
| **DESCRIPTION:** 15KW, 60 HZ<br>120V SINGLE PHASE<br>GENERATOR ONLY<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-15.0-MD<br><br>**SERIAL NO.** 16037-G<br><br>**REF.** MIL-STD-705/505.3 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>OVERSPEED TEST<br>(GENERATOR ONLY) | **TEST NO.** 3<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 107 | | 316 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | FREQUENCY | | | | | | | | | | | | | |
| **UNITS** | HRS | | VOLTS | | Hz | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 1015 | | 120.0 | | 60.0 | | | | | | | | | | | | |
| | 1017 | | 120.0 | | 75.0 | | | | | | | | | | | | |
| | 1032 | | 120.0 | | 75.0 | | | | | | | | | | | | |
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| **NOTES** | NO NOTICEABLE INCREASE IN VIBRATION LEVELS DURING TEST | | | | | | | | | | | | | | | | |
| | NO EVIDENCE OF DAMAGE AFTER TEST | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 505.3-1 Typical test record for overspeed test (generator only).

# METHOD 506.1b

## UNDERSPEED PROTECTIVE DEVICE TEST

**NOTE**: Method 506.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

506.1.1 General. The underspeed protective device protects both the generator and the load against a speed (frequency) that is below acceptable limits. Operating a generator set at a speed that is below design limits can cause excessive field currents, inability to carry rated load, and damage to frequency sensitive loads such as motors, motor operated equipment, and transformers.

506.1.2 Apparatus. Load instrumentation shall be as described and illustrated in MIL-HDBK-705.

506.1.3 Procedure.

506.1.3.1 Preparation for test. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for one voltage connection and frequency specified in the procurement document.

506.1.3.2 Test.

a. Start and operate the set at rated voltage and rated speed at no load.

b. Close the circuit interrupter.

c. Slowly decrease the speed from rated, recording the speed at which the underspeed protective device causes the circuit interrupter to open. (see FIGURE 506.1-I). If the set is equipped with a low frequency (speed) malfunction indicator, record its indication.

d. Return the speed to rated and apply rated load.

e. Slowly decrease the speed from rated and record the speed at which the underspeed protective device causes the circuit interrupter to open. If the set is equipped with a low frequency (speed) malfunction indicator, record its indication.

f. Attempt to reclose the circuit interrupter with the set at this underspeed condition and record if circuit interrupter actuation was possible.

g. If the generator set is equipped with an electrical type underspeed protective device repeat steps a through f above with the set operating at the maximum and minimum specified voltage operating range limits.

h. Repeat steps a through g above for any other rated speed specified in the procurement document.

506.1.4 Results. The underspeed protective device actuation shall be compared with the requirements specified in the procurement document.

506.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection(s) at which this method shall be performed.

b. The speed at which the underspeed protective device shall actuate for each frequency condition.

c. The frequency(ies) at which this method shall be performed.

d. The voltage operating limits, if applicable.

e. Circuit interrupter non-closure requirements at underspeed conditions.

f. Malfunction indicator requirements, if applicable.

**DESCRIPTION:** 15KW, 60HZ
120V, SINGLE-PHASE
GENERATOR SET

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-15.0-MD

**SERIAL NO.** 11718

**REF.** MIL-STD-705/506.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

UNDERSPEED PROTECTIVE DEVICE TEST

**TEST NO.** 61

**SHEET:** 1 OF 1

**DATE:** JAN 15, 1971

**RECORDER:** L WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 377 | 153 | | 217 | | 706 | 208 | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLT. | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | - | HZ | | | | | | | | | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0912 | STARTED SET | | | | | | | | | | | | | | | |
| | 0912 | 120.0 | 0 | 0 | 0 | 0 | - | 60.0 | CIRCUIT INTERRUPTER CLOSED | | | | | | | | 73 |
| | 0913 | | | | | | | 56.3 | UNDERSPEED PROTECTIVE DEVICE ACTUATED | | | | | | | | |
| | | | | | | | | | LOW FREQ LIGHT ON | | | | | | | | |
| | 0914 | | | | | | | 60.0 | RETURNED SPEED TO RATED AND CLOSED | | | | | | | | |
| | | | | | | | | | CIRCUIT INTERRUPTER. | | | | | | | | |
| | 0916 | APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0917 | 120.0 | 3.9 | 156 | .375 | 15.0 | 0.80 | 60.0 | | | | | | | | | |
| | 0918 | | | | | | | 56.4 | UNDERSPEED PROTECTIVE DEVICE ACTUATED | | | | | | | | 74 |
| | | | | | | | | | LOW FREQ LIGHT ON | | | | | | | | |
| | 0920 | | | | | | | 56.4 | COULD NOT RECLOSE CIRCUIT INTERRUPTER | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C. T. NO. 1038 | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

FIGURE 506.1-I Typical test record for underspeed protective device test.

# METHOD 507.1e

## PHASE SEQUENCE TEST (ROTATION)

507.1.1 General. Unless the phase sequence (rotation) of the load terminals of a three-phase power system is correct, serious damage or injury could be done to connected equipment and to personnel as a result of reversed motor rotation or excessive current surges.

507.1.2 Apparatus. Use a phase sequence (rotation) indicator as described and illustrated in METHOD 116.1 or a three-phase motor whose direction of operation in relation to phase sequence is known shall be required. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

507.1.3 Procedure.

a. Connect the power system load terminals to the applicable test apparatus for one of the power system three-phase voltage connections. Recheck the connections to insure that $L_1$, $L_2$, and $L_3$ of the power system are connected to $L_1$, $L_2$, and $L_3$ of the test apparatus, respectively.

b. Start and operate the power system at rated voltage and frequency. The power system indicating instruments shall be sufficient indication of output voltage and frequency.

c. Close the circuit interrupter and determine the direction of phase sequence (rotation) by observing the indicator, or by noting the direction of rotation if a three-phase motor is used. Record results per METHOD 203.1 (see FIGURE 507.1-1).

d. Check the phase sequence (rotation) of the power output of each power receptacle on the power system by connecting the applicable test apparatus to that receptacle and repeating steps a through c above.

e. Repeat steps a through d above for all other three-phase voltage output connections of the power system.

507.1.4 Results. Compare the phase sequence (rotation) as indicated by the test against the power system wiring diagram and the requirements of the procurement document.

507.1.5 Procurement document requirements. The following detail must be specified in the procurement document:

a. Phase sequence (rotation).

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60 HZ<br>120/208V CR 120V<br>3-PHASE, POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/507.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>PHASE SEQUENCE TEST<br>(ROTATION) | **TEST NO.** 62<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | PHASE INDICATOR #1376 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | | | | | | | | | | | | | | | | |
| **UNITS** | | | | | | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | | | | | | | | | | | | | | | | | |
| | 1015 | 120/208V WYE PHASE SEQUENCE $L_1$-$L_2$-$L_3$ | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1045 | 120V DELTA PHASE SEQUENCE $L_1$-$L_2$-$L_3$ | | | | | | | | | | | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |
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FIGURE 507.1-1 Typical test record for phase sequence test.

# METHOD 508.1e

## PHASE BALANCE TEST (VOLTAGE)

508.1.1 General. Polyphase electrical equipment may not operate properly or may be damaged if the phase voltages of a polyphase generator differ greatly from each other. Also, large differences between the phase voltages of a polyphase generator may be an indication that the power system has been improperly manufactured or damaged.

508.1.2 Apparatus. Use a frequency meter (or tachometer) as described and illustrated in METHOD 104.1 (or METHOD 109.1) and a RMS indicating AC voltmeter having an accuracy in accordance with 4.2. If load is required in Procedure I, 508.1.3.1, use instrumentation for measuring load conditions as described and illustrated in METHOD 205.1. Use a means of separately exciting the generator if Procedure II, 508.1.3.2, is performed. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

508.1.3 Procedure.

508.1.3.1 Procedure I (Generator with exciter and voltage regulator).

508.1.3.1.1 Preparation for test.

a. Connect the power system for one of the voltage connections and frequencies specified in the procurement document.

b. Connect the frequency meter to the power system output.

508.1.3.1.2 Test.

a. Start and operate the power system at no load.

b. Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

c. Record the power system frequency, all line-to-neutral voltages, and all line-to-line voltages per METHOD 203.1 (see FIGURE 508.1-1).

d. Repeat steps a through c above at each of the other voltage connections and frequencies specified in the procurement document.

e. If additional load conditions, other than no load, are specified in the procurement document, repeat steps a through d above for all specified load conditions maintaining balanced loads.

508.1.3.2 Procedure II (Generator with separate excitation).

508.1.3.2.1 Preparation for test.

a. Completely isolate the generator windings (armature coils and field winding).

b. Connect the frequency meter to one of the armature coils of the generator.

c. Provide separate excitation for the generator. For generators with static exciters, excite the generator field; for brushless generators, energize the exciter field.

508.1.3.2.2 Test.

a. Start and operate the generator at one of its rated frequencies (speeds) and at no load.

b. Adjust the excitation so that any one of the coil voltages is at rated value.

c. Record the generator frequency (speed) and the voltage of each armature coil per METHOD 203.1 (see FIGURE 508.1-1).

d. Repeat steps a through c above for any other specified frequency.

508.1.4 Results.

508.1.4.1 Procedure I (Generator with exciter and voltage regulator).

a. From the data obtained in 508.1.3.1.2, determine the maximum and minimum line-to-neutral voltages for one voltage, frequency and load condition.

b. Determine the line-to-neutral voltage unbalance, in percent, as the difference between the maximum voltage ($V_{max}$) and minimum voltage ($V_{min}$) determined in step a above divided by the rated line-to-neutral voltage ($V_{rated}$) (at the voltage connection used) and multiplied by 100.

$$Voltage\ Unbalance\ (L\text{-}N), in\ percent\ = \frac{V_{max} - V_{min}}{V_{rated}} * 100$$

c. Repeat steps a and b above substituting line-to-line voltages for line-to-neutral voltages.

d. Repeat steps a through c above for each voltage connection, frequency and load condition.

e. Compare the results of steps b through d above with the requirements of the procurement document.

508.1.4.2 Procedure II (Generator with separate excitation).

a. Determine from the data obtained in 508.1.3.2.2, the maximum and minimum armature coil voltages.

b. Determine the voltage unbalance as the difference between the maximum armature coil voltage ($V_{max}$) and minimum armature coil voltage ($V_{min}$). To express this in percent, divide this difference by rated armature coil voltage ($V_{rated}$) and multiply by 100.

$$Voltage\ Unbalance\ (Coil), in\ percent\ = \frac{V_{max} - V_{min}}{V_{rated}} * 100$$

c. Repeat steps a and b above for any other specified frequency.

d. Compare the results of steps b and c above with the requirements of the procurement document.

508.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Requirement as to whether the procedure of 508.1.3.1 or 508.1.3.2 or both shall be performed.

508.1.5.1 Procedure I.

a. Maximum allowable line-to-neutral voltage unbalance, in percent of rated line-to-neutral voltage.

b. Maximum allowable individual line-to-line voltage unbalance, in percent of rated line-to-line voltage, if required.

c. Load conditions if other than no load at which this Method is to be performed.

d. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

508.1.5.2 Procedure II.

a. Maximum allowable individual armature coil voltage unbalance in percent of rated armature coil voltage or maximum allowable voltage difference between armature coils.

b. Frequency(ies) at which this Method is to be performed.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60 Hz<br>120/208V - 3 PHASE WYE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 4097<br><br>**REF.** MIL-STD-705/508.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>PHASE BALANCE TEST<br>(VOLTAGE) | **TEST NO.** 7<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 1306 | | | 1307 | | | | 312 | | | | | | | | 916 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | | | TERM VOLTAGE | | | | FREQUENCY | | VOLTAGE UNBAL. L-N | VOLTAGE UNBAL. L-L | | | | | AVG AMB TEMP |
| | | $L_1$-N | $L_2$-N | $L_3$-N | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | | | | | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | | | Hz | % | % | | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 0815 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| | 0820 | 120.0 | 120.1 | 119.9 | 207.8 | 208.0 | 208.1 | | | 60.0 | 0.17 | 0.14 | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 0830 | 120.0 | 120.1 | 119.9 | 207.8 | 208.0 | 208.1 | | | 60.0 | 0.17 | 0.14 | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 0835 | 120.0 | 120.1 | 119.9 | 207.8 | 208.0 | 208.1 | | | 60.0 | 0.17 | 0.14 | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY

FIGURE 508.1-1 Typical test record for phase balance (voltage) test (procedure 1).

# METHOD 509.1b

## CIRCULATING CURRENT TEST

**NOTE**: Method 509.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

509.1.1 General. Excessive circulating current will shorten the useful life of the generator.

509.1.2 Apparatus. Instrumentation for measuring voltage, current, and frequency shall be as described and illustrated in MIL-HDBK-705.

509.1.3 Procedure.

509.1.3.1 Preparation for test.

a. Connect the voltage and frequency instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 to measure all line-to-line and line-to-neutral voltages.

b. Connect the necessary ammeters, for the applicable voltage and winding configuration, in accordance with FIGURE 509.1-I.

509.1.3.2 Test.

a. Start and operate the generator set at rated voltage, rated frequency, and at no load.

b. Record all instrument readings (see FIGURE 509.1-II).

509.1.4 Results. Compare the results with the procurement document requirements.

509.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Voltage connection(s) and frequency(ies) at which this method is to be performed.

b. Allowable circulating currents.

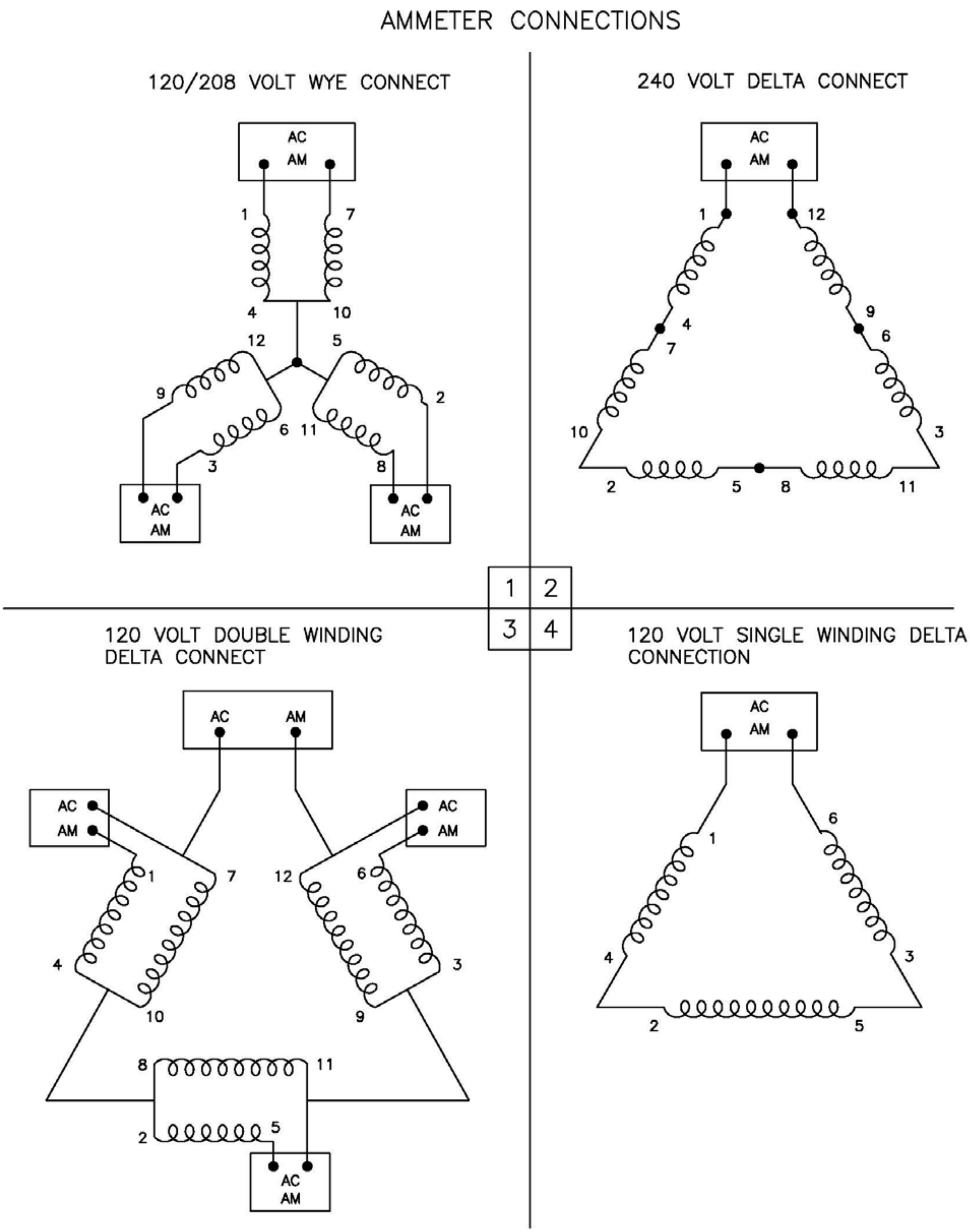


FIGURE 509.1-I Apparatus hookup for circulating current test.

**DESCRIPTION:** 3KW, 60HZ
120V, 3-PHASE-DELTA
GENERATOR SET

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-3.0-MD

**SERIAL NO.** 10779

**REF.** MIL-STD-705/509.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

CIRCULATING CURRENT TEST

**TEST NO.** 12

**SHEET:** 1 OF 1

**DATE:** APRIL 13, 1971

**RECORDER:** L WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** W. COX

| **INST→** | | 107 | | | 211 | | 487 | | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | CIRCULATING CURRENT | | FREQUENCY | | | | | | | | | | AVG AMB TEMP |
| | | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | | | | | | | | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | | AMPS | | HZ | | | | | | | | | °F |
| **SYM** | | | | | | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0910 | STARTED SET | | | | | | | | | | | | | | | |
| | 0915 | 120.0 | 119.8 | 120.2 | | 1.78 | | 60.0 | | | | | | | | | 77 |
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| **NOTES** | | | | | | | | | | | | | | | | | |

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FOR ILLUSTRATIVE
PURPOSE ONLY

FIGURE 509.1-II Typical test record for circulating current test.

# METHOD 510.1d

# RHEOSTAT RANGE TEST

**NOTE**: Method 510.1d was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

510.1.1 General. The manual field or manual control rheostat provided with the generator set must have adjustment capable of varying the excitation to compensate for the inherent voltage regulation of the generator. It must also be capable of providing an operating voltage other than rated voltage for special types of equipment and it must be capable of compensating for voltage drop on the distribution system.

510.1.2 Apparatus. Instrumentation for measuring load conditions and ambient temperature shall be as described and illustrated in MIL-HDBK-705. Electrical instrumentation used for this test shall have an accuracy of ±0.5 percent of reading or better.

510.1.3 Procedure.

510.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1 for one voltage connection and frequency specified in the procurement document.

b. Render the voltage regulator inoperative by positioning the "manual-automatic voltage regulation selector switch" at the "MANUAL" position.

510.1.3.2 Test.

510.1.3.2.1 No load.

a. Start and operate the generator set at rated speed.

b. Adjust the manual field rheostat such that the terminal voltage is at the minimum specified voltage at no load. Record all instrument readings.

c. Adjust the manual field rheostat such that the terminal voltage is at the maximum specified voltage at no load. Record all instrument readings.

510.1.3.2.2 Rated load.

a. With the generator set operating at no load adjust the manual field rheostat such that the terminal voltage is at the minimum specified voltage.

b. Increase the load, adjust the voltage, speed and load until the set is operating at rated load, rated speed and at the minimum specified voltage. Record all instrument readings (see FIGURE 510.1-I).

**NOTE**: At this point the set will be carrying greater than rated current.

c. Reduce the voltage to the minimum possible value using the manual field rheostat. Next, remove the load.

d. With the generator operating at no load, adjust the manual field rheostat such that the terminal voltage is at the maximum specified voltage.

e. Increase the load, adjust the voltage, speed and load until the set is operating at rated load, rated speed and at the maximum specified voltage. Record all instrument readings.

**NOTE**: At this point the set will be carrying less than rated current.

f. Reduce the voltage to the minimum possible value using the manual field rheostat. Next remove the load.

**CAUTION: The voltage must be reduced prior to removing the load to avoid possible high voltages that will damage the set and the apparatus.**

510.1.4 Results. Compare the recorded results with the procurement document requirements.

510.1.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. The voltage connection(s) and frequency(ies) at which this method is to be performed.

b. The maximum and minimum voltages for each voltage connection and frequency.

| | | |
|---|---|---|
| **DESCRIPTION:** 100KW, 60HZ<br>120/208V, 3-PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-100.0-MD<br><br>**SERIAL NO.** 116<br><br>**REF.** MIL-STD-705/510.1 | **PHILADELPHIA REGION<br>DEFENSE CONTRACT ADMINISTRATION<br>SERVICE**<br><br>RHEOSTAT RANGE TEST | **TEST NO.** 6<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** FEBRUARY 16, 1971<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 107 | | | | | | 218 | | | 456 | | | | 319 | 676 | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | TERMINIAL VOLTAGE | | | | | | LINE CURRENT | | | OUTPUT POWER | | | | POWER FACTOR | FREQ | AVG AMB TEMP |
| | | $L_1$-$L_0$ | $L_2$-$L_0$ | $L_3$-$L_0$ | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | $L_1$ | $L_2$ | $L_3$ | $L_1$ | $L_2$ | $L_3$ | TOTAL | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | KW | KW | KW | KW | - | HZ | °F |
| **SYM** | | | | | | | | X80 | X80 | X80 | X80 | X80 | X80 | X1 | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0810 | STARTED SET | | | | | | | | | | | | | | | |
| | 0812 | 114.0 | 114.0 | 114.0 | 198.0 | 198.0 | 198.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 77 |
| | 0815 | 126.0 | 126.0 | 126.0 | 218.0 | 218.0 | 218.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 77 |
| | 0830 | 114.0 | 114.0 | 114.0 | 198.0 | 198.0 | 198.0 | 4.66 | 4.66 | 4.66 | .416 | .416 | .416 | 100.0 | .80 | 60.0 | 78 |
| | 0850 | 124.0 | 124.0 | 124.0 | 215.0 | 215.0 | 215.0 | 4.19 | 4.19 | 4.19 | .416 | .416 | .416 | 100.0 | .80 | 60.0 | 78 |
| | | VOLTAGE ADJUST RHEOSTAT AT MIXIMUM | | | | | | | | | | | | | | | |
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| **NOTES** | LINE CURRENT MEASURED USING C. T. $L_1$-$N_0$ 1376; $L_2$-1377; $L_3$-1378 | | | | | | | | | | | | | | | | |
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FIGURE 510.1-I Typical test record for rheostat range test.

# METHOD 511.1d

## REGULATOR RANGE TEST

511.1.1 General. The power system voltage adjust device must have an adjustment range capable of varying the output voltage under various loads and temperature ranges without causing the voltage droop to exceed specified limits. The voltage adjust device also must provide an operating voltage other than rated voltage for special types of equipment and to compensate for external line losses.

**NOTE**: The Regulator Range Test is required by the Indicating Instrument Test (METHOD 513.1). If METHOD 513.1 is to be performed, a separate Regulator Range Test is not required.

511.1.2 Apparatus. Use instrumentation for measuring load conditions, ambient temperature, and the generator field (or exciter field) voltage and current as described and illustrated in the 100 series methods, as applicable. Electrical instrumentation used for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

511.1.3 Procedure.

511.1.3.1 Preparation for the test.

a. Connect the load and field instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

b. Bypass the circuit interrupter, if necessary, except on power systems equipped with overvoltage and undervoltage protection devices.

511.1.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 511.1-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 511.1.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 511.1.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. Do not make further adjustments to any power system control for the remainder of this test except the control panel voltage adjust device.

c. Record all instrument readings.

d. Remove load.

e. Record all instrument readings (after transients have subsided).

f. Adjust the voltage to the maximum specified value.

g. Record all instrument readings.

**CAUTION: At voltages above rated values, the power system will be supplying less than rated current; and at voltages below rated values, the power system will be supplying greater than rated current. Caution should be taken to avoid damage to instrumentation and load banks.**

h. Apply rated load (rated kW at rated power factor).

i. Record all instrument readings (after transients have subsided).

j. Remove load and adjust voltage to the maximum attainable value or to a value just prior to actuation of the overvoltage protection device. (Set the voltage adjust device to its maximum limit, e.g., to its mechanical stop, the end of its rotation, via soft keys or other means).

k. Record all instrument readings (after transients have subsided).

l. Apply rated load.

m. Record all instrument readings (after transients have subsided).

n. Adjust voltage to the minimum specified value at rated load.

o. Record all instrument readings (after transients have subsided).

p. Remove load.

q. Record all instrument readings (after transients have subsided).

r. Adjust voltage to the minimum attainable value or the value just prior to activation of the undervoltage protection device. (Set the voltage adjust device to its minimum limit, e.g., to its mechanical stop, the end of its rotation, via soft keys or other means).

s. Record all instrument readings (after transients have subsided).

t. Repeat steps a through s above for any other voltage connection(s) and frequency(ies) specified in the procurement document.

511.1.4 Results. Indicate the voltage regulation as a percent of rated voltage within the specified limits at the minimum and maximum specified voltages and the regulation as a percent of rated voltage at the extremes, the maximum and minimum voltages attainable and the actuation of the protection devices (if applicable) on the data sheets. Compare these results with the procurement document requirements.

511.1.4.1 Sample calculations. Voltage regulation (droop) expressed in percent, is defined for the purposes of this Method as the no-load value minus the rated load value divided by the rated load value.

$$Percent\ Regulation = \frac{V_{NL} - V_{RL}}{V_{RL}} * 100$$

Where:

$V_{NL}$ = No-load voltage.

$V_{RL}$ = Rated load voltage.

511.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum and minimum voltages between which the power system shall perform.

b. The maximum allowable regulation (droop).

c. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Load conditions at which this Method is to be performed, if other than those specified herein.

e. Minimum and maximum voltage adjustments, if applicable.

**DESCRIPTION:** 10KW, 60 HZ
120V SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 21067

**REF.** MIL-STD-705/511.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

REGULATOR RANGE TEXT

**TEST NO.** 9

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | | 377 | | 153 | | | 217 | | | 706 | | 809 | | | | 912 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | | TERM VOLTAGE | | LINE CURRENT | | | POWER OUTPUT | | | POWER FACTOR | | FREQ | VOLT REG | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | | AMPS | AMPS | | KW | KW | | - | | Hz | % | | | °F |
| **SYM** | | | | | X40 | X1 | | X40 | X1 | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | | | | | | | | | | | | | | | | | |
| 1 | 2013 | | 120.0 | | 2.60 | 104.0 | | 0.250 | 10.0 | | 0.80 | | 60.1 | | | | 76 |
| 2 | | | 121.6 | | 0 | 0 | | 0 | 0 | | - | | 61.2 | 1.33 | | | |
| 3 | | | 126.0 | | 0 | 0 | | 0 | 0 | | - | | 61.2 | | | | |
| 4 | | | 124.3 | | 2.51 | 120.4 | | 0.250 | 10.0 | | 0.80 | | 60.8 | 1.37 | | | |
| 5 | | | 137.8 | | 0 | 0 | | 0 | 0 | | - | | 62.0 | | | | |
| 6 | | | 135.2 | | 2.31 | 92.4 | | 0.250 | 10.0 | | 0.80 | | 60.8 | 1.92 | | | |
| 7 | | | 114.0 | | 2.74 | 109.6 | | 0.250 | 10.0 | | 0.80 | | 60.0 | | | | |
| 8 | | | 115.5 | | 0 | 0 | | 0 | 0 | | - | | 61.8 | 1.31 | | | |
| 9 | | | 107.1 | | 0 | 0 | | 0 | 0 | | - | | 61.8 | | | | 77 |
| | | | | | | | | | | | | | | | | | |

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PURPOSES ONLY

**NOTES** CT #1136

FIGURE 511.1-1 Portion of a typical test record for regulator range test.

# METHOD 511.2d

## FREQUENCY ADJUSTMENT RANGE TEST

511.2.1 General. If necessary the frequency of a power system shall be adjustable to provide rated frequency at various load conditions as required in certain applications and to synchronize two or more power systems for parallel operation.

511.2.2 Apparatus. Use instrumentation for measuring load conditions, field voltage and current, and ambient temperature as described and illustrated in the 100 series methods, as applicable. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

511.2.3 Procedure.

511.2.3.1 Preparation for test. Connect the load and field instrumentation in accordance with the applicable figure of 205.1.10.

511.2.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 511.2-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 511.2.5) after the last adjustment to load, voltage, and frequency has been made.

   1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

   2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 511.2.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. Do not make further adjustments to any power system control for the remainder of this test except for the control panel frequency adjust device.

c. For each of the conditions in the following steps, allow approximately 2 minutes between each adjustment and the subsequent instrument readings.

d. Adjust the power system frequency for the specified maximum frequency at rated load. (Set the frequency adjust device to its maximum limit, e.g., to its mechanical stop, the end of its rotation, via soft keys or other means.) Record all instrument readings.

e. Adjust the power system frequency for the specified minimum frequency at rated load. (Set the frequency adjust device to its minimum limit, e.g., to its mechanical stop, the end of its rotation, via soft keys or other means.) Record all instrument readings.

f. Reduce the load to zero.

g. Slowly adjust the power system frequency control for the maximum attainable frequency. (Set the frequency adjust device to its maximum limit, e.g., to its mechanical stop, the end of its rotation, via soft keys or other means.) Rcord all instrument readings. During this adjustment carefully observe the frequency meter and record the frequency at which the overspeed device alarms and actuates, if so equipped.

h. Slowly adjust the power system frequency control for the minimum attainable frequgency. (Set the frequency adjust device to its minimum limit, e.g., to its mechanical stop, the end of its rotation, via soft keys or other means.) Record all instrument readings. On power systems with protection devices, record all readings just prior to point of actuation if the underfrequency or underspeed protection device actuates. Record on the data sheet whether the protection device actuated.

i. Repeat 511.2.3.1 and 511.2.3.2 steps a through h for each frequency specified in the procurement document.

511.2.4 Results. Show the maximum and minimum frequencies attained at rated load, the maximum and minimum attainable frequencies at no load and actuation of the protection devices (if applicable) on the data sheet. Compare these results with the requirements of the procurement document.

511.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum frequency adjustment(s).

b. Minimum frequency adjustment(s).

c. Power system voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Load conditions at which this Method is to be performed if other than those specified herein.

e. Protective device actuation requirements.

**DESCRIPTION:** 10KW, 60 HZ
120V SINGLE PHASE
0.8 pf
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 4097

**REF.** MIL-STD-705/511.2

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

FREQUENCY ADJUSTMENT RANGE TEST

**TEST NO.** 10

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | | 377 | | 153 | | | 217 | | | 809 | | 700 | | | | 918 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | | TERM VOLT | | LINE CURRENT | | | POWER OUTPUT | | | FREQ | | POWER FACTOR | | | | AVG AMB TEMP |
| **UNITS** | | | VOLTS | | AMPS | AMPS | | KW | KW | | HZ | | - | | | | |
| **SYM** | | | | | X40 | X1 | | X40 | X1 | | | | | | | | °F |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 101 | 0900 | STARTED POWER SYSTEM APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| 102 | 0910 | | 120.0 | | 2.60 | 104.0 | | 0.250 | 10.00 | | 60.2 | | 0.80 | | | | 76 |
| 103 | 0920 | | 120.4 | | 2.62 | 105.0 | | 0.251 | 10.04 | | 60.3 | | 0.796 | | | | 77 |
| 104 | 0930 | | 120.4 | | 2.62 | 105.0 | | 0.251 | 10.04 | | 60.3 | | 0.796 | | | | 77 |
| 105 | ADJUSTED LOAD, VOLTAGE, AND FREQUENCY TO RATED | | | | | | | | | | | | | | | | |
| 106 | 0940 | | 120.0 | | 2.60 | 104.0 | | 0.250 | 10.0 | | 60.0 | | 0.80 | | | | 78 |
| 107 | 0950 | | 120.0 | | 2.60 | 104.0 | | 0.250 | 10.0 | | 60.0 | | 0.80 | | | | 78 |
| 108 | 1000 | | 120.0 | | 2.60 | 104.0 | | 0.250 | 10.0 | | 60.0 | | 0.80 | | | | 78 |
| 109 | 1010 | | 120.0 | | 2.60 | 104.0 | | 0.250 | 10.0 | | 60.0 | | 0.80 | | | | 77 |
| 110 | 1020 | | 120,0 | | 2.60 | 104.0 | | 0.250 | 10.0 | | 60.0 | | 0.80 | | | | 77 |
| | | | | | | | | | | | | | | | | | |
| 111 | 1025 | | 120.0 | | 2.60 | 104.0 | | 0.250 | 10.0 | | 60.0 | | 0.80 | | | | 77 |
| | | | | | | | | | | | | | | | | | |
| 112 | 1030 | | 120.0 | | 2.60 | 104.0 | | 0.250 | 10.0 | | 59.0 | | 0.80 | | | | 77 |
| | | | | | | | | | | | | | | | | | |
| | 1035 | DROPPED LOAD AND SHUTDOWN POWER SYSTEM | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSES ONLY

**NOTES**
NO MECHANICAL STOPS ON THIS UNIT

FIGURE 511.2-1 Typical test record for frequency adjustment range test.

METHOD 512.1e

CIRCUIT INTERRUPTER TEST
(SHORT CIRCUIT)

512.1.1 General. A circuit interrupter is connected between the power system voltage reconnection system and the power system output terminals to disconnect the generator output from the load and also to protect the generator from a short circuit. The circuit interrupter is operated from a current sensor either internal or external to the interrupter.

512.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. In addition, use a current transformer or non-inductive shunt, a short-circuiting switch, and a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter. Any digitized testing and evaluating system shall meet the requirements of 4.4.

512.1.3 Procedure.

512.1.3.1 Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

b. Connect the current transformer or shunt, data recorder, and short-circuiting switch as illustrated in FIGURE 512.1-1.

c. If applicable, ensure the bond between neutral (N) and ground (G) is connected.

512.1.3.2 Test.

**WARNING:**

**Ensure the power system is not operating when connecting the short-circuit switch. Failure to do so may cause personal injury or death.**

a. Connect the short-circuit switch to the applicable condition listed in 512.1.3.2g. Start and operate the power system at rated voltage, rated frequency and rated load. Record all instrument readings per METHOD 203.1 (see FIGURE 512.1-3).

b. Set the data recorder time marker to a minimum of 0.01 seconds or use a 60 Hertz timing trace.

1. For AC power systems, set the data recorder such that the individual peaks of the current waveform are clearly visible.

2. For DC power systems, set the data recorder such that the timing markers or timing trace is clearly visible.

c. Prior to closing the short-circuiting switch, record a portion of the steady state load current for calibration. With the same load conditions, record all instrument readings.

d. With the data recorder still recording the steady state current, close the short-circuiting switch.

**CAUTION: If the circuit interrupter fails to operate within the specified time, remove the short circuit to prevent damage. Note the failure to operate on the data sheet.**

e. If the power system contains a short-circuit malfunction indicator, check and record its indication.

f. If the power system control circuitry contains a specified time delay to prevent the circuit interrupter from operating on short duration faults, check the circuitry as follows:

1. Open the short-circuiting switch and reapply rated load.

2. Operate the data recorder as in 512.1.3b above.

3. Momentarily close and open the short-circuiting switch, being certain that the switch is not closed for a period of time equal to or greater than the specified time delay.

4. Record on the data sheet if the circuit interrupter operated and the indication of the malfunction indicator (if applicable).

g. Allow the power system to cool at rated load for a minimum of 15 minutes between short circuits. Turn off the power system and repeat steps a through f for the following applicable short-circuit switch conditions:

1. $L_1 - L_2$
2. $L_1 - L_3$
3. $L_2 - L_3$
4. $L_1 - N$
5. $L_2 - N$
6. $L_3 - N$
7. $L_1 - G$
8. $L_2 - G$

9. $L_3 – G$
10. $L_1 – L_2 – L_3$
11. $L_1 – L_2 – N$
12. $L_1 – L_3 – N$
13. $L_2 – L_3 – N$
14. $L_1 – L_2 – G$
15. $L_1 – L_3 – G$
16. $L_2 – L_3 – G$
17. $L_1 – L_2 – L_3 – N$
18. $L_1 – L_2 – L_3 – G$

**Note**: The test can be performed in any order of short-circuit switch conditions.

h. Repeat steps a through g above for each voltage connection and frequency specified in the procurement document.

512.1.4 Results.

a. From the data recorder readings taken in 512.1.3.2d, determine the time between the indicated closure of the short-circuiting switch and the opening of the circuit interrupter (see FIGURE 512.1-2).

b. The short-circuit current shall be measured over 1 cycle and refreshed every ½ cycle at the zero-crossing (see FIGURE 512.1-2).

c. For power systems having a time delay, use the data recorder readings taken in 512.1.3.2f and determine if the circuit interrupter actuated upon application of the momentary short circuit load.

d. Tabulate the above results and the malfunction indicator indication for each line connection at each voltage connection and frequency and compare the results with the procurement document requirements (see FIGURE 512.1-3).

512.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The time for the circuit interrupter to operate after the short-circuit load is applied.

b. The current value, in percent of rated current, at which the circuit interrupter shall operate, if necessary.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Short circuit conditions if other than as specified herein.

e. Short-circuit malfunction indicator requirements.

f. Circuit interrupter delay time, if applicable.

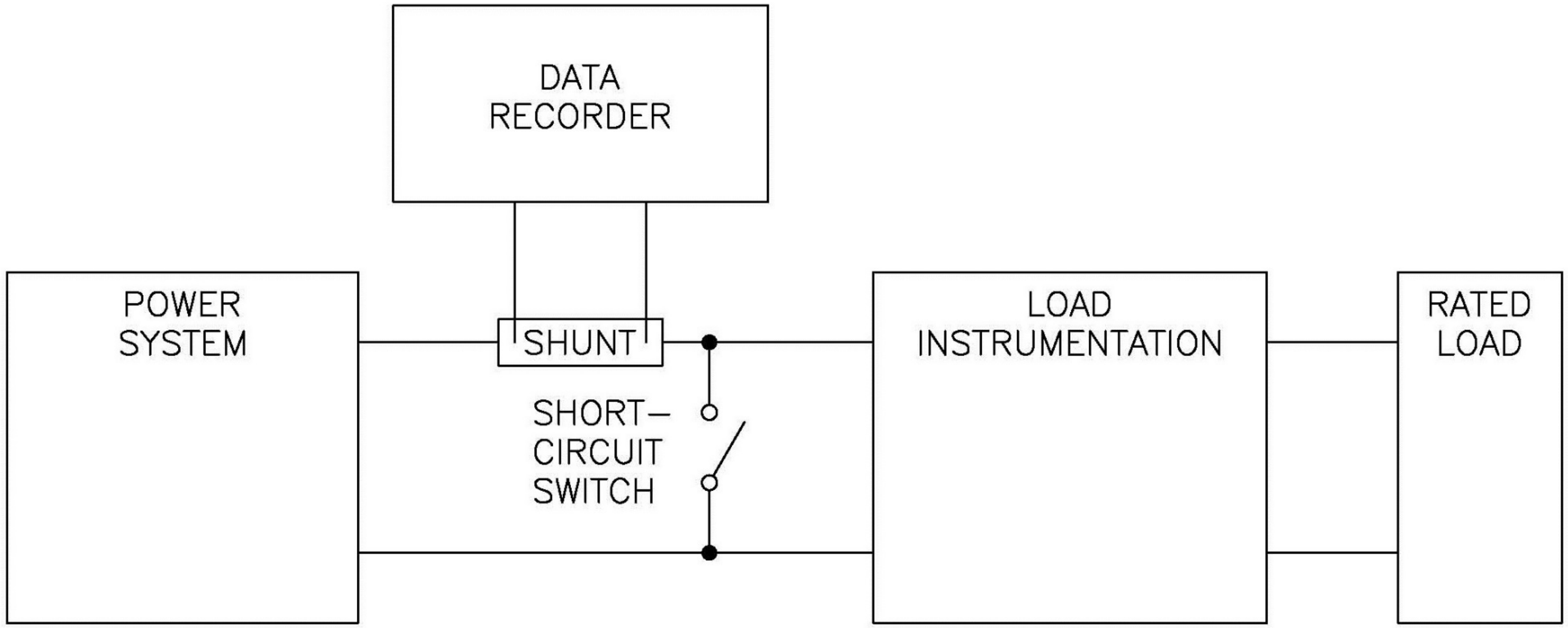
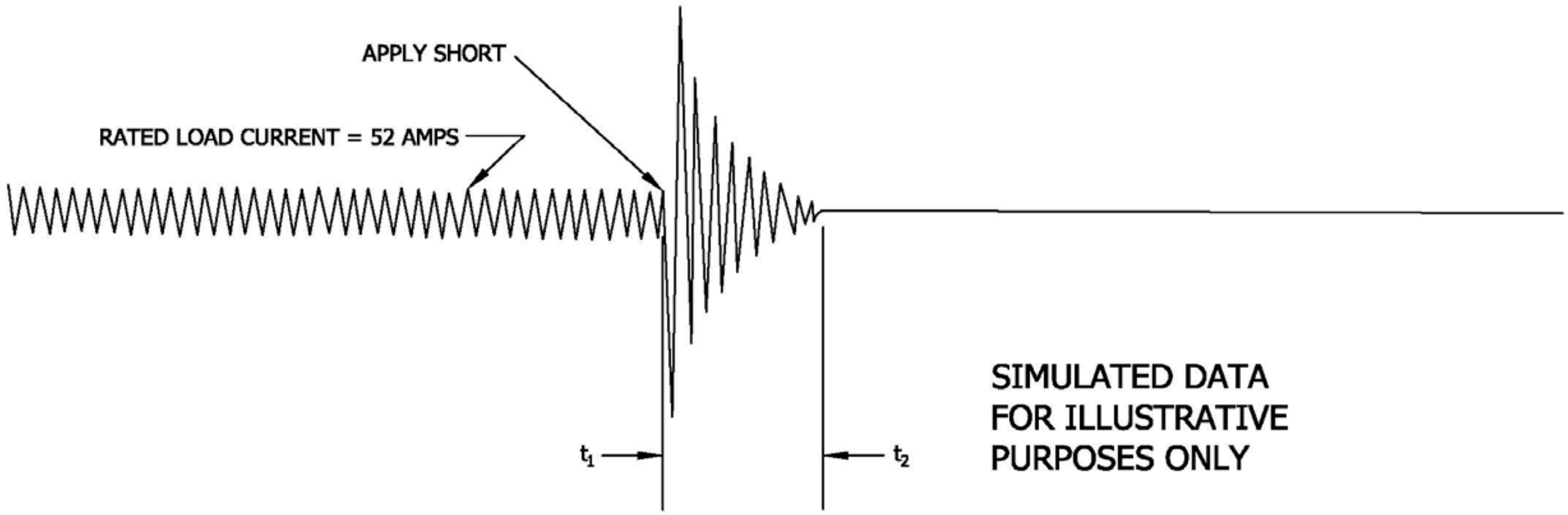



FIGURE 512.1-1 Apparatus connection for circuit interrupter (short-circuit) test.




CIRCUIT INTERRUPTER OPERATED IN $t_2$-$t_1$ MILLISECONDS

SHORT CIRCUIT LOAD CURRENT = MAX $\{I_{1/2\ rms}\}$

$t_1$=INITIAL POINT WHERE WAVEFORM DEVIATES FROM NORMAL OSCILLATION INDICATING SHORT.

$t_2$=POINT WHERE WAVEFORM DEVIATES FROM SHORT CIRCUIT OSCILLATION INDICATING CONTACTOR OPEN.

$I_{1/2\ rms}$=VALUE OF RMS CURRENT MEASURED OVER 1 CYCLE, AND REFRESHED EVERY 1/2 CYCLE.

FIGURE 512.1-2 Portion of an oscillogram showing interrupter operation and calculations.

| | | |
|---|---|---|
| **DESCRIPTION:** 5KW, 60 Hz<br>240V - SINGLE PHASE<br>120V - SINGLE PHASE<br>120V - DELTA<br>120/208V WYE POWER SYSTEM<br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-5.0-MD<br><br>**SERIAL NO.** 7514 30<br><br>**REF.** MIL-STD-705/512.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>CIRCUIT INTERRUPTER TEST<br>(SHORT CIRCUIT) | **TEST NO.** 37<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 2313 | | | 6710 | | | 6901 | | | 338 | 510 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | LINE CURRENT | | | OUTPUT POWER | | | POWER FACTOR | FREQ | SHORT CIRCUIT CONN | PEAK CURRENT | TRIP TIME | | AVG AMB TEMP |
| | | $L_1$-N | $L_2$-N | $L_3$-N | $L_1$ | $L_2$ | $L_3$ | $L_1$-N | $L_2$-N | $L_3$-N | | | | | | | |
| **UNITS** | HRS | VOLT | VOLT | VOLT | AMPS | AMPS | AMPS | KW | KW | KW | -- | HZ | | AMPS | SEC | | |
| **SYM** | | | | | X20 | X5 | X5 | X20 | X5 | X5 | | | | X1 | | | °F |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | | 120V SINGLE PHASE CONNECTION | | | | | | | | | | | | | | | |
| 1 | 1310 | 120.0 | | | 2.60 | | | 0.25 | | | .80 | 60.0 | $L_1$-$L_2$ | 310 | .076 | | 73 |
| | CHANGED TO 120/202V WYE CONNECTION | | | | | | | | | | | | | | | | |
| | | | | | X5 | | | X5 | | | | | | | | | |
| 2 | 1430 | 120.0 | 120.0 | 120.0 | 3.47 | 3.47 | 3.47 | 0.33 | 0.33 | 0.33 | .80 | 60.0 | $L_1$-N | 97 | .170 | | 74 |
| 3 | 1440 | 120.0 | 120.0 | 120.0 | 3.47 | 3.47 | 3.47 | 0.33 | 0.33 | 0.33 | .80 | 60.0 | $L_2$-N | 106 | .163 | | 73 |
| 4 | 1452 | 120.0 | 120.0 | 120.0 | 3.47 | 3.47 | 3.47 | 0.33 | 0.33 | 0.33 | .80 | 60.0 | $L_3$-N | 99 | .171 | | 73 |
| 5 | 1459 | 120.0 | 120.0 | 120.0 | 3.47 | 3.47 | 3.47 | 0.33 | 0.33 | 0.33 | .80 | 60.0 | $L_1$-$L_2$ | 175 | .131 | | 73 |
| 6 | 1510 | 120.0 | 120.0 | 120.0 | 3.47 | 3.47 | 3.47 | 0.33 | 0.33 | 0.33 | .80 | 60.0 | $L_2$-$L_3$ | 181 | .126 | | 73 |
| 7 | 1520 | 120.0 | 120.0 | 120.0 | 3.47 | 3.47 | 3.47 | 0.33 | 0.33 | 0.33 | .80 | 60.0 | $L_3$-$L_1$ | 178 | .127 | | 73 |
| 8 | 1535 | 120.0 | 120.0 | 120.0 | 3.47 | 3.47 | 3.47 | 0.33 | 0.33 | 0.33 | .80 | 60.0 | $L_1$-$L_2$-$L_3$ | 167 | .125 | | 74 |
| | CHANGED TO 240V SINGLE PHASE | | | | | | | | | | | | | | | | |
| | | | | | X10 | | | X10 | | | | | | | | | |
| 9 | 1610 | 240.0 | | | 2.60 | | | 0.25 | | | .80 | 60.0 | $L_1$-$L_2$ | 153 | .137 | | 73 |
| | CHANGED TO 120V DELTA | | | | | | | | | | | | | | | | |
| | | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | X10 | | | | | | | | | | | | |
| 10 | 1640 | 120.0 | 120.0 | 120.0 | 3.00 | 3.00 | 3.00 | 0.167 | 0.167 | 0.167 | .80 | 60.0 | $L_1$-$L_2$ | 182 | .131 | | 73 |
| 11 | 1645 | 120.0 | 120.0 | 120.0 | 3.00 | 3.00 | 3.00 | 0.167 | 0.167 | 0.167 | .80 | 60.0 | $L_2$-$L_3$ | 177 | .140 | | 73 |
| 12 | 1650 | 120.0 | 120.0 | 120.0 | 3.00 | 3.00 | 3.00 | 0.167 | 0.167 | 0.167 | .80 | 60.0 | $L_3$-$L_1$ | 188 | .126 | | 73 |

| | | |
|---|---|---|
| **NOTES** | SHUNT #1377 $L_1$ CT #6752 | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY |
| | $L_2$ CT #6753 | |
| | $L_3$ CT #6754 | |

FIGURE 512.1-3 Typical test record for circuit interrupter (short-circuit) test.

METHOD 512.2e

CIRCUIT INTERRUPTER TEST
(OVERLOAD CURRENT)

512.2.1 General. A circuit interrupter is connected between the voltage reconnection system and the output terminals to disconnect the output from the load and to protect the power system from a sustained overload current. The circuit interrupter is operated from a current sensor either internal or external to the interrupter.

512.2.2 Apparatus. Use instrumentation for measuring load conditions and field voltage and current as described and illustrated in the 100 series methods, as applicable. In addition, use a stopwatch/timer, a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter, a current transformer or non-inductive shunt as described and illustrated in 106.1.3. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

512.2.3 Procedure.

512.2.3.1 Preparation for test. Connect the load and field instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document.

512.2.3.2 Test.

**CAUTION: The power system may be damaged if the overload condition is not removed. If the circuit interrupter fails to operate within the time specified in the procurement document at any time during the performance of this Method, manually open the circuit interrupter and reduce the load impedance to rated value before reclosing the circuit interrupter. Record on the data sheet the failure of the interrupter to operate and the total elapsed time the overload was on the power system.**

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 512.2-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 512.2.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

   a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

   b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 512.2.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE**: The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. In one continuous operation, increase the load current reactively to the overload current value specified in the procurement document. Simultaneously with the load current increase, start the stopwatch/timer.

**NOTE**: Maintain the frequency at rated conditions. Balance the load current equally among the phases.

c. Record all load instrumentation and the time, in seconds, required for the circuit interrupter to operate.

d. If the power system contains an overload malfunction indicator, check and record its indication.

e. Allow the power system to cool at rated load for a minimum of 15 minutes.

f. Repeat steps c through e except that the load current is increased to the overload current value in $L_1$ only. $L_2$ and $L_3$ remain at the rated load current value of wye connections or equally share the increase for delta connections. (This step is not applicable for 2 wire single phase or DC power systems).

g. Repeat step f except that the load is increased to the overload current value in $L_2$ only. $L_1$ and $L_3$ remain at the rated load value of current.

h. Repeat step f except that the load is increased to the overload current value in $L_3$ only. $L_1$ and $L_2$ remain at the rated load value of current.

i. If the procurement document requires circuit interrupter operation at overload currents other than that used in steps b through h above, repeat steps a through h above for the specified overload current(s).

j. Repeat steps a through i above for each voltage connection and frequency specified in the procurement document.

k. If the procurement document requires that the circuit interrupter not trip at a specified load above 100 percent of rated load current, load the power system to the value specified and operate at this load for a two hour period. Record whether or not the circuit interrupter tripped.

512.2.4 Results. Show, as a minimum, whether or not the circuit interrupter operated, the time(s) required for the interrupter to operate, the indication of the malfunction indicator, the overload load condition(s) and the stabilization data on the data sheets. Compare the time(s) required for the circuit interrupter to operate with the procurement document requirements.

512.2.5 Procurement document requirements.Specify the following items in the individual procurement document:

a. The time(s), in seconds, for the circuit interrupter to operate after the overload(s) is (are) applied.

b. The percent overload trip current(s) at which this Method is to be performed.

c. The percent overload hold current(s) at which this Method is to be performed, if applicable.

d. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

e. Overload malfunction indicator requirements.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60HZ<br>120 V SINGLE – PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 27016<br><br>**REF.** MIL-STD-705/512.2 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>CIRCUIT INTERRUPTER TEST<br>(OVERLOAD CURRENT) | **TEST NO.** 38<br><br>**SHEET**: 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 107 | | 1177 | | 916 | | 514 | | 577 | | | | | | | 177 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | TRIP TIME | | | AVG AMB TEMP |
| **UNITS** | | | VOLTS | AMPS | AMPS | KW | KW | | - | | Hz | | | | SEC | | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0830 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| | 0840 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0850 | | 120.0 | 2.62 | 105 | 0.255 | 10.08 | | .81 | | 60.2 | | | | | | 76 |
| | 0900 | | 120.8 | 2.73 | 108 | 0.260 | 10.40 | | .81 | | 60.3 | | | | | | 76 |
| | 0900 | ADJUST VOLTAGE, FREQUENCY AND LOAD TO RATED | | | | | | | | | | | | | | | |
| | 0910 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0920 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0930 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0940 | | 120.0 | 2.60 | 104 | 0.25 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0942 | APPLIED OVERLOAD CURRENT 130% OF RATED | | | | | | | | | | | | | | | |
| | | | 120.0 | 3.37 | 135 | 0.26 | 10.4 | | .66 | | 60.0 | | | | 177.3 | | 77 |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | C. T. # 1151 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 512.2-1 Typical test record for circuit interrupter test (overload current).

METHOD 512.3e

CIRCUIT INTERRUPTER TEST
(OVERVOLTAGE AND UNDERVOLTAGE)

512.3.1 General. To protect the load from malfunction (e.g. overvoltage or undervoltage) a circuit interrupter is connected between the voltage reconnection system and the output terminals. A voltage sensing circuit operates the circuit interrupter if an overvoltage or undervoltage condition occurs and thus protects the load from a malfunction.

512.3.2 Apparatus. Use instrumentation for measuring voltage and frequency as described and illustrated in the 100 series methods, as applicable. Use resistor(s), galvanometer matching networks, and a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

512.3.3 Procedure.

512.3.3.1 Procedure I (Overvoltage).

512.3.3.1.1 Preparation for test.

a. Locate and disconnect the input circuit to the input terminals of the overvoltage protective sensing circuit and connect the apparatus as illustrated in FIGURE 512.3-1 for the voltage connection and frequency specified in the procurement document.

b. Connect the frequency meter to the output terminals of the power system.

512.3.3.1.2 Test.

a. Start and operate the power system at rated frequency and no load.

b. Close the switch (see FIGURE 512.3-1) and use resistance, $R_1$, to adjust the voltage (Voltmeter Number 1, $V_1$) to the overvoltage value specified in the procurement document. If the power system has provisions for shutdown or removal of excitation from the generator upon an overvoltage condition, temporarily deactivate this provision to permit adjustment of the overvoltage value. Do this by activating the "protective by-pass" (Battle Short) switch, if provided. Do not deactivate the circuit interrupter trip circuitry.

c. Open the switch, reset the overvoltage circuit and adjust the resistance, $R_2$, until the Voltmeter Number 2 ($V_2$) reads rated voltage.

d. Repeat steps b and c to assure that the specified overvoltage and rated voltage settings are correct.

e. Set the data recorder such that the individual waveform peaks are clearly visible.

f. Record both voltmeter readings per METHOD 203.1 (see FIGURE 512.3-2).

g. With the data recorder operating and the circuit interrupter closed, close the switch. See FIGURE 512.3-1.

h. Reactivate the shutdown provision if used.

i. If the power system contains an overvoltage malfunction indicator, check and record its indication.

j. If power system shutdown or removal of generator excitation is required, record whether or not the shutdown or generator excitation removal occurred.

k. Open the switch, reset the overvoltage circuit if necessary, restart the power system if required, and close the circuit interrupter.

l. Repeat steps e through k above two additional times.

512.3.3.2 Procedure II (Undervoltage).

512.3.3.2.1 Preparation for test.

a. Locate the input terminals of the undervoltage sensing circuit and connect the apparatus as illustrated in FIGURE 512.3-1.

b. Connect the frequency meter to the output terminals of the power system.

512.3.3.2.2 Test.

a. Start and operate the power system at rated frequency and no load.

b. Close the switch (see FIGURE 512.3-1) and use the resistance, $R_1$, to adjust the voltage to the rated value.

c. Open the switch and adjust the resistance, $R_2$, until Voltmeter Number 2 ($V_2$) reads the undervoltage value specified in the procurement document. If the power system has provisions for shutdown or removal of excitation from the generator upon an undervoltage condition, temporarily deactivate this provision for this adjustment. Do not deactivate the circuit interrupter trip circuitry. When two or more undervoltage values are specified, repeat this test for each undervoltage value. In addition, if the procurement document specifies a voltage bandwidth in which the undervoltage protection device shall not operate instantaneously, also check the operation within this bandwidth.

d. Repeat steps b and c above to assure that the specified undervoltage and rated voltage settings are correct.

e. Set the data recorder such that the individual waveform peaks are clearly visible.

f. With the power system operating and the circuit interrupter and the switch open, record both voltmeter readings per METHOD 203.1 (see FIGURE 512.3-2).

g. Close the switch and circuit interrupter.

h. Reactivate the power system shutdown provision if used.

i. With the data recorder operating, open the switch.

j. After allowing sufficient time for the circuit interrupter to operate, check and record the indication of the undervoltage malfunction indicator if the power system contains one.

k. If power system shutdown or removal of generator excitation is required, record whether or not the shutdown or generator excitation removal occurred.

l. Close the switch, reset the undervoltage circuit if necessary, restart the power system if required, and close the circuit interrupter.

m. Repeat steps e through l above two additional times.

n. If the undervoltage protection circuitry contains a time delay to prevent circuit interrupter operation on a momentary undervoltage condition, check the circuitry as follows:

    1. With the data recorder operating, momentarily open and close the switch making sure that the switch is not closed for a period of time equal to or longer than the specified delay time.

    2. Record on the data sheet if the circuit interrupter operated and the indication of the malfunction indicator (if applicable).

o. If more than one undervoltage value is specified in the procurement document, repeat 512.3.3.2.1 and 512.3.3.2.2 for each value specified.

512.3.3.3 Repeat procedure. Repeat 512.3.3.1 and 512.3.3.2 at each of the voltage connections and frequencies specified in the procurement document.

512.3.4 Results.

a. From the data recorder readings made in 512.3.3, determine and tabulate the time between the application of the overvoltage and operation of the circuit interrupter for each application of overvoltage.

b. From the data recorder readings made in 512.3.3, determine and tabulate the time between the application of the undervoltage and operation of the circuit interrupter for each application of undervoltage.

c. For power systems having a time delay, use the data recorder readings taken in 512.3.3.2.2n1, and determine if the circuit interrupter actuated upon application of a momentary undervoltage.

d. Compare these results with the requirements of the procurement document.

512.3.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The value of overvoltage in volts and time in seconds required for the circuit interrupter to operate after application of the overvoltage.

b. The value(s) of undervoltage in volts and time(s) in seconds required for the circuit interrupter to operate after application of the undervoltage.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Overvoltage and undervoltage malfunction indicator requirements.

e. Conditions of power system shutdown or removal of generator excitation as applicable.

f. Circuit interrupter delay time if applicable.

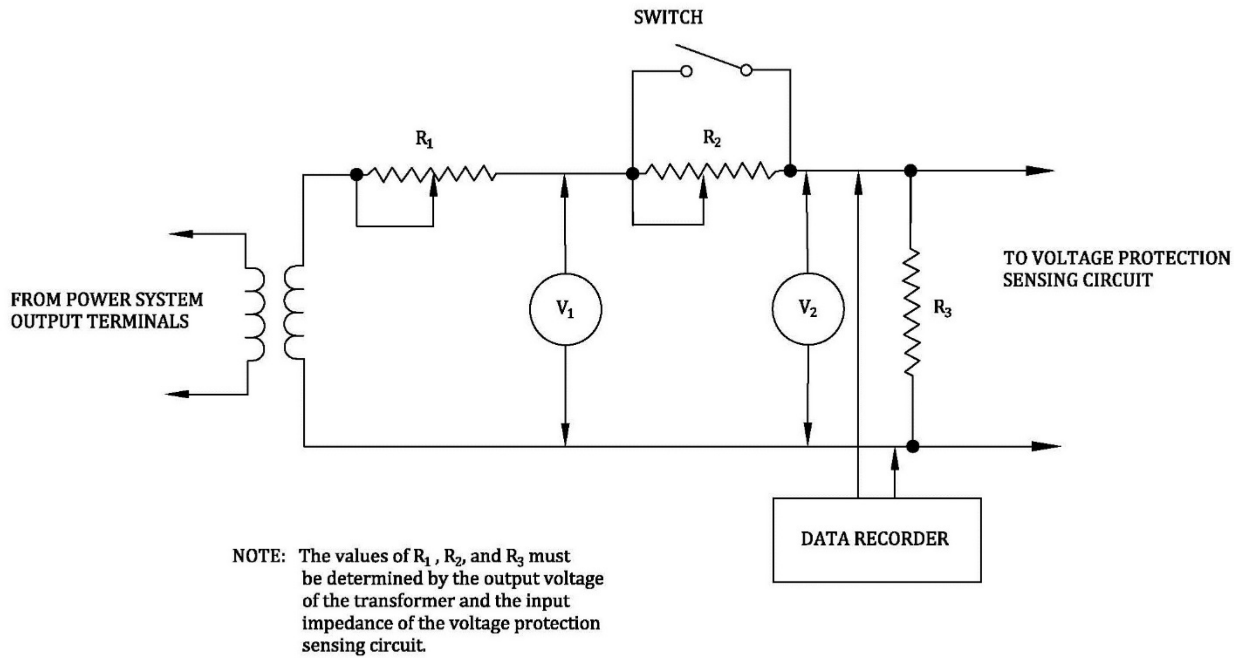



FIGURE 512.3-1 Apparatus connection for circuit interrupter test (overvoltage and undervoltage).

| | | |
|---|---|---|
| **DESCRIPTION:** 60KW, 60HZ<br>120/208, 640/416 V<br>0.8PF POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-60.0-MD/CIED<br><br>**SERIAL NO.** 4097<br><br>**REF.** MIL-STD-705/512.3 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>CIRCUIT INTERRUPTER TEST<br>(OVERVOLTAGE AND UNDERVOLTAGE) | **TEST NO.** 5<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 139 | 421 | 1035 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | VOLTAGE | | FREQ | REMARKS | | | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | VOLTS | HZ | | | | | | | | | | | | °F |
| **SYM** | | # 1 | # 2 | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 1 | 0900 | 148.0 | 120.0 | 60.0 | CIRCUIT INTERRUPTER OPENED, POWER SYSTEM SHUTDOWN O. V. INDICATOR ON | | | | | | | | | | | | 73 |
| 2 | 0905 | 148.0 | 120.0 | 60.0 | SAME AS READING NO. 1 | | | | | | | | | | | | |
| 3 | 0910 | 148.0 | 120.0 | 60.0 | SAME AS READING NO. 1 | | | | | | | | | | | | |
| 4 | 0930 | 120.0 | 102.0 | 60.0 | CIRCUIT INTERRUPTER OPENED, U. V. INDICATOR ON | | | | | | | | | | | | 75 |
| 5 | 0935 | 120.0 | 102.0 | 60.0 | SAME AS READING NO. 4 | | | | | | | | | | | | |
| 6 | 0940 | 120.0 | 102.0 | 60.0 | SAME AS READING NO. 4 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | OVER AND UNDERVOLTAGE PROTECTION DEVICES CONNECTED TO COIL $T_9$-$T_{12}$ | | | | | | | | | | | | | | | | |

FIGURE 512.3-2 Typical test record for circuit interrupter test (overvoltage and undervoltage).

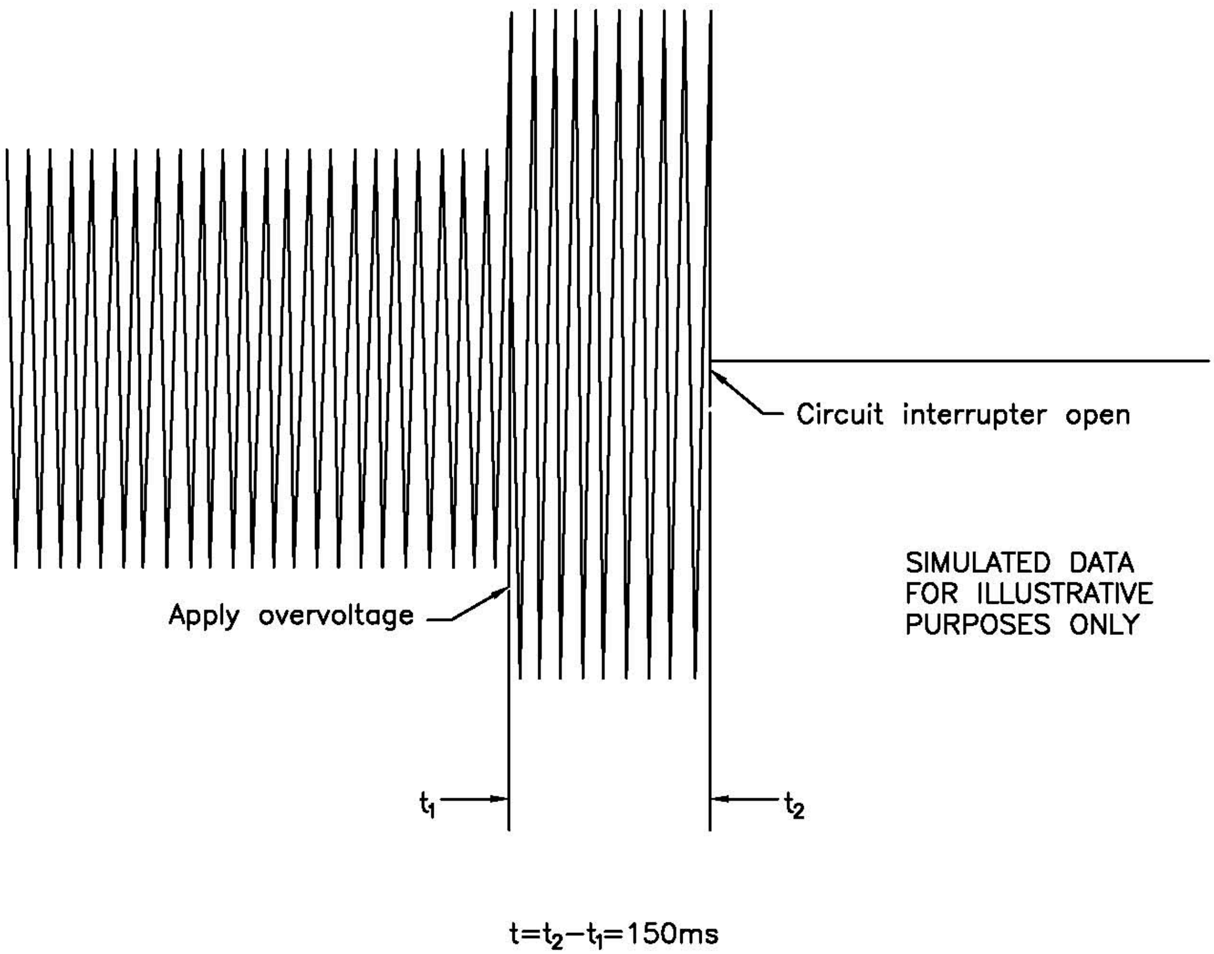


FIGURE 512.3-3 Portion of an oscillogram showing circuit interrupter operation upon application of an overvoltage.

METHOD 513.1e

INDICATING INSTRUMENT TEST
(ELECTRICAL)

513.1.1 General. Accurate power system instrumentation is necessary for determination of proper operation of the power system and to prevent overload or connected equipment problems.

513.1.2 Apparatus. Use instrumentation for measuring load conditions and ambient temperature as described and illustrated in the 100 series methods, as applicable. Electrical instrumentation used for this test shall have an accuracy in accordance with 4.2. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

513.1.3 Procedure.

513.1.3.1 Preparation for test.

a. Connect the load instrumentation as illustrated in the applicable figure in 205.1.10 for the applicable voltage connection and frequency.

b. If applicable, set the power system instruments to mechanical zero and do not readjust them once the test is in progress.

**NOTE**: During this Method, set the power system instruments to the desired value and read the actual value from the standard instruments.

513.1.3.2 Test.

a. Start and operate the power system at no load, and rated frequency and voltage.

b. Record all power system and standard instrument readings concurrently per METHOD 203.1 (see FIGURE 513.1-1 and FIGURE 513.1-2).

c. If a frequency adjust device is provided, reduce the frequency to obtain a panel frequency indication at the extreme low end of the meter operating range or to a value just prior to the activation of the under frequency protective device, if applicable.

d. Record all power system and standard instrument readings concurrently, (see FIGURE 513.1-1 and FIGURE 513.1-2).

e. Increase the frequency to obtain a power system frequency indication at the extreme high end of the meter operating range or to a value just prior to the activation of the overspeed protective device.

f. Record all power system and standard instrument readings concurrently.

g. Return frequency to rated value.

h. If a voltage adjust device is provided, reduce the voltage to obtain a panel voltage indication at the extreme low end of the meter operating range or to a value just prior to the activation of the undervoltage protective device (if an undervoltage protective device is provided).

i. Record all power system and standard instrument readings concurrently.

j. Increase the voltage to obtain a power system voltage indication at the extreme high end of the meter operating range or to a value just prior to the activation of the overvoltage protective device.

k. Record all power system and standard instrument readings concurrently.

l. Return voltage to rated value.

m. Repeat steps a through l except at 25 percent rated load.

n. Repeat steps a through l except at 50 percent rated load.

o. Repeat steps a through l except at 75 percent rated load.

p. Repeat steps a through l except at 100 percent rated load.

q. Perform METHOD 511.1 Regulator Range Test.

r. Repeat steps a through q for any other rated frequency.

s. Repeat steps a through r for all other rated line-to-line or line-to-neutral voltages.

513.1.4 Results.

a. Compute the accuracy for each power system instrument at each condition given in 513.1.3 above, using the following equation.

$$Accuracy = \frac{(Instrument_{power\ system} - Instrument_{standard})}{(Instrument_{standard})} * 100$$

Where:

$Instrument_{power\ system}$ = The instrument on the power system.

$Instrument_{standard}$ = The instrument used to determine the accuracy of the power system instrument.

b. Tabulate the results of step a above for each power system instrument.

c. Compare these results with the requirements of the procurement document.

513.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The accuracy of each power system instrument.

b. Standard instrument calibration requirements if different than those required by 4.2.

c. Maximum and minimum frequencies and voltages between which the power system shall perform.

d. The maximum allowable regulation.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60HZ<br>120V SINGLE PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 4087<br><br>**REF.** MIL-STD-705/513.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONRACT ADMINISTRATION SERVICE**<br><br>INDICATING INSTRUMENT TEST (ELECTRICAL)<br><br>MASTER INSTRUMENTS | **TEST NO.** 26<br><br>**SHEET:** 1 OF 2<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |

| **INST→** | | 106 | 308 | 1517 | | | | 1517 | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | TERMINAL VOLTAGE | LINE CURRENT | | OUTPUT POWER | | | FREQUENCY | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | | Hz | | | | | | | | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |
| | 0910 | STARTED POWER SYSTEM | | | | | | | | | | | | | | 77 |
| | 0912 | 121.0 | 0 | 0 | 0 | 0 | | 60.2 | | | | | | | | |
| | 0915 | 121.0 | 0 | 0 | 0 | 0 | | 54.9 | | | | | | | | |
| | 0920 | 121.0 | 0 | 0 | 0 | 0 | | 65.4 | | | | | | | | |
| | 0925 | 121.0 | 0.625 | 25 | 0.063 | 2.52 | | 60.2 | | | | | | | | |
| | 0930 | 121.0 | 0.625 | 25 | 0.063 | 2.52 | | 54.9 | | | | | | | | |
| | 0935 | 121.0 | 0.625 | 25 | 0.063 | 2.52 | | 65.4 | | | | | | | | |
| | 0940 | 121.0 | 1.33 | 52.6 | 0.126 | 5.04 | | 60.2 | | | | | | | | |
| | 0945 | 121.0 | 1.33 | 52.6 | 0.126 | 5.04 | | 54.9 | | | | | | | | |
| | 0950 | 121.0 | 1.33 | 52.6 | 0.126 | 5.04 | | 65.4 | | | | | | | | |
| | 0955 | 121.0 | 1.95 | 78 | 0.188 | 7.52 | | 60.2 | | | | | | | | |
| | 1000 | 121.0 | 1.95 | 78 | 0.188 | 7.52 | | 54.9 | | | | | | | | |
| | 1005 | 121.0 | 1.95 | 78 | 0.188 | 7.52 | | 65.4 | | | | | | | | |
| | 1010 | 121.0 | 2.63 | 105 | 0.252 | 10.08 | | 60.2 | | | | SIMULATED DATA | | | | |
| | 1015 | 121.0 | 2.63 | 105 | 0.252 | 10.08 | | 54.9 | | | | FOR ILLUSTRATIVE | | | | |
| | 1020 | 121.0 | 2.63 | 155 | 0.252 | 10.08 | | 65.4 | | | | PURPOSE ONLY | | | | |
| | 1030 | PERFORMED METHOD 511.1, REGULATOR RANGE TEST | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. #1305 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |

FIGURE 513.1-1 Portion of a typical test record for indicating instrument test.

**DESCRIPTION:** 10KW, 60HZ
120V SINGLE PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 4087

**REF.** MIL-STD-705/513.1

**PHILADELPHIA REGION**
**DEFENSE CONRACT ADMINISTRATION SERVICE**

INDICATING INSTRUMENT TEST(ELECTRICAL)

POWER SYSTEM INSTRUMENTS

**TEST NO.** 26

**SHEET:** 2 OF 2

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | VOLTAGE | | | | PERCENT LOAD CURRENT | | | | FREQUENCY | | | | | | | |
| **UNITS** | HRS | VOLTS | | % | | % | | % | | Hz | | % | | | | | |
| **SYM** | | | | ERROR | | | | ERROR | | | | ERROR | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0912 | 120 | | 0.83 | | 0 | | 0 | | 60.0 | | 0.3 | | | | | |
| | 0915 | 120 | | 0.83 | | 0 | | 0 | | 55 | | 0.2 | | | | | |
| | 0920 | 120 | | 0.83 | | 0 | | 0 | | 65 | | 0.7 | | | | | |
| | 0925 | 120 | | 0.83 | | 25 | | 4.0 | | 60 | | 0.3 | | | | | |
| | 0930 | 120 | | 0.83 | | 25 | | 4.0 | | 55 | | 0.2 | | | | | |
| | 0935 | 120 | | 0.83 | | 25 | | 4.0 | | 65 | | 0.7 | | | | | |
| | 0940 | 120 | | 0.83 | | 50 | | 1.2 | | 60 | | 0.3 | | | | | |
| | 0945 | 120 | | 0.83 | | 50 | | 1.2 | | 55 | | 0.2 | | | | | |
| | 0950 | 120 | | 0.83 | | 50 | | 1.2 | | 65 | | 0.7 | | | | | |
| | 0955 | 120 | | 0.83 | | 75 | | 0 | | 60 | | 0.3 | | | | | |
| | 1000 | 120 | | 0.83 | | 75 | | 0 | | 55 | | 0.2 | | | | | |
| | 1005 | 120 | | 0.83 | | 75 | | 0 | | 65 | | 0.7 | | | | | |
| | 1010 | 120 | | 0.83 | | 100 | | 0.95 | | 60 | | 0.3 | | | | | |
| | 1015 | 120 | | 0.83 | | 100 | | 0.95 | | 55 | | 0.2 | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 1020 | 120 | | 0.83 | | 100 | | 0.96 | | 65 | | 0.7 | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 513.1-2 Portion of a typical test record for indicating instrument test.

METHOD 513.2b

# INDICATING INSTRUMENT TEST
# (PRODUCTION POWER SYSTEMS)
# (ELECTRICAL)

513.2.1 General. Accurate power system instrumentation is necessary for determination of proper operation of the power system and to prevent power system overload or connected equipment problems.

513.2.2 Apparatus. Use instrumentation for measuring load conditions and ambient temperature as described and illustrated in the 100 series methods, as applicable. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

513.2.3 Procedure.

513.2.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure in 205.1.10 for one voltage connection and frequency.

b. If applicable, set the power system instruments to mechanical zero and do not readjust them once the test is in progress.

**NOTE**: During this Method set the power system instruments to the desired value and read the actual value from the standard instruments.

513.2.3.2 Test.

a. Start and operate the power system at no load, and at rated frequency and voltage.

b. Record all power system and standard instrument readings concurrently for each instrument selector switch position per METHOD 203.1 (see FIGURE 513.2-1 and FIGURE 513.2-2).

c. If a frequency adjust device is provided, reduce the frequency to obtain a power system frequency indication at the extreme low end of the instrument's operating range or to a value just prior to the actuation of the underfrequency protection device, if applicable.

d. Record all power system and standard instrument readings concurrently.

e. Increase the frequency to obtain a power system frequency indication at the extreme high end of the instrument's operating range or to a value just prior to the actuation of the overspeed protection device.

f. Record all power system and standard instrument readings concurrently.

g. Return frequency to rated value.

h. If a voltage adjust device is provided, reduce the voltage to obtain a panel voltage indication at the extreme low end of the meter operating range or to a value just prior to the activation of the undervoltage protective device, if applicable.

i. Record all power system and standard instrument readings concurrently.

j. Increase the voltage to obtain a power system voltage indication at the extreme high end of the meter operating range or to a value just prior to the activation of the overvoltage protective device.

k. Record all power system and standard instrument readings concurrently.

l. Return voltage to rated value.

m. Repeat steps a and b except at 25 percent of rated load.

n. Repeat steps a and b except at 50 percent of rated load.

o. Repeat steps a and b except at 75 percent of rated load.

p. Repeat steps a and b except at 100 percent of rated load.

q. Repeat steps a, b, and p for any other rated frequency.

r. Repeat steps a, b, p and q for all other rated line-to-line or line-to-neutral voltages.

513.2.4 Results.

a. Compute the accuracy for each power system instrument at each condition given in 513.2.3 above, using the following equation:

$$Accuracy = \frac{(Instrument_{power\ system} - Instrument_{standard})}{(Instrument_{standard})} * 100$$

Where:

$Instrument_{power\ system}$ = The instrument on the power system.

$Instrument_{standard}$ = The instrument used to determine the accuracy of the power system instrument.

b. Tabulate the results of step a above for each power system instrument.

c. Compare these results with the requirements of the procurement document.

513.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The accuracy of each power system instrument.

b. Standard instrument calibration requirements if different than those required by 4.2.

**DESCRIPTION:** 10KW, 60HZ
120 V SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC.

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 4087

**REF.** MIL-STD-705/513.2

**PHILADELPHIA REGION**
**DEFENSE CONRACT ADMINISTRATION SERVICE**

INDICATING INSTRUMENT TEST
(PRODUCTION POWER SYSTEMS)
(ELECTRICAL)

MASTER INSTRUMENTS

**TEST NO.** 26

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** W. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 106 | | 217 | | 308 | | 1517 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | FREQUENCY | | | | | | | | | |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | HZ | | | | | | | | |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 1 | 0910 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| 2 | 0912 | | 120.0 | 0 | 0 | 0 | 0 | | 60.0 | | | | | | | | |
| 3 | 0915 | | 120.0 | 0 | 0 | 0 | 0 | | 55.0 | | | | | | | | |
| 4 | 0920 | | 120.0 | 0 | 0 | 0 | 0 | | 64.8 | | | | | | | | |
| 5 | 0925 | | 120.0 | .65 | 26.0 | .0625 | 2.5 | | 60.0 | | | | | | | | |
| 6 | 0930 | | 120.0 | .65 | 26.0 | .0625 | 2.5 | | 55.0 | | | | | | | | |
| 7 | 0935 | | 120.0 | .65 | 26.0 | .0625 | 2.5 | | 65.0 | | | | | | | | |
| 8 | 0940 | | 120.0 | 1.30 | 52.0 | .1250 | 5.0 | | 60.0 | | | | | | | | |
| 9 | 0945 | | 120.0 | 1.30 | 52.0 | .1250 | 5.0 | | 55.0 | | | | | | | | |
| 10 | 0950 | | 120.0 | 1.30 | 52.0 | .1250 | 5.0 | | 65.0 | | | | | | | | |
| 11 | 0955 | | 120.0 | 1.95 | 78.0 | .1875 | 7.5 | | 60.0 | | | | | | | | |
| 12 | 1000 | | 120.0 | 1.95 | 78.0 | .1875 | 7.5 | | 55.0 | | | | | | | | |
| 13 | 1005 | | 120.0 | 1.95 | 78.0 | .1875 | 7.5 | | 65.0 | | | | | | | | |
| 14 | 1010 | | 120.0 | 2.60 | 104 | .2500 | 10.0 | | 60.0 | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| 15 | 1015 | | 120.0 | 2.60 | 104 | .2500 | 10.0 | | 55.0 | | | | | | | | |
| 16 | 1020 | | 120.0 | 2.60 | 104 | .2500 | 10.0 | | 65.0 | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | C. T. NO. 1304 | | | | | | | | | | | | | | | | |

FIGURE 513.2-1 Typical test record for indicating instrument test (electrical).

| **DESCRIPTION:** 10KW, 60HZ 120 V SINGLE-PHASE POWER SYSTEM | **PHILADELPHIA REGION DEFENSE CONRACT ADMINISTRATION SERVICE** | **TEST NO.** 26 |
|---|---|---|
| **MFGR:** ENGENSETS, INC. | INDICATING INSTRUMENT TEST (PRODUCTION POWER SYSTEMS) (ELECTRICAL) | **SHEET:** 1 OF 1 |
| **MODEL NO.** SF-10.0-MD | | **DATE:** 15 JANUARY 2016 |
| **SERIAL NO.** 4087 | | **RECORDER:** L. WRIGHT |
| **REF.** MIL-STD-705/513.2 | PANEL INSTRUMENTS | **PROJ. ENGR** J. J. JONES |
| | | **SHIFT LEADER:** W. SMITH |
| | | **OBSERVER:** L. SEE |

| **INST→** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | | TERMINAL VOLTAGE | | | LOAD CURRENT | | | FREQUENCY | | | | | | | | | |
| **UNITS** | | VOLTS | | % | % | | % | HZ | | % | | | | | | | |
| **SYM** | | | | ERROR | | | ERROR | | | ERROR | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0912 | 121 | | 0.83 | 0 | | 0 | 60.0 | | 0 | | | | | | | |
| | 0915 | 121 | | 0.83 | 0 | | 0 | 55.0 | | 0 | | | | | | | |
| | 0920 | 121 | | 0.83 | 0 | | 0 | 65.0 | | 0 | | | | | | | |
| | 0925 | 121 | | 0.83 | 24 | | 4.0 | 60.0 | | 0 | | | | | | | |
| | 0930 | 121 | | 0.83 | 24 | | 4.0 | 55.0 | | 0 | | | | | | | |
| | 0935 | 121 | | 0.83 | 24 | | 4.0 | 65.0 | | 0 | | | | | | | |
| | 0940 | 121 | | 0.83 | 51 | | 2.0 | 60.0 | | 0 | | | | | | | |
| | 0945 | 121 | | 0.83 | 51 | | 2.0 | 55.0 | | 0 | | | | | | | |
| | 0950 | 121 | | 0.83 | 50 | | 0 | 65.0 | | 0 | | | | | | | |
| | 0955 | 121 | | 0.83 | 75 | | 0 | 60.0 | | 0 | | | | | | | |
| | 1000 | 121 | | 0.83 | 75 | | 0 | 55.0 | | 0 | | | | | | | |
| | 1005 | 121 | | 0.83 | 74 | | 1.25 | 65.0 | | 0 | | | | | | | |
| | 1010 | 121 | | 0.83 | 101 | | 1.0 | 60.0 | | 0 | | | | | | | |
| | 1015 | 121 | | 0.83 | 101 | | 1.0 | 55.0 | | 0 | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 1020 | 121 | | 0.83 | 100 | | 0 | 65.0 | | 0 | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 513.2-2 Typical test record for indicating instrument test (electrical).

METHOD 515.1c

LOW OIL PRESSURE PROTECTIVE DEVICE TEST

515.1.1 General. Since power systems frequently operate unattended for long periods, the engine is usually equipped with a low oil pressure protective device. This device shuts down the engine when the oil pressure drops below the safe limit.

515.1.2 Apparatus. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4. Use the following equipment to perform this Method.

Oil pressure gage (±1 percent accuracy)
Flexible oil line (or copper tubing)
Regulating valves
Brass fittings

515.1.3 Procedure.

515.1.3.1 Preparation for test. With the power system not operating, remove the protective device tap from the engine block and reconnect as shown in FIGURE 515.1-2 with the protective device and oil pressure gage in approximately the same horizontal plane as the protective device tap located on the engine.

515.1.3.2 Test.

a. With the bleeder valve closed and the shut-off valve in the oil pressure line open, start and operate the power system at rated speed (use the power system instrumentation) and at no load.

b. Open the bleeder valve slightly to purge air from the system.

c. Close the bleeder valve and record the oil pressure as indicated on the external gage.

d. Almost completely close the shut-off valve.

e. Slowly open the bleeder valve until the low oil pressure protective device shuts down the engine. Record the reading of the oil pressure gage at the point of power system shutdown per METHOD 203.1 (see FIGURE 515.1-1).

f. Record operation of the malfunction indicator, if so equipped.

515.1.4 Results. Compare the value of shutdown pressure with that given in the procurement document.

515.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Oil pressure at which the engine must shutdown.

b. Low oil pressure malfunction indicator requirements, if applicable.

| **DESCRIPTION:** 10KW, 60HZ<br>120 V SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 27016<br><br>**REF.** MIL-STD-705/515.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONRACT ADMINISTRATION SERVICE**<br><br>LOW OIL PRESSURE PROTECTIVE DEVICE TEST | **TEST NO.** 39<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST→** | | SET | | 11377 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | FREQUENCY | | OIL PRESSURE AT SHUTDOWN | | | | | | | | | | | | | |
| **UNITS** | HRS | | HZ | | PSIG | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1115 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| | 1120 | | 60.0 | | 15.7 | POWER SYSTEM SHUTDOWN | | | | | | | | | | | |
| | 1125 | | | | | | | | | | | | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 515.1-1 Typical test record for low oil pressure protective device test.

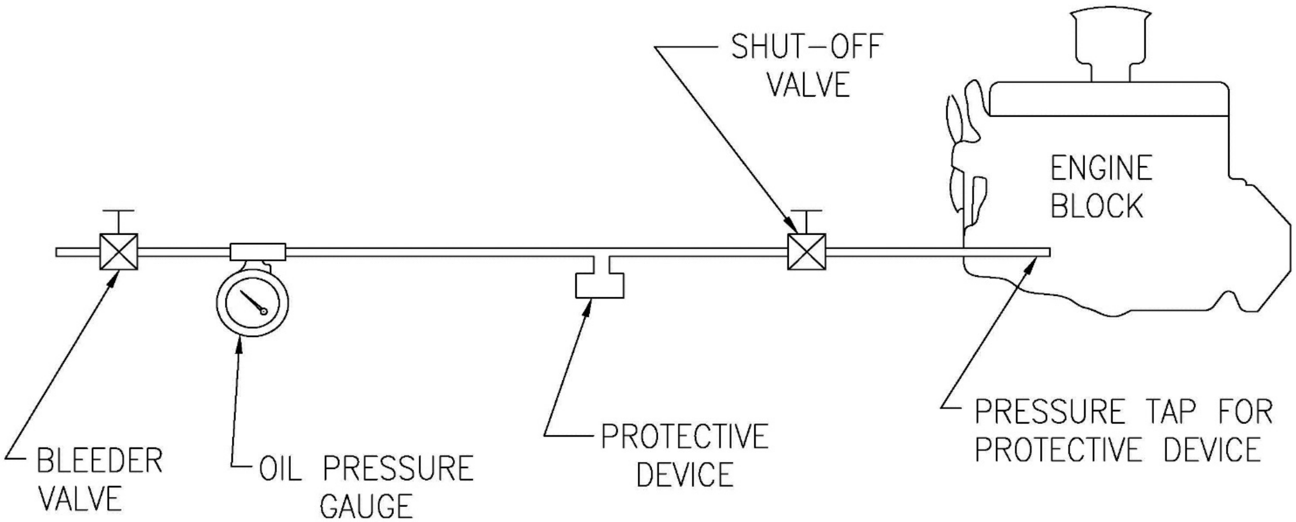


FIGURE 515.1-2 Apparatus hookup for low oil pressure protective device test.

METHOD 515.2b

OVERTEMPERATURE PROTECTIVE DEVICE TEST

515.2.1 General. The overtemperature device must be capable of protecting the power system against overheating for any reason.

515.2.2 Apparatus. Use instrumentation for measuring load conditions and power system and ambient temperatures as described and illustrated in the 100 series methods, as applicable. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

515.2.3 Procedure.

515.2.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10.

b. Install a thermocouple to measure the same temperature as seen by the protective device sensor. Record the position of the thermocouple.

515.2.3.2 Test.

a. Start and operate the power system at rated voltage, rated frequency (speed), and rated load.

b. Disable the cooling system by any suitable means.

c. Continuously monitor the temperature seen by the thermocouple installed in 515.2.3.1b above. Record the temperature at which the overtemperature protective device actuates per METHOD 203.1 (see FIGURE 515.2-1). Record the temperature at which the warning alarm device actuates, if applicable.

**CAUTION: If the power system fails to shutdown when the temperature exceeds the maximum trip value specified in the procurement document, shutdown power system and discontinue test immediately.**

d. Record the operation of the malfunction indicator, if applicable.

515.2.4 Results. Compare the results with the procurement document requirements.

515.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Range of temperature or maximum temperature in which the overtemperature protective device shall actuate.

b. Overtemperature malfunction indicator requirements, if applicable.

c. Range of temperature in which the warning alarm device shall actuate, if applicable.

| | | |
|---|---|---|
| **DESCRIPTION:** 15KW, 60HZ<br>120/208V, 3-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-15.0-MD<br><br>**SERIAL NO.** 10778<br><br>**REF.** MIL-STD-705/515.2 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>OVERTEMPERATURE PROTECTIVE<br>DEVICE TEST | **TEST NO.** 76<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 1076 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | COOLANT TEMPERATURE | | | | | | | | | | | | | | | |
| **UNITS** | HRS | | °F | | | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0810 | | | STARTED POWER SYSTEM | | | | | | | | | | | | | |
| | 0815 | | | BLOCKED ENGINE COOLING AIR | | | | | | | | | | | | | |
| | 0828 | | 199 | WARNING ALARM SOUNDED | | | | | | | | | | | | | |
| | 0833 | | 208 | ENGINE SHUT DOWN – OVERTEMPERATURE INDICATOR "ON" | | | | | | | | | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 515.2-1 Typical test record for overtemperature protective device test.

METHOD 515.5b

LOW FUEL PROTECTIVE DEVICE TEST

515.5.1 General. The low fuel protective device is designed to prevent evacuation and loss of prime in the fuel system.

515.5.2 Apparatus. Use load instrumentation as described and illustrated in the 100 series methods as applicable, a continuity indicating device, and a stopwatch/timer. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

515.5.3 Procedure.

515.5.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

b. Level the power system.

c. Fill the onboard fuel tank to 1/4 capacity.

515.5.3.2 Test.

a. Start and operate the power system at rated load, voltage and frequency, simultaneously start the stopwatch/timer. Record time, load, voltage, and frequency per METHOD 203.1 (see FIGURE 515.5-1).

b. Note the exact time the low fuel protective device actuates. Record whether the low fuel malfunction indicator activated, if applicable. Record all readings.

c. Record the length of time the power system contimued to operate at rated load after the actuation of the fuel protective device.

d. After the power system stops, refill the onboard fuel tank to 1/4 capacity. Restart power system and record if power system started.

515.5.4 Results. Compare the times recorded with the minimum times of operation specified in the procurement document.

515.5.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The minimum time of operation on the onboard fuel tank before the low fuel protective device actuates, if applicable.

b. The minimum time of operation after the low fuel protective device actuates.

c. The voltage connection and frequency at which this Method is to be performed.

d. The load condition at which this Method is to be performed, if other than as specified herein.

e. Low fuel malfunction indicator requirements, if applicable.

| DESCRIPTION / IDENTIFICATION | | |
|---|---|---|
| **DESCRIPTION:** 15KW, 60HZ<br>120V, SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-15.0-MD<br><br>**SERIAL NO.** 1377<br><br>**REF.** MIL-STD-705/515.5 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>LOW FUEL PROTECTIVE DEVICE TEST | **TEST NO.** 39<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 108 | | 209 | | 310 | | 411 | | 512 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINIAL VOLTAGE | | LINE CURRENT | | POWER OUTPUT | | POWER FACTOR | | FREQUENCY | | SET OPTERATING TIME | | | | | |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | - | | HZ | MIN | SEC | | | | |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1245 | STARTED POWER SYSTEM, APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1247 | | 120.0 | 3.90 | 156 | .375 | 15.0 | | .80 | | 60.0 | | | | | | |
| | 1258 | LOW FUEL PROTECTIVE DEVICE ACTUATED | | | | | | | | | | 13 | 10 | | | | |
| | 1300 | POWER SYSTEM SHUTDOWN. | | | | | | | | | | 15 | 13 | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

**NOTES**

FIGURE 515.5-1 Typical test record for low fuel protective device.

METHOD 516.1a

CONTROLS, DIRECTION OF ROTATION

**NOTE**: Method 516.1a was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

516.1.1 General. The direction of rotation of the controls must be standard for generator sets to assure proper use by operating personnel.

516.1.2 Apparatus. Instrumentation for measuring load conditions shall be as described and illustrated in MIL-HDBK-705.

516.1.3 Procedure.

516.1.3.1 Preparation for test. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for one voltage connection and frequency specified in the procurement document.

516.1.3.2 Test.

a. Start and operate the power system at rated voltage, rated frequency, and a load condition specified in the procurement document with the "unit-parallel" switch in the "unit" position, if applicable.

b. Vary the voltage adjusting control. Record the effect of clockwise rotation on the output voltage (see FIGURE 516.1-I).

c. Vary the frequency adjusting control. Record the effect of clockwise rotation of the frequency.

d. Vary the frequency droop control, if applicable. Record the effect of clockwise rotation of the control.

e. Vary the cross-current compensating control. Record the effect of clockwise rotation of the control.

f. Repeat steps b through e above at any other specified load condition.

g. Repeat steps b through f with the "unit-parallel" switch in the "parallel" position, if applicable.

516.1.4 Results. Compare the results with the procurement document requirements.

516.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Direction of rotation of each control and the effect on the set.

b. The voltage connection(s) and frequency(ies) at which this method is to be performed.

c. Load condition(s) at which this method is to be performed.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60HZ<br>120V, SINGLE-PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 10776<br><br>**REF.** MIL-STD-705/516.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>CONTROLS, DIRECTION OF ROTATION TEST | **TEST NO.** 28<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** APRIL 13, 1971<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 171 | | 407 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | FREQUENCY | | | | | | | | | | | | | |
| **UNITS** | HRS | | VOLTS | | HZ | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | | | | | | | | | | | | | | | | | |
| | 1115 | STARTED SET | | | | | | | | | | | | | | | |
| | 1117 | | 120.0 | | 60.0 | | | | | | | | | | | | |
| | 1118 | CLOCKWISE ROTATION OF VOLTAGE CONTROL KNOB INCREASED VOLTAGE | | | | | | | | | | | | | | | |
| | | COUNTERCLOCKWISE ROTATION DECREASED VOLTAGE | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | | |
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| **NOTES** | NO OTHER CONTROLS ON FRONT PANEL | | | | | | | | | | | | | | | | |
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FIGURE 516.1-I Typical test record for controls, direction of rotation test.

METHOD 516.2b

REVERSE POWER PROTECTIVE DEVICE TEST

516.2.1 General. This Method ensures a reverse power protective device is operating properly. This device prevents a power system from drawing excessive power from a connected bus when two or more power systems are connected in parallel.

516.2.2 Apparatus. Use instrumentation for measuring load conditions and ambient temperature of the "system" to which the power system under test is paralleled as described and illustrated in the 100 series methods, as applicable. In addition, use a power system of equal rating as the power system under test. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

516.2.3 Procedure.

516.2.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for one voltage connection and frequency to the power system acting as the "bus" (power system No. 2). Parallel power system No. 1 (power system under test) with power system No. 2.

b. Connect the voltage and frequency sensing instruments to the line side of the circuit interrupter of power system No. 2 in accordance with the applicable figure(s) of 205.1.4 and 205.1.9 for the same voltage connection and frequency used in step a above.

c. Connect the output terminals of power system No. 2 to the output terminals of power system No. 1 with the correct phase relationship ($L_1$-$L_1$; $L_2$-$L_2$; $L_3$-$L_3$; N-N).

516.2.3.2 Test.

a. Start and operate power system No. 2 at rated voltage, rated frequency and 75 percent of rated load. Operate the power system in this manner for 15 minutes and then record all instrument readings per METHOD 203.1 (see FIGURE 516.2-1). These readings are the baseline for the reverse power test.

b. Start and operate power system No. 1 at rated voltage, rated frequency, and at no load.

c. Parallel power system No. 1 with power system No. 2 in accordance with the instructions on the power systems or in the technical manuals.

d. Slowly reduce the setting of the frequency adjust device on power system No. 1 until the reverse power protective device removes power system No. 1 from the "bus" power system No. 2. Record the load instrumentation (in kilowatts) at the point just prior to the actuation of the reverse power protection device.

e. Record the operation of the malfunction indicator, if so equipped.

f. Repeat steps c through e above two additional times.

g. Repeat 516.2.3 for each voltage connection and frequency specified in the procurement document.

516.2.4 Results.

a. Average the kilowatt readings taken during each trial of 516.2.3.2d above. Subtract the kilowatt reading(s) taken in step 516.2.3.2a above from the average. This value is the reverse power necessary to activate the reverse power protective device.

b. Compare the value(s) obtained in step a above with the requirements of the operation of the reverse power protective device as specified in the procurement document.

516.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The maximum allowable reverse power at which the reverse power protective device shall actuate.

b. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

c. Reverse power malfunction indicator requirements, if applicable.

**DESCRIPTION:** 15KW, 60HZ
120/208V, 3-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC.
**MODEL NO.** SF-15.0-MD
**SERIAL NO.** 16039 (POWER SYSTEM NO.1)
**REF.** MIL-STD-705/516.2

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

REVERSE POWER PROTECTIVE DEVICE TEST

**TEST NO.** 16

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J. J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST→** | | 116 | | | 3035 | 3036 | 3037 | | 317 | 318 | 319 | | 516 | 717 | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | BUS VOLTAGE | | | SYSTEM CURRENT | | | TOTAL CURRENT | SYSTEM POWER | | | TOTAL SYSTEM POWER | POWER FACTOR | FREQ | | | AVG AMB TEMP |
| | | | | | | | | | $L_1$-N | $L_2$-N | $L_3$-N | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | AMPS | KW | KW | KW | KW | - | HZ | | | °F |
| **SYM** | | $L_1$-N | $L_2$-N | $L_3$-N | X20 | X20 | X20 | X1 | X20 | X20 | X20 | X1 | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1400 | STARTED POWER SYSTEM NO. 2 – APPLIED 75% RATED LOAD | | | | | | | | | | | | | | | 75 |
| | 1415 | 120.0 | 120.0 | 120.0 | 1.95 | 1.95 | 1.95 | 117 | 0.188 | 0.188 | 0.188 | 11.2 | 0.80 | 60.0 | | | 75 |
| | 1420 | STARTED POWER SYSTEM NO. 1 – PARALLED WITH POWER SYSTEM NO. 2 | | | | | | | | | | | | | | | |
| | 1422 | REDUCED GOVERNOR SETTING UNTIL POWER SYSTEM | | | | | | | 0.200 | 0.200 | 0.200 | 12.0 | 0.37 | 60.0 | | | 75 |
| | | NO. 1 CIRCUIT BREAKER OPENED – REVERSE POWER MALFUNCTION INDICATOR ON | | | | | | | | | | | | | | | |
| | 1425 | 120.0 | 120.0 | 120.0 | 1.95 | 1.95 | 1.95 | 117 | 0.188 | 0.188 | 0.188 | 11.2 | 0.80 | 60.0 | | | 75 |
| | 1430 | PARALLELED POWER SYSTEM NO. 1 WITH POWER SYSTEM NO. 2 | | | | | | | | | | | | | | | |
| | 1433 | REDUCED GOVERNOR SETTING UNTIL POWER SYSTEM NO. 1 C/B OPENED | | | | | | | 0.200 | 0.200 | 0.200 | 12.0 | 0.37 | 60.0 | | | 75 |
| | | REVERSE POWER MALFUNCTION INDICATOR ON | | | | | | | | | | | | | | | |
| | 1435 | 120.0 | 120.0 | 120.0 | 1.95 | 1.95 | 1.95 | 117 | 0.188 | 0.188 | 0.188 | 11.2 | 0.80 | 60.0 | | | 75 |
| | 1440 | PARALLELED POWER SYSTEM NO. 1 WITH POWER SYSTEM NO. 2 | | | | | | | | | | | | | | | |
| | 1443 | REDUCED GOVERNOR SETTING UNTIL POWER SYSTEM NO. 1 C/B OPENED | | | | | | | 0.200 | 0.200 | 0.200 | 12.0 | 0.37 | 60.0 | | | 75 |
| | | REVERSE POWER MALFUNCTION INDICATOR ON | | | | | | | | | | | | | | | |
| | 1445 | SHUTDOWN BOTH POWER SYSTEMS | | | | | | | | | | | | | | | |
| | | | | | | | AVERAGE SYSTEM POWER 11.2KW | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | AVERAGE C/B OPEN 12.0KW | | | | | | | | | | |
| | | REVERSE POWER REQUIRED TO ACTUATE REVERSE POWER PROTECTIVE DEVICE ON POWER SYSTEM NO. 1 = 0.8 KW | | | | | | | | | | | | | | | |
| **NOTES** | SYSTEM CURRENT MEASURED USING CURRENT TRANSFORMERS NO. 1305-$L_1$ | | | | | | | | | | | | | | | | |
| | 1306-$L_2$ | | | | | | | | | | | | | | | | |
| | 1307-$L_3$ | | | | | | | | | | | | | | | | |

FIGURE 516.2-1 Typical test record for reverse power protective device test.

METHOD 516.5b

REVERSE BATTERY POLARITY TEST

516.5.1 General. The power system should not be damaged if the polarity of the battery connections are reversed. Some power systems may have a reverse polarity reset time associated with them. This reverse polarity reset time is the duration between the time when the reverse polarity protective device actuates and the time when the power system is able to start with the battery polarity corrected.

516.5.2 Apparatus. Use a slave battery cable and slave batteries of the proper voltage and size to start the power system. Use a stopwatch/timer. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

516.5.3 Procedure.

a. With the power system batteries installed in their normal operating position in accordance with the instructions on the power system or in the technical manual, start and operate the power system at rated voltage, rated frequency (speed) and no load for a period of 5 minutes. The power system instruments shall be sufficient to indicate voltage and frequency.

b. After the 5 minute operation, shutdown the power system. Reverse the polarity of the power system batteries and attempt to start the power system following the instructions on the power system or in the technical manual. If the power system starts, immediately stop the power system and record failure of test per METHOD 203.1 (see FIGURE 516.5-1). Otherwise record that the power system did not start. Start stopwatch/timer.

c. Record operation of reverse polarity malfunction indicator, if so equipped.

d. Open the control panel and visually check for damage to any component. Record observations on the data sheet. If there is damage, stop test and record failure. Reset circuit breaker or replace fuse, if applicable.

e. Correct the polarity of the power system batteries. Attempt to start the power system in accordance with the instructions on the power system or in the technical manual. Record if the power system started and record the stopwatch/timer reading. This time is the reverse polarity reset time.

f. If the power system did not start, continue to start the power system in accordance with technical manual requirements. Record the time when the power system started. If the power system does not start after the time required in the procurement document, stop test and report failure on data sheet.

g. If the power system is equipped with a battery slave receptacle, disconnect the power system batteries and using a slave cable and slave batteries, repeat steps a through f above.

h. Perform any other checks as specified in the procurement document.

516.5.4 Results. Compare the operation or non-operation of the power system with the requirements of the procurement document.

516.5.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The requirements of the reverse battery polarity protection.

b. Any additional checks on the battery polarity other than those specified in 516.5.3.

c. Reverse polarity malfunction indicator requirements, if applicable.

d. Allowable reverse polarity reset time, if applicable.

e. Time required to attempt to restart the power system, if applicable.

| | | |
|---|---|---|
| **DESCRIPTION:** 15KW, 60HZ<br>120V, SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC.<br>**MODEL NO.** SF-15.0-MD<br>**SERIAL NO.** 1077<br>**REF.** MIL-STD-705/516.5 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>REVERSE BATTERY POLARITY TEST | **TEST NO.** 29<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J. J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |

| **INST→** | | | | | | | | | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | | | | | | | | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | | | | | | | | | | | | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0915 | STARTED POWER SYSTEM WITH BATTERIES CONNECTED IN ACCORDANCE WITH POWER SYSTEM SCHEMATIC – POWER SYSTEM OPERATING AT NO LOAD | | | | | | | | | | | | | | | 73 |
| | 0920 | SHUTDOWN POWER SYSTEM. | | | | | | | | | | | | | | | |
| | 0930 | ATTEMPED TO START POWER SYSTEM WITH BATTERY POLARIY OPPOSITE THAT SHOWN ON POWER SYSTEM SCHEMATIC. POWER SYSTEM DID NOT CRANK – NO VISUAL FAILURES NOTED. | | | | | | | | | | | | | | | |
| | 0940 | STARTED POWER SYSTEM WITH BATTERIES CONNECTED IN ACCORDANCE WITH POWER SYSTEM SCHEMATIC. | | | | | | | | | | | | | | | |
| | 0942 | SHUTDOWN POWER SYSTEM. | | | | | | | | | | | | | | | |
| | 1000 | STARTED POWER SYSTEM WITH SLAVE BATTERIES CONNECTED IN ACCORDANCE WITH POWER SYSTEM SCHEMATIC – POWER SYSTEM OPERATING AT NO LOAD. | | | | | | | | | | | | | | | |
| | 1005 | SHUTDOWN POWER SYSTEM. | | | | | | | | | | | | | | | |
| | 1008 | ATTEMPTED TO START POWER SYSTEM WITH SLAVE BATTERIES – POLARITY OPPOSITE THAT SHOWN ON POWER SYSTEM SCHEMATIC. POWER SYSTEM DID NOT CRANK. NO VISUAL FAILURES NOTED. | | | | | | | | | | | | | | | |
| | 1010 | STARTED POWER SYSTEM WITH SLAVE BATTERIES CONNECTED IN ACCORDANCE WITH POWER SYSTEM SCHEMATIC. | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 516.5-1 Typical test record for reverse battery polarity test.

# METHOD 521.1a

# PARALLELING AID DEVICE TEST

**NOTE**: Method 521.1a was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

521.1.1 General. The paralleling aid device is designed to prevent the paralleling of a generator set with another generator set or operating system unless the voltage and phase relations are within certain limits to prevent damage to either the generator set or the system.

521.1.2 Apparatus. Instrumentation for measuring load conditions of the generator set acting as the system, and voltage and frequency of the generator set to be paralleled, shall be as described and illustrated in MIL-HDBK-705. In addition, a synchroscope or phase relationship indicating equipment as described and illustrated in MIL-HDBK-705, method 117.1, to detect the phase relationship between the system and the generator set, shall be required.

521.1.3 Procedure. The generator set acting as the "system" shall be designated as set No. 1. The generator set with the paralleling aid device under test shall be designated as set No. 2.

521.1.3.1 Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 to set No. 1 for a voltage connection and frequency specified in the procurement document.

b. Connect the voltage and frequency sensing instruments to the line side of the circuit interrupter of set No. 2 in accordance with the applicable figure(s) of MIL-HDBK-705, method 205.1, paragraphs 205.1.4 and 205.1.9 for the same voltage connection and frequency used in step a above.

c. Connect the output terminals of set No. 2 to the output terminals of set No. 1 with the correct phase relationship ($L_1$-$L_1$; $L_2$-$L_2$; $L_3$-$L_3$; $L_0$-$L_0$).

d. Connect the synchroscope, or phase relation indicating equipment, in accordance with the manufacturer's instructions in such a manner that the same phase voltage of each set (No. 1 and No. 2) is sensed and the phase difference, in degrees, can be readily determined.

521.1.3.2 Test.

a. Start and operate set No. 1 at rated voltage, rated frequency and rated load.

b. Start and operate set No. 2 with the frequency difference between the two sets within the limits specified in the procurement document for the paralleling aid device to activate and with the voltage 10 percent below the voltage of set No. 1.

c. With the operator selector switch of set No. 2 in the "Parallel Operation" position, slowly raise the voltage of set No. 2. Record the voltage of both sets and the phase difference in degrees at the time the sets are paralleled.

d. Repeat steps b and c above with the operator selector switch in the "Single Unit Operation" position and the circuit interrupter control switch held in the "closed" position.

e. Repeat steps b and c above except that the voltage of set No. 2 shall be 10 percent above the voltage of set No. 1 and the voltage of set No. 2 shall be slowly lowered.

f. Repeat step e above with the operator selector switch in the "Single Unit Operation" position and the circuit interrupter control switch held in the "closed" position.

g. Operate set No. 2 such that the voltage difference between the two sets is within the limits specified in the procurement document for the paralleling aid device to activate and the frequency is 2.5 percent below the frequency of set No. 1.

h. With the operator selector switch of set No. 2 in the "Parallel Operation" position, slowly raise the frequency of set No. 2. Record the frequency of both sets and the phase difference in degrees just prior to the time the sets are paralleled.

i. Repeat steps g and h above with the operator selector switch in the "Single Unit Operation" position and the circuit interrupter control switch held in the "closed" position.

j. Repeat steps g and h above except that the frequency of set No. 2 shall be 2.5 percent above the frequency of set No. 1 and the voltage of set No. 2 shall be slowly lowered.

k. Repeat step j above with the operator selector switch in the "Single Unit Operation" position and the circuit interrupter control switch held in the "closed" position.

l. Shut down set No. 1. With set No. 2 operator selector switch in the "Parallel Operation" position, record the operation of set No. 2's circuit interrupter.

m. Repeat steps a through l above for any other voltage connection(s) and frequency(ies) specified in the procurement document.

521.1.4 Results. Compare the parallel and device activation readings with the limits as specified in the procurement document.

521.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Voltage tolerance in percent of rated voltage beyond which the paralleling aid device must not permit paralleling.

b. Frequency tolerance in percent of rated frequency beyond which the paralleling aid device must not permit paralleling.

c. Phase angle tolerance in degrees beyond which the paralleling aid device must not permit paralleling.

d. Voltage connection(s) and frequency(ies) at which this Method shall be performed.

**DESCRIPTION:** 15 KW, 60 HZ
120/208V 3 PHASE
GENERATOR SET

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-15.0-MD

**SERIAL NO.** 2177

**REF.** MIL-STD-705/521.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

PARALLELING AID DEVICE TEST

**TEST NO.** 14

**SHEET:** 1 OF 1

**DATE:** 5 NOV, 1971

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 117 | | 601 | | | 119 | | 218 | | 312 | | 406 | | 612 | | 1001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | SET | | | | | SYSTEM | | | | | | | | | | PHASE |
| | | TERM VOLTAGE | | FREQUENCY | | | TERM VOLTAGE | | LINE CURRENT | | OUTPUT | POWER | POWER FACTOR | | FREQUENCY | | DIFF |
| **UNITS** | HRS | | VOLTS | | HZ | | | VOLTS | AMPS | AMPS | KW | KW | | —— | | HZ | DEG |
| **SYM** | | | | | | | | | X20 | X1 | X20 | X1 | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0830 | STARTED SYSTEM APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0831 | STARTED SET | | | | | | | | | | | | | | | |
| | 0833 | | 108 | | 60.0 | | | 120 | 2.6 | 52 | .25 | 5.0 | | 0.80 | | 60.0 | 0 |
| | 0835 | | 112 | SET PARALLELED WITH SYSTEM | | | | | | | | | | | | | 0 |
| | 0840 | OPENED SET CIRCUIT INTERRUPTER | | | | | | | | | | | | | | | |
| | 0841 | | 108 | | 60.0 | | | 120 | 2.6 | 52 | .25 | 5.0 | | 0.80 | | 60.0 | 0 |
| | 0842 | ATTEMPTED TO CLOSE CIRCUIT INTERRUPTER WITH UNIT PARALLEL SWITCH IN THE UNIT | | | | | | | | | | | | | | | |
| | | POSITION –SET WOULD NOT PARALLEL | | | | | | | | | | | | | | | |
| | 0845 | | 132 | | 60.0 | | | 120 | 2.6 | 52 | .25 | 5.0 | | 0.80 | | 60.0 | 0 |
| | 0847 | | 129 | | 60.0 | | SET PARALLELED WITH SYSTEM | | | | | | | | | | |
| | 0850 | OPENED SET CIRCUIT INTERRUPTER | | | | | | | | | | | | | | | |
| | 0851 | | 132 | | 60.0 | | | 120 | 2.6 | 52 | .25 | 5.0 | | 0.80 | | 60.0 | 0 |
| | 0853 | ATTEMPTED TO CLOSE CIRCUIT INTERRUPTER WITH UNIT – PARALLEL SWITCH IN THE | | | | | | | | | | | | | | | |
| | | UNIT POSITION – SET WOULD NOT PARALLEL | | | | | | | | | | | | | | | |
| | 0900 | | 120 | | 58.5 | | | 120 | 2.6 | 52 | .25 | 5.0 | | 0.80 | | 60.0 | 0 |
| | 0902 | | 120 | | 60.0 | | | 120 | 2.6 | 52 | .25 | 5.0 | | 0.80 | | 60.0 | 0 |
| | | SET PARALLELED WITH SYSTEM | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 0905 | OPENED SET CIRCUIT INTERRUPTER | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | C.T. FOR LINE CURRENT N. 1305, 1306, 1307 | | | | | | | | | | | | | | | | |
| | LOAD WAS BALANCED ON THE SYSTEM THE READINGS SHOWN | | | | | | | | | | | | | | | | |
| | FOR VOLTS, AMPS, KW, POWER FACTOR WERE FROM PHASE 1 ONLY | | | | | | | | | | | | | | | | |

FIGURE 521.1-1 Portion of typical test record for paralleling aid device test.

# METHOD 601.1e

## VOLTAGE WAVEFORM TEST

601.1.1 General. Voltage waveform is the value of voltage as a function of time. A graphic representation of a voltage waveform may be obtained using a data recorder.

Generally, the voltage waveform produced by alternating-current power systems is approximately sinusoidal; however, since the design of power systems varies, the voltage waveform also varies or deviates differently for each power system design. The term deviation factor is used to describe the maximum deviation of a power system voltage waveform from that of a true sine wave. The deviation factor of a wave is defined as the ratio of the maximum difference between corresponding ordinates of the wave and the equivalent true sine wave to the peak value of the equivalent true sine wave when the two waves are superposed in such a manner as to make this maximum difference as small as possible.

Since some equipment powered by a power system may not function properly if the voltage waveform deviates too much from a true sine wave, it is important that the deviation factor be maintained within practical limits.

601.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. In addition, use a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter (unless otherwise specified in the procurement document). Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

601.1.3 Procedure.

601.1.3.1 Preparation for test. Connect the load and instrumentation in accordance with the applicable figure of 205.1.10, the data recorder manufacturer's instructions, and the instructions given in this Method for one voltage connection and frequency specified in the procurement document.

601.1.3.2 Test.

a. Connect the data recorder to one of the line connections ($L_1$-$L_2$, $L_1$-N, etc.) specified in the procurement document.

b. Start and operate the power system at one of the load conditions specified in the procurement document.

c. Save and plot sine wave data from data recorder.

d. Read and record the load instrumentation and line connection per METHOD 203.1 (see FIGURE 601.1-1).

e. Repeat steps b through d above for each of the other line connections specified in the procurement document.

f. Repeat steps b through e above for each of the other voltage connections, frequencies, and load conditions specified in the procurement document.

601.1.4 Results.

a. Measure the equivalent sine wave by the following method (see FIGURE 601.1-2 and FIGURE 601.1-3):

1. Construct the zero potential line of the voltage trace midway between the positive and negative peaks, being careful to use the center of the trace width.

2. Using one complete cycle of the trace, divide the zero potential line into at least 36 equal parts beginning and ending at the points where the trace crosses the zero potential line.

3. Construct line (ordinates) perpendicular to the zero potential line at each of the points established in step 2 above.

4. Measure the length of each ordinate from the zero potential line to the center of the trace width, to the nearest millimeter.

5. Square each measured ordinate and sum the squares. Divide this sum by the total number of equal parts.

6. Take the square root of the value obtained in step 5 above and multiply this value by the square root of 2.

7. Using the value obtained in step 6 above as the peak value of the equivalent sine wave, calculate the lengths of the remaining ordinates using the sine of the electrical degree angles at each of the remaining points established in step 2 above.

8. Construct the equivalent sine wave with a time base equal to the complete cycle of the generator voltage waveform trace used in step 2 above. This construction must be on a separate sheet of paper in order to proceed with part b below.

b. Comparison of waves:

1. Superpose the complete cycle used in 601.1.4a.2 over the equivalent sine wave constructed in 601.1.4a.8 so that the maximum vertical difference between the two traces is as small as possible. Accomplish this by shifting

one trace with respect to the other, keeping the zero potential lines of the two traces superposed.

2. Determine, to the nearest 0.25 millimeter, the maximum vertical difference between the two traces.

3. Divide the result of step 2 above by the peak value obtained in 601.1.4a.6, then multiply by 100. This is the deviation factor of the generator waveform, in percent.

c. Compare the deviation factor determined in 601.1.4b.3 above with the requirement of the procurement document.

601.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable deviation factor.

b. Load conditions at which this Method is to be performed.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Line connections ($L_1$-$L_2$, $L_1$-N, etc.) for which this Method is to be performed.

**DESCRIPTION:** 10KW, 60HZ
120/208 VOLTS 3-PHASE
0. 8 P. F. POWER SYSTEM

**MFGR:** ENGENSETS, INC.

**MODEL NO.** SF-10.0-MD/SIED

**SERIAL NO.** 21067

**REF.** MIL-STD-705/601.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE WAVEFORM
TEST

**TEST NO.** 40

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

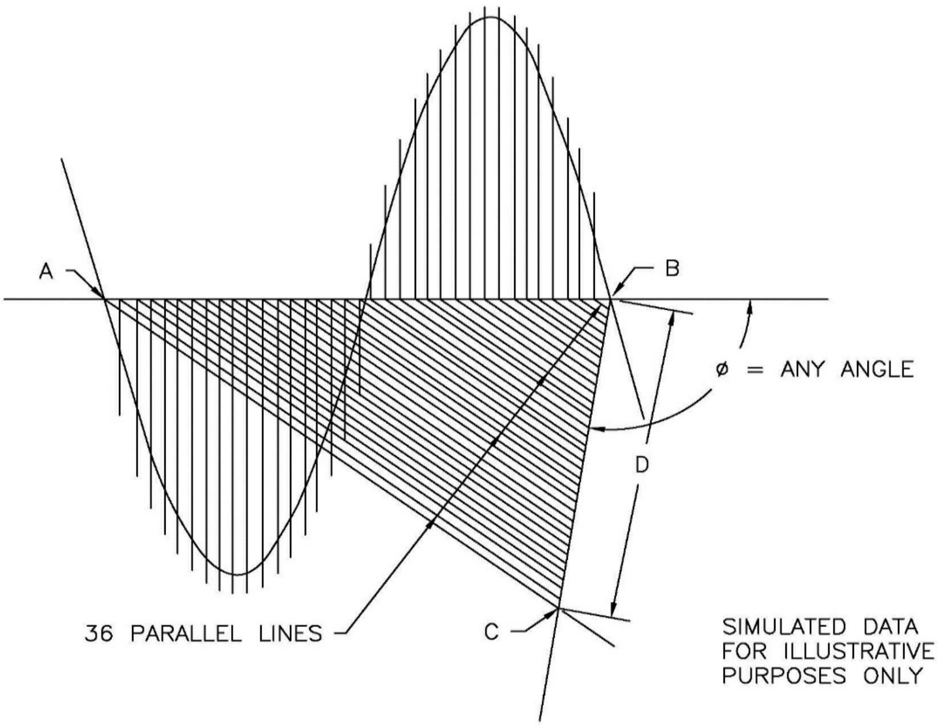
**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | | 495 | 317 | 425 | | | | 465 | 010 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | LINE CONN | TERM VOLT | LINE CURR | OUTPUT POWER | | | | POWER FACTOR | FREQ | PIC NO | | | | | | |
| **UNITS** | HRS | | VOLTS | AMPS | KW | KW | KW | KW | -- | HZ | | | | | | | |
| **SYM** | | | | X10 | X10 | X10 | X10 | X1 | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1300 | $L_1$-$L_2$ | 208 | 3.5 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 1 | | | | | | |
| | | $L_2$-$L_3$ | 208 | 3.5 | 0.33 | 0.33 | 0.33 | 9.9 | 0.80 | 60.0 | 2 | | | | | | |
| | | $L_3$-$L_1$ | 208 | 3.5 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 3 | | | | | | |
| | | $L_1$-N | 120 | 3.5 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 4 | | | | | | |
| | | $L_2$-N | 120 | 3.5 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 5 | | | | | | |
| | | $L_3$-N | 120 | 3.5 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 6 | | | | | | |
| | | $L_1$-$L_2$ | 208 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 7 | | | | | | |
| | | $L_2$-$L_3$ | 208 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 8 | | | | | | |
| | | $L_3$-$L_1$ | 208 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 9 | | | | | | |
| | | $L_1$-N | 120 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 10 | | | | | | |
| | | $L_2$-N | 120 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 11 | | | | | | |
| | | $L_3$-N | 120 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 12 | | | | | | |
| | | $L_1$-$L_2$ | 208 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 13 | | | | | | |
| | | $L_2$-$L_3$ | 208 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 14 | | | | | | |
| | | $L_3$-$L_1$ | 208 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 15 | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | $L_1$-N | 120 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 16 | | | | | | |
| | | $L_2$-N | 120 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 17 | | | | | | |
| | | $L_3$-N | 120 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 18 | | | | | | |
| **NOTES** | CT # 1151 | | | | | | | | | | | | | | | | |

FIGURE 601.1-1 Typical test record for voltage waveform test.




D = ANY DISTANCE EASILY DIVIDED INTO 36 EQUAL PARTS.

NOTES:

1. (A) is the intersection of the zero potential line with the voltage trace and shall be the start of the complete cycle.

2. (B) is the second intersection of the zero potential line with the voltage trace counting from (A) and shall be the end of the complete cycle.

3. (C) is 36 equal distances from (B) along any line starting at (B).

4. Line A-C is the direction of the 36 parallel lines dividing the zero potential line into 36 equal parts. These lines start at each of the 36 equal divisions of line B-C.

FIGURE 601.1-2 Typical oscillogram of a voltage waveform.

| ORDINATE NO. | ORDINATE LENGTH (mm) | ORDINATE SQUARED $(mm)^2$ | ANGLE ELECTRICAL DEGREES | SINE OF ANGLE | ORDINATE LENGTH EQUIV. SINE WAVE |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 10 | 100 | 10 | 0.174 | 9 |
| 2 | 20 | 400 | 20 | 0.342 | 18 |
| 3 | 29 | 841 | 30 | 0.500 | 26 |
| 4 | 35 | 1225 | 40 | 0.643 | 34 |
| 5 | 41 | 1681 | 50 | 0.766 | 40 |
| 6 | 45 | 2025 | 60 | 0.866 | 45 |
| 7 | 49 | 2401 | 70 | 0.940 | 49 |
| 8 | 51 | 2601 | 80 | 0.985 | 51.5 |
| 9 | 52 | 2704 | 90 | 1.000 | 52 |
| 10 | 51 | 2601 | 100 | 0.985 | 51.5 |
| 11 | 50 | 2500 | 110 | 0.940 | 49 |
| 12 | 46 | 2116 | 120 | 0.866 | 45 |
| 13 | 42 | 1764 | 130 | 0.766 | 40 |
| 14 | 37 | 1369 | 140 | 0.643 | 34 |
| 15 | 30 | 900 | 150 | 0.500 | 26 |
| 16 | 23 | 529 | 160 | 0.342 | 18 |
| 17 | 15 | 225 | 170 | 0.174 | 9 |
| 18 | 6 | 36 | 180 | 0 | 0 |
| 19 | -2 | 4 | 190 | -0.174 | -9 |
| 20 | -12 | 144 | 200 | -0.342 | -18 |
| 21 | -21 | 441 | 210 | -0.500 | -26 |
| 22 | -31 | 961 | 220 | -0.643 | -34 |
| 23 | -37 | 1369 | 230 | -0.766 | -40 |
| 24 | -42 | 1764 | 240 | -0.866 | -45 |
| 25 | -47 | 2209 | 250 | -0.940 | -49 |
| 26 | -50 | 2500 | 260 | -0.985 | -51.5 |
| 27 | -52 | 2704 | 270 | -1.000 | -52 |
| 28 | -51 | 2601 | 280 | -0.985 | -51.5 |
| 29 | -50 | 2500 | 290 | -0.940 | -49 |
| 30 | -46 | 2116 | 300 | -0.866 | -45 |
| 31 | -41 | 1681 | 310 | -0.766 | -40 |
| 32 | -35 | 1225 | 320 | -0.643 | -34 |
| 33 | -26 | 676 | 330 | -0.500 | -26 |
| 34 | -19 | 361 | 340 | -0.342 | -18 |
| 35 | -10 | 100 | 350 | -0.174 | -9 |
| 36 | 0 | 0 | 360 | 0 | 0 |
| | TOTAL | 49,374 | | | |
| | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY | |

PEAK VALUE OF EQUIV. SINE WAVE = $\sqrt{\frac{49{,}374}{36}} \text{ X } \sqrt{2} = 52 \text{ mm}$

TYPICAL EQUIVALENT SINE WAVE ORDINATE CALCULATION:

ORDINATE AT 10 DEGREES = SINE 10° X 52 (PEAK VALUE OF EQUIV. SINE WAVE)
= 0.174 X 52 = 9 mm

FIGURE 601.1-3 Sample calculation of equivalent sine wave.

# METHOD 601.4c

## VOLTAGE WAVEFORM TEST
## (HARMONIC ANALYSIS)

601.4.1 General. The voltage waveform of a power system may be analyzed by determining the magnitude of the specific frequency components, other than the fundamental, contained in the waveform. The method of analysis is called harmonic analysis. A harmonic is defined as a frequency component whose frequency is an integral multiple of the fundamental frequency of the waveform.

601.4.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. In addition, use a waveform analyzer and a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter (unless otherwise specified in the procurement document). Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

601.4.3 Procedure.

601.4.3.1 Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figure in 205.1.10 for a voltage connection and frequency specified in the procurement document.

b. Connect the waveform analyzer and data recorder signal inputs directly to the power system output terminals, for one of the line connections ($L_1$-$L_2$, $L_1$-N, etc.) specified in the procurement document.

> **NOTE**: If the power system output voltage magnitude will be greater than the voltage input ratings of either the waveform analyzer or data recorder, use a voltage divider of noninductive-resistive components to lower the input voltage such that it is compatible with the signal input voltage ratings of the waveform analyzer or data recorder. For the data recorder, a probe may be used but care must be exercised to insure that it is properly adjusted in accordance with the manufacturer's instructions.

601.4.3.2 Test.

a. Start and operate the power system at rated voltage, rated frequency, and at one of the load conditions specified in the procurement document.

b. Operate the waveform analyzer in accordance with the manufacturer's instructions and record, as a percentage of the fundamental, the magnitude of each harmonic in excess of 0.05 percent. On preproduction power systems, record all the harmonics through the 50th, fractional order harmonics and slot harmonics per METHOD 203.1 (see FIGURE 601.4-1). Scan the frequencies through 50 kHz and record any harmonics greater than 0.05 percent. On production power systems, record the harmonics through the 20th.

**NOTE**: The calibration of the waveform analyzer must be checked, using the internal calibrator, before proceeding to the next condition (e.g. load condition, line connection, etc.).

c. Repeat 601.4.3 for each of the other load conditions, line connections, voltage conditions and frequencies specified in the procurement document.

601.4.4 Results. In addition to the load instrumentation readings, show the values of the harmonics in percent of the fundamental for each line connection, load condition, voltage connection and frequency on the data sheet. Compare these results with the procurement document requirements.

601.4.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable value of a single harmonic, in percent of the fundamental.

b. Line connection(s) at which this Method is to be performed.

c. Load conditions(s) at which this Method is to be performed.

d. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

e. Discontinuities in the voltage waveform allowed, if any.

**DESCRIPTION:** 10KW, 60HZ
120/208 VOLTS 3-PHASE
0. 8 P. F. POWER SYSTEM

**MFGR:** ENGENSETS, INC.

**MODEL NO.** SF-10.0-MD/SIED

**SERIAL NO.** 21067

**REF.** MIL-STD-705/601.4

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE WAVEFORM TEST
(HARMONIC ANALYSIS)

**TEST NO.** 15

**SHEET:** 1 OF 4

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | | 495 | 317 | 425 | | | | 465 | 010 | 792 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | LINE CONN | TERM VOLT | LINE CURR | OUTPUT POWER | | | | POWER FACTOR | FREQ | HARMONIC | | | | | | |
| | | | | | | | | | | | FUND | 2ND | 3RD | 4TH | 5TH | 6TH | 7TH |
| **UNITS** | | | VOLTS | AMPS | $L_1$ | $L_2$ | $L_3$ | KW | | HZ | % | % | % | % | % | % | % |
| **SYM** | | | | X10 | X10 | X10 | X10 | X1 | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1300 | $L_1$-$L_3$ | 208 | 3.4 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 100 | 0.10 | 1.30 | 0.08 | 0.72 | 0.06 | 0.43 |
| | | $L_2$-$L_3$ | 208 | 3.4 | 0.33 | 0.33 | 0.33 | 10.0 | 0.80 | 60.0 | 100 | 0.11 | 1.27 | 0.06 | 0.71 | 0.05 | 0.43 |
| | | $L_3$-$L_1$ | 208 | 3.5 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 100 | 0.11 | 1.29 | 0.07 | 0.70 | 0.06 | 0.42 |
| | | $L_1$-N | 120 | 3.4 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 100 | 0.09 | 1.75 | 0.13 | 0.92 | 0.09 | 0.27 |
| | | $L_2$-N | 120 | 3.4 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 100 | 0.10 | 1.72 | 0.11 | 0.84 | 0.06 | 0.24 |
| | | $L_3$-N | 120 | 3.5 | 0.33 | 0.33 | 0.34 | 10.0 | 0.80 | 60.0 | 100 | 0.09 | 1.75 | 0.12 | 0.91 | 0.08 | 0.26 |
| | | $L_1$-$L_2$ | 208 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 100 | 0.07 | 1.10 | 0.06 | 0.65 | - | 0.39 |
| | | $L_2$-$L_3$ | 208 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 100 | 0.06 | 1.15 | 0.07 | 0.64 | - | 0.37 |
| | | $L_3$-$L_1$ | 208 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 100 | 0.07 | 1.13 | 0.05 | 0.63 | - | 0.38 |
| | | $L_1$-N | 120 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 100 | 0.08 | 1.52 | 0.09 | 0.86 | 0.05 | 0.09 |
| | | $L_2$-N | 120 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 100 | 0.07 | 1.97 | 0.07 | 0.84 | - | 0.08 |
| | | $L_3$-N | 120 | 2.8 | 0.33 | 0.33 | 0.34 | 10.0 | 1.0 | 60.0 | 100 | 0.08 | 1.51 | 0.08 | 0.85 | 0.06 | 0.10 |
| | | $L_1$-$L_2$ | 208 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 100 | - | 2.11 | - | 0.30 | - | 0.18 |
| | | $L_2$-$L_3$ | 208 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 100 | - | 2.33 | - | 0.28 | - | 0.16 |
| | | $L_3$-$L_1$ | 208 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 100 | - | 2.16 | - | 0.29 | - | 0.15 |
| | | $L_1$-N | 120 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 100 | - | 2.30 | - | 0.41 | - | 0.06 |
| | | $L_2$-N | 120 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 100 | - | 2.28 | - | 0.42 | - | 0.07 |
| | | $L_3$-N | 120 | 0 | 0 | 0 | 0 | 0 | - | 60.0 | 100 | - | 2.26 | - | 0.40 | - | 0.07 |
| **NOTES** | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |

FIGURE 601.4-1 Portion of a typical test record for voltage waveform test (harmonic analysis).

# METHOD 601.5a

## VOLTAGE WAVEFORM TEST (DEVIATION FACTOR)

601.5.1 General. Voltage waveform is the value of voltage as a function of time. The deviation factor of a wave is the ratio of the maximum difference between corresponding ordinates of the wave and of the equivalent sine wave to the maximum ordinate of the equivalent sine wave when the waves are superposed in such a way as to make this maximum difference as small as possible. Since some equipment powered by a power system may not function properly if the voltage waveform deviates too much from a true sine wave, the deviation factor must be maintained within practical limits.

601.5.2 Apparatus. Use Instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. In addition, use a data acquisition instrument or system capable of digitizing, storing, and displaying one cycle of the voltage waveform in an x-y format will also be required. Data acquisition instruments are described in METHOD 106.1. Also a non-inductive voltage divider may be required to reduce the generator line voltage to a voltage compatible with the instrumentation input. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

601.5.3 Procedure.

601.5.3.1 Preparation of test. Connect the load and instrumentation in accordance with the applicable figure of METHOD 205.1, the data acquisition instrument manufacturer's instructions, and the instructions contained herein for one voltage connection and frequency specified in the procurement document.

601.5.3.2 Test.

601.5.3.2.1 Waveform acquisition.

**CAUTION: Some digital equipment may have single-ended inputs; that is, one input load is connected to the chassis ground. This chassis ground is electrically the same as "House Power" ground and the engine generators utilized during this test may have their neutral tied to earth ground. This condition presents no problem for phase-to-neutral (L-N) voltage waveform measurements. For phase-to-phase ($L_1$-$L_2$, $L_2$-$L_3$, etc.) measurements however, it may be necessary to "float" the instrument (lift the chassis ground). A phase-to-phase non-inductive voltage divider may be used to reduce the signal voltage to the instrument.**

a. Connect the voltage waveform deviation measurement system to one of the line connections ($L_1$-$L_2$, $L_1$-N, etc.) specified in the procurement document.

b. Start and operate the power system at one of the load conditions specified in the procurement document. Record load instrumentation, line connection and voltage connection on the data sheet per METHOD 203.1 (see FIGURE 601.5-1).

c. Store the sampled waveform in memory.

d. Record the voltage waveform in an x-y format.

e. From the stored digital waveform data, analyze the waveform for deviation from a true sine wave. If the data acquisition system has the capability of storing the data, the waveform analysis may be performed after all waveform samples are obtained.

f. Repeat steps a through e for each of the other line connections, load conditions, voltage outputs, and frequencies specified in the procurement document. Once the waveform is digitized, the waveform deviation should be processed by calculator or computer on a numerical basis.

601.5.3.2.2 Waveform analysis. The mathematical data reduction techniques described herein require the accurate shifting of the theoretical sine wave in 0.25 degree increments. Therefore, the shifting operation should be performed on a numerical basis utilizing a computer or a programmable calculator.

a. From the recorded waveform, establish the zero potential line midway between the positive and negative peaks of the voltage waveform.

b. Divide the zero potential line into at least 36 parts for 1 complete waveform.

c. Determine the voltage waveform amplitude at each of these points.

d. Square each value in step c and sum the squares. Divide this sum by the total number of sample points used in step b.

e. Take the square root of the value obtained in step d and multiply this value by the square root of two.

f. Using the value obtained in step e as the peak value of the equivalent sine wave, calculate the lengths of the remaining ordinates using the sine of the electrical degree angles at each of the remaining points established in step b above.

g. Compare sample waveform actual values versus theoretical values.

h. Determine the maximum difference at each ordinate.

i. Divide the results of step h above by the peak value obtained in step e above. This is a deviation factor.

j. Shift the ordinates established in step f above by a maximum of $\pm$0.25 degrees steps. Recalculate the amplitude of these ordinates.

k. Repeat steps h, i, and j until the deviation factor is minimized. This is the deviation factor of the generator in percent. Record the deviation factor on the data sheet.

l. Compare the minimum deviation factor determined in step k above with the requirements of the procurement document.

601.5.4 Results. The data required from this test shall include:

a. Data sheet showing line connection, load instrument readings, frequency, etc.

b. x-y presentation of each sample generator waveform for each line connection, load condition, voltage connection and frequency specified in the procurement document.

c. Maximum deviation in percent from a true sine wave.

d. An equipment list showing all load measuring equipment, data acquisition system components, and data analysis equipment utilized.

e. Data analysis program utilized. For example, if a computer based data reduction system is used, supply the computer program listing.

601.5.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable deviation factor.

b. Load conditions at which this Method is to be performed.

c. Voltage(s) connections and frequency(ies) at which this Method is to be performed.

d. Line connections ($L_1$-$L_2$, $L_1$-N, etc.) for which this Method is to be performed.

**DESCRIPTION:**
120V, 10KW, 0.8PF
POWER SYSTEM

**MFGR:** ACE MFG. CO.

**MODEL NO.** MEP-003A

**SERIAL NO.** XX0001

**REF.** MIL-STD-705/601.5

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE WAVEFORM TEST
(DEVIATION FACTOR)

**TEST NO.** 601.1

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | | 495 | 317 | 425 | 465 | 010 | 216 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | LINE CONN | TERM V | LINE I | PWR | P.F. | FREQ | X-Y | | MAX DEV | | | | | | | AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | KW | -- | HZ | | | % | | | | | | | °C |
| **SYM** | | | | X40 | X40 | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 1 | 0900 | $L_1$-$L_3$ | 120.0 | 2.60 | 2.50 | 0.8 | 60.0 | 1 | | 2.31 | | | | | | | 21 |
| 2 | 0930 | $L_1$-$L_3$ | 120.0 | 0 | 0 | - | 60.0 | 2 | | 1.20 | | | | | | | 21 |
| 3 | 1000 | $L_1$-$L_3$ | 120.0 | 2.08 | 2.50 | 1.0 | 60.0 | 3 | | 1.72 | | | | | | | 21 |
| 4 | 1030 | $L_1$-$L_3$ | 120.0 | 1.04 | 1.25 | 1.0 | 60.0 | 4 | | 1.51 | | | | | | | 21 |
| 5 | 1100 | $L_1$-$L_3$ | 120.0 | 1.30 | 1.25 | 0.8 | 60.0 | 5 | | 2.21 | | | | | | | 21 |
| 6 | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| 9 | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | |
| **NOTES** | CURRENT TRANSFORMER RATIO 200/5 SN: 1151. WAVEFORM INSTRUMENT/SYSTEM DESCRIPTION | | | | | | | | | | | | | | | | |

FIGURE 601.5-1 Typical test record for voltage waveform test (deviation factor).

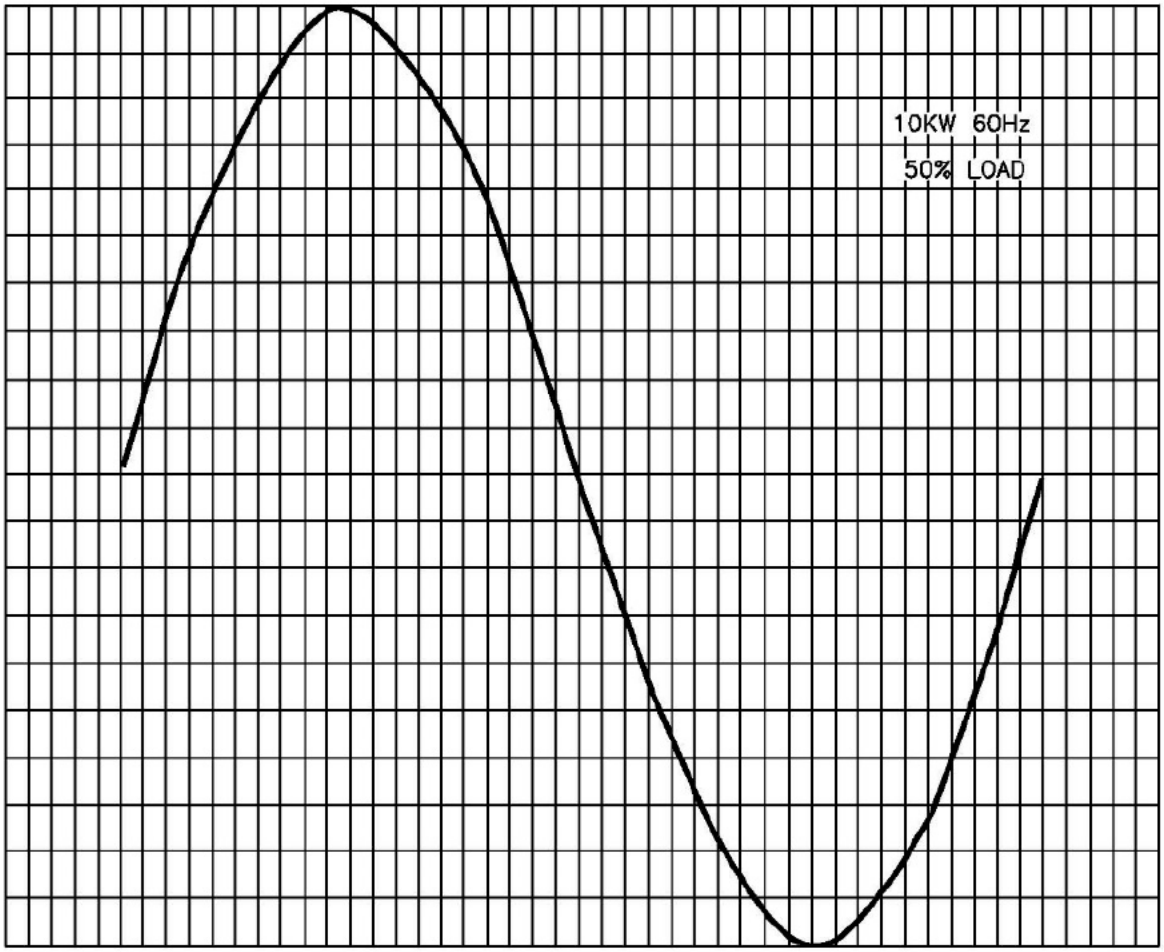



FIGURE 601.5-2 Typical x-y graph of voltage waveform.

# METHOD 602.1c

## VOLTAGE MODULATION TEST

602.1.1 General. If the peak value of a voltage wave is not constant but varies with time, the wave is considered to be voltage modulated. In many cases, the rate at which the peak value varies is so rapid or the magnitude of variation so small that the modulation cannot be detected by observation of a voltmeter. Voltage modulation can affect the operation of the power system as well as some types of electrical equipment.

602.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. In addition, use a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter (unless otherwise specified in the procurement document) to measure the output voltage waveform. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

602.1.3 Procedure.

602.1.3.1 Preparation for test.

a. Connect the load apparatus in accordance with the applicable figure of 205.1.10.

b. Operate the power system at rated frequency and voltage at no load.

602.1.3.2 Test.

a. With the power system operating at rated voltage, rated frequency, and at the load specified in the procurement document, collect one second worth of waveform data.

b. Repeat step a above for each of the conditions specified in the procurement document.

602.1.4 Results.

a. Examine the positive peaks of the voltage waveform throughout the 1 second worth of collected data, to determine the highest and lowest amplitudes of the peaks. Calculate the difference between the highest and lowest peaks; this will be designated $V_P$. Calculate voltage modulation as follows:

$$Percent\ modulation = \frac{V_P}{rated\ voltage} * 100$$

b. Repeat step a for the negative peaks.

c. Select the larger of the values obtained from steps a and b. This larger value is the voltage modulation for the particular conditions tested.

d. Determine from the data if any repetitive pattern is present in the positive or negative peak pattern and the number of positive or negative peaks between the repetitions if it exists. Divide this number into the frequency meter reading at the time the data was taken. This value is the frequency of the modulation.

$$Percent\ frequency\ modulation = \frac{time\ between\ repetitive\ peaks}{rated\ frequency} * 100$$

e. Compare the results with procurement document requirements.

602.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Allowable voltage modulation.

b. Frequency limitations (if any) on modulation.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Load conditions at which this Method is to be performed.

e. Individual phases to be tested, if required.

METHOD 608.1c

# FREQUENCY AND VOLTAGE REGULATION, STABILITY AND TRANSIENT RESPONSE TEST (SHORT-TERM)

608.1.1 General. The frequency regulation (sometimes referred to as droop) of a power system is the maximum difference between the no load value of frequency and the value at any load up to and including rated load. This difference is expressed as a percentage of the rated frequency of the power system. The voltage regulation is expressed similarly except that the RMS value of voltage is used.

Frequency stability describes the tendency of the frequency to remain at a constant value at a constant load. Generally, the instantaneous value of frequency is not constant but varies randomly above and below a mean value. Stability may be described as either short-term or long-term depending upon the length of time that the frequency is observed. This Method defines the short-term stability to be based on 30 seconds. Another term, bandwidth, describes the limits of these variations. Bandwidth is expressed as a percentage of the rated frequency of the power system. Voltage stability is described similarly.

Frequency transient response describes the reaction of the frequency to a sudden change in some condition; such as, a load change on a power system. This response consists of the amount of excursion beyond the mean of the new operating band, and the recovery time. The recovery time is the interval beginning at the point where the frequency leaves the original prescribed operating band and ending at the point where it enters and remains within the new prescribed operating band. The amount of surge is expressed as a percentage of the rated frequency of the power system. The recovery time is expressed in seconds. The voltage transient response is described similarly.

FIGURE 608.1-4 is a diagrammatic representation of the above terms.

608.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. If power system stabilization is to be determined through the temperature of the oil (see 608.1.3.2a), use instrumentation for measuring the oil temperature in the oil sump as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.

– Output shall be ±5 volts DC maximum.

– The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

608.1.3 Procedure.

608.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

b. Record the following items on both data sheets and file(s):

1. The date.

2. The serial number(s) of the recording meter(s).

3. Power system identification.

4. The data reading number (indexing).

(Refer to FIGURE 608.1-1, FIGURE 608.1-2, and FIGURE 608.1-3)

c. Place all instrumentation referred to in 608.1.2 in operation.

608.1.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 608.1-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 608.1.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

   a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

   b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 608.1.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. After stabilization has occurred, operate the power system at each of the following load conditions (one step) for 60 seconds. During each load condition record all instrument readings except thermal instrumentation. For three-phase power systems do not record line-to-line voltages. Apply each load condition to the power system in one step at the end of the short-term stability period for the previous load condition. Process, analyze and present each transient in the data report. The load conditions are:

1. Maintain Rated Load (RL) for 60 seconds to collect stability data prior to first transient event.

**NOTE:** 60 seconds is used throughout this Method to ensure the transients have recovered after the required 30 second steady-state stability.

a. Transient 1 – RL to No Load (NL).
b. Transient 2 – NL to RL.
c. Transient 3 – RL to NL.
d. Transient 4 – NL to RL.
e. Transient 5 – RL to NL.
f. Transient 6 – NL to RL.
g. At this point, examine data results and determine whether the power system is operating within requirements. At a minimum, check voltage and frequency regulation to determine that the power system meets the procurement document requirements (see 608.1.5). If the power system does not meet requirements, stop test and report failure.

2. Maintain Rated Load (RL) for 60 seconds to collect stability data prior to first transient event.

a. Transient 1 – RL to No Load (NL).
b. Transient 2 – NL to RL.
c. Transient 3 – RL to NL.
d. Transient 4 – NL to RL.
e. Transient 5 – RL to NL.
f. Transient 6 – NL to RL.

**NOTE:** Paragraph 2 may be omitted if the results from paragraph 1 includes all of the analysis requirements in 608.1.4 and is to be treated as valid data for the test.

3. Adjust load to 75% of RL. Make no adjustments to either voltage or frequency. Maintain 75% rated load for a minimum of 60 seconds to collect stability data prior to first transient event.

   a. Transient 7 – 75% to NL.
   b. Transient 8 – NL to 75%.
   c. Transient 9 – 75% to NL.
   d. Transient 10 – NL to 75%.
   e. Transient 11 – 75% to NL.
   f. Transient 12 – NL to 75%.

4. Adjust load to 50% of RL. Make no adjustments to either voltage or frequency. Maintain 50% rated load for a minimum of 60 seconds to collect stability data prior to first transient event.

   a. Transient 13 – 50% to NL.
   b. Transient 14 – NL to 50%.
   c. Transient 15 – 50% to NL.
   d. Transient 16 – NL to 50%.
   e. Transient 17 – 50% to NL.
   f. Transient 18 – NL to 50%.

5. Adjust load to 25% of RL. Make no adjustments to either voltage or frequency. Maintain 25% rated load for a minimum of 60 seconds to collect stability data prior to first transient event.

   a. Transient 19 – 25% to NL.
   b. Transient 20 – NL to 25%.
   c. Transient 21 – 25% to NL.
   d. Transient 22 – NL to 25%.
   e. Transient 23 – 25% to NL.
   f. Transient 24 – NL to 25%.

6. Adjust load to RL. Make no adjustments to either voltage or frequency shall be made. Maintain rated load for a minimum of 60 seconds to collect stability data prior to first transient event.

   a. Transient 25 – RL to NL.
   b. Transient 26 – NL to RL.
   c. Transient 27 – RL to NL.
   d. Transient 28 – NL to RL.
   e. Transient 29 – RL to NL.
   f. Transient 30 – NL to RL.

c. Repeat steps a and b for any other voltage connection(s) and frequency(ies) specified in the procurement document.

608.1.4 Results. Prepare a data sheet for all voltage connection(s) similar to FIGURE 608.1-3 giving for each transient the short-term stability bandwidth, the maximum overshoot or undershoot, the recovery time, and regulation.

a. To determine the observed short-term stability voltage bandwidth as a percentage (referring to FIGURE 608.1-4, bandwidth B):

1. Determine the highest and lowest voltage during each constant load. See $B_H$ and $B_L$ of FIGURE 608.1-4, respectively.

2. Take half the difference between the highest and lowest voltage and divide it by the rated voltage and multiply it by 100. This is the observed short-term stability voltage bandwidth as a percentage. For example, using FIGURE 608.1-4, calculate the observed short-term stability voltage bandwidth (B) as follows:

$$B = \frac{B_H - B_L}{2 * (Rated\ Voltage)} * 100$$

b. To determine the location of the prescribed short-term stability voltage bandwidth for each load (referring to FIGURE 608.1-4, bandwidth D):

1. Take the mean of all voltage readings during each $T_S$. This is the observed short-term stability voltage for the constant load. See $C_L$ or $C_N$ of FIGURE 608.1-4.

2. To calculate the prescribed short-term stability voltage bandwidth: multiply the short-term stability voltage found in step 1 by half the allowable bandwidth in percentage according to the procurement document (see 608.1.5).

$$D_{Limit} = C_L * \frac{(Allowable\ Bandwidth)}{2}$$

3. Add the value found in step 2 to the short-term stability voltage found in step 1 to get the upper bandwidth voltage. Subtract the value found in step 2 from the short-term stability voltage to get the lower bandwidth voltage. This is the prescribed short-term stability voltage bandwidth. For example, see prescribed short-term stability bandwidth D from FIGURE 608.1-4.

$$D_{High} = C_L + D_{Limit}$$

$$D_{Low} = C_L - D_{Limit}$$

c. To determine the maximum overshoot/undershoot voltage at each transient as a percentage of its rated voltage:

1. From the data, calculate the difference between the maximum overshoot/undershoot voltage (see $S_O$ or $S_U$ of FIGURE 608.1-4) and the new observed steady-state voltage following the transient.

$$S_O = S_{MAX} - C_N$$

$$S_U = C_L - S_{MIN}$$

2. Divide the voltage determined in step 1 by the rated voltage of the power system, then multiply by 100 to convert to percentage. This is the maximum overshoot/undershoot voltage as a percentage of its rated voltage.

$$Maximum\ Overshoot = \frac{S_O}{(Rated\ Voltage)} * 100$$

$$Maximum\ Undershoot = \frac{S_U}{(Rated\ Voltage)} * 100$$

**NOTE:** Do not use the constant operating voltage at each load as the divisor in the computation. Use only the rated voltage of the power system.

d. To determine the recovery time required to restore stable voltage conditions after each transient:

1. For each transient, determine the time at which the voltage leaves the prescribed short-term stability bandwidth. For example, see point E on FIGURE 608.1-4.

2. For each transient, determine the time at which the voltage enters and remains within the new prescribed short-term stability bandwidth. For example, see point F on FIGURE 608.1-4.

3. The recovery time is the duration of time between the beginning of the transient (step 1) and the end of the transient (step 2). For example, see $T_{FN}$ on FIGURE 608.1-4.

e. To determine the voltage regulation for all transients (e.g. rated load to no load, 3/4 rated load to no load, 1/2 rated load to no load, 1/4 rated load to no load) as a percentage:

   1. Take the mean of all voltage readings during each $T_S$. This is the observed short-term stability voltage for the constant load. See $C_L$ or $C_N$ of FIGURE 608.1-4.

   2. Subtract the load value of the short-term stability voltage (see $C_L$ of FIGURE 608.1-4) from the no load value of the short-term stability voltage (see $C_N$ of FIGURE 608.1-4) for all transients. For voltage regulators utilizing single-phase voltage sensing, only use the value of the short-term stability voltage in the sensed phase in these calculations.

   3. Divide each of the values obtained in step 2 by the rated voltage of the power system and multiply by 100. This is the voltage regulation expressed as a percentage. A sample calculation for FIGURE 608.1-4 follows:

$$Voltage\ Regulation = \frac{C_N - C_L}{(Rated\ Voltage)} * 100$$

f. Repeat steps a through e substituting frequency for voltage.

g. Compare the results tabulated above with the requirements of the procurement document.

608.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Frequency:

   1. Maximum allowable short-term stability bandwidth or deviation in percent of rated frequency.

   2. Maximum allowable recovery time.

   3. Maximum allowable overshoot and undershoot.

   4. Maximum allowable regulation.

   5. Frequency(ies) at which this Method is to be performed.

b. Voltage:

1. Maximum allowable short-term stability bandwidth or deviation in percent of rated voltage.

2. Maximum allowable recovery time.

3. Maximum allowable overshoot and undershoot.

4. Maximum allowable regulation.

5. Voltage connection(s) at which this Method is to be performed.

c. The short-term stability duration if not based on 30 seconds.

| **DESCRIPTION:** 10KW, 60HZ 120 VOLT, SINGLE-PHASE POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/608.1 | **PHILADELPHIA REGION<br>DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>FREQUENCY AND VOLTAGE REGULATION, STABILITY AND TRANSIENT RESPONSE TEST (SHORT-TERM) | **TEST NO.** 4<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST→** | | 201 | | 113 | | 476 | | 194 | | 819 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | - | | HZ | | | | | | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0850 | STARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0855 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 80 |
| | 0900 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 82 |
| | 0905 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 82 |
| | 0910 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 82 |
| | 0915 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 83 |
| | 0920 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 84 |
| | 0925 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 84 |
| | 0930 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 84 |
| | 0935 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 84 |
| | 0940 | STARTED TEST | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 0945 | COMPLETED TEST – SHUTDOWN POWER SYSTEM | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | VOLTAGE AND FREQUENCY RECORDER NO. 1176 | | | | | | | | | | | | | | | | |
| | LINE CURRENT MEASURED USING C.T. NO. 1277 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 608.1-1 Typical test record for stabilization for frequency and voltage regulation, stability and transient response test.

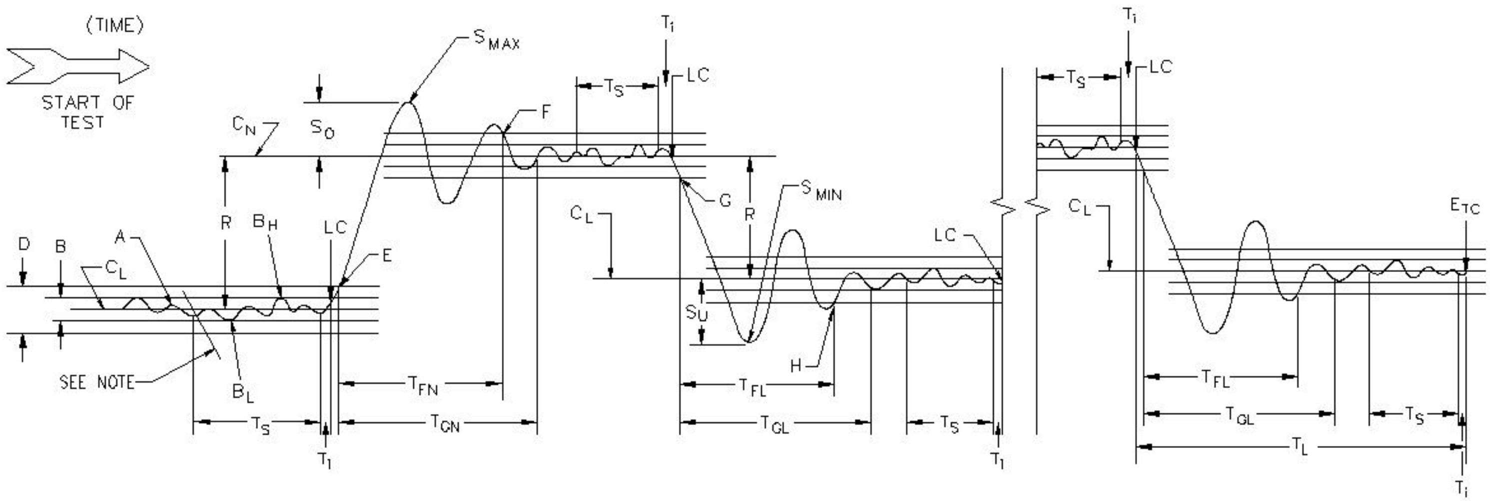
| **DESCRIPTION:** 10KW, 60HZ 120 VOLTS, SINGLE-PHASE POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/608.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>FREQUENCY AND VOLTAGE REGULATION, STABILITY AND TRANSIENT REPONSE TEST (SHORT – TERM) | **TEST NO.** 4<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST→** | | | 201 | 113 | 476 | | 194 | 819 | | | 201 | 113 | 476 | | 194 | 819 | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | LOAD | TERM VOLT | LINE CURR | OUTPUT POWER | | POWER FACTOR | FREQ | | LOAD | TERM VOLT | LINE CURR | OUTPUT POWER | | POWER FACTOR | FREQ | AVG AMB TEMP |
| **UNITS** | HRS | % | VOLTS | AMPS | KW | KW | - | HZ | | % | VOLTS | AMPS | KW | KW | - | HZ | °F |
| **SYM** | | | | X40 | X40 | X1 | | | | | | X40 | X40 | X1 | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1033 | 100 | 120.0 | 2.60 | .250 | 10.0 | .80 | 60.0 | | 50 | 121.0 | 1.30 | .125 | 5.0 | .80 | 61.0 | 84 |
| | | 0 | 121.3 | 0 | 0 | 0 | - | 61.8 | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | |
| | | 100 | 120.0 | 2.60 | .250 | 10.0 | .80 | 60.0 | | 50 | 121.0 | 1.30 | .125 | 5.0 | .80 | 61.0 | |
| | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | |
| | | 100 | 120.0 | 2.60 | .250 | 10.0 | .80 | 60.0 | | 25 | 121.5 | .65 | .063 | 2.5 | .80 | 61.5 | |
| | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | |
| | | 100 | 120.0 | 2.60 | .250 | 10.0 | .80 | 60.0 | | 25 | 121.5 | .65 | .063 | 2.5 | .80 | 61.5 | |
| | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | |
| | | 75 | 120.5 | 1.95 | .187 | 7.5 | .80 | 60.5 | | 25 | 121.5 | .65 | .063 | 2.5 | .80 | 61.5 | |
| | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | |
| | | 75 | 120.5 | 1.95 | .187 | 7.5 | .80 | 60.5 | | 100 | 120.0 | 2.60 | .250 | 10.0 | .80 | 60.0 | |
| | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | |
| | | 75 | 120.5 | 1.95 | .187 | 7.5 | .80 | 60.5 | | 100 | 120.0 | 2.60 | .250 | 10.0 | .80 | 60.0 | |
| | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | |
| | | 50 | 121.0 | 1.30 | .125 | 5.0 | .80 | 61.0 | | 100 | 121.0 | 2.60 | .250 | 10.0 | .80 | 60.0 | |
| | | 0 | 121.8 | 0 | 0 | 0 | - | 61.5 | | 0 | 121.8 | 0 | 0 | 0 | - | 61.8 | |

| **NOTES** | | |
|---|---|---|
| | VOLTAGE AND FREQUENCY RECORDER NO. 1176 | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY |
| | LINE CURRENT MEASURED USING C.T. NO. 1377 | |
| | | |

FIGURE 608.1-2 Portion of a typical test record for frequency and voltage regulation, stability and transient response test.

TRACE AND DEFINITIONS APPLY TO EITHER FREQUENCY OR RMS VOLTAGE




Note: Chart marked at start of test.

A Actual trace of frequency or RMS voltage.

B Observed short-term stability bandwidth (two lines parallel to the axis of chart movement, one each passing through the center points of maximum ($B_H$) and minimum ($B_L$) trace excursion respectively during the prescribed short-term stability period, $T_S$).

$C_L$ Mean value at selected load.

$C_N$ Mean value at no load.

D Prescribed short-term stability bandwidth.

E Point at which trace initially leaves prescribed load bandwidth under condition of decrease in load.

$E_{TC}$ End of transient cycle.

F Point at which trace enters and remains within prescribed no load bandwidth.

G Point at which trace initially leaves prescribed no load bandwidth.

H Point at which trace enters and remains within prescribed load bandwidth.

LC Point at which load change is triggered.

R Regulation between any two loads.

$S_{MAX}$ Maximum excursion during transient from load to no load.

$S_{MIN}$ Maximum excursion during transient from no load to load.

$S_O$ Surge, frequency overshoot or voltage overshoot.

$S_U$ Surge, frequency undershoot or voltage undershoot.

$T_{FL}$ Observed recovery time, no load to load.

$T_{FN}$ Observed recovery time, load to no load.

$T_{GL}$ Maximum allowable recovery time – no load to load.

$T_{GN}$ Maximum allowable recovery time – load to no load.

$T_i$ 0.2 - 0.3 seconds, Interim time between end of $T_S$ and LC.

$T_L$ 60 seconds, Time between load changes, LC.

$T_S$ Prescribed short-term time for determining stability.

FIGURE 608.1-3 Diagrammatic representation of regulation, stability and transient response terms.

**DESCRIPTION:** 10KW, 60HZ
120 VOLTS, SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS INC.

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 21067

**REF.** MIL-STD-705/608.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

FREQUENCY AND VOLTAGE REGULATION,
STABILITY AND TRANSIENT RESPONSE TEST
(SHORT-TERM)

**TEST NO.** 4

**SHEET:** 1 OF 3

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | VOLTAGE | | | | | | | | | FREQUENCY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | LOAD STEP | MAX VOLT EXCURSION | | EXCURSION AS % RATED | | REC TIME | VARIATION | | REGULATION VOLT | REGULATION FREQ | MAX FREQ EXCURSION | | EXCURSION AS % RATED | | REC TIME | VARIATION | |
| **UNITS** | | VOLTS | VOLTS | % | % | SEC | VOLT | % | % | % | HZ | HZ | % | % | SEC | HZ | % |
| **SYM** | | DROP | ADD | DROP | ADD | | | | | | DROP | ADD | DROP | ADD | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1 | | | | | | 0.20 | 0.17 | | | | | | | | 0.22 | 0.37 |
| | 1-2 | 14.0 | | 11.7 | | 0.60 | | | 1.50 | 3.0 | 2.6 | | 4.3 | | 1.15 | | |
| | 2 | | | | | | 0.20 | 0.17 | | | | | | | | 0.12 | 0.20 |
| | 2-3 | | 11.0 | | 9.2 | 0.45 | | | 1.50 | 3.0 | | 2.4 | | 4.0 | 0.70 | | |
| | 3 | | | | | | 0.20 | 0.17 | | | | | | | | 0.12 | 0.20 |
| | 3-4 | 14.0 | | 11.7 | | 0.60 | | | 1.50 | 3.0 | 2.4 | | 4.0 | | 0.50 | | |
| | 4 | | | | | | 0.50 | 0.42 | | | | | | | | 0.22 | 0.37 |
| | 4-5 | | 11.0 | | 9.2 | 0.30 | | | 1.25 | 3.0 | | 2.0 | | 4.7 | 0.60 | | |
| | 5 | | | | | | 0 | 0 | | | | | | | | 0.15 | 0.26 |
| | 5-6 | 14.0 | | 11.7 | | 0.50 | | | 1.25 | 3.0 | 2.4 | | 4.0 | | 0.80 | | |
| | 6 | | | | | | 0.50 | 0.42 | | | | | | | | 0.22 | 0.37 |
| | 6-7 | | 11.0 | | 9.2 | 0.35 | | | 1.33 | 3.0 | | 2.4 | | 4.0 | 0.65 | | |
| | 7 | | | | | | 0.20 | 0.17 | | | | | | | | 0.15 | 0.25 |
| | 7-8 | 14.0 | | 11.7 | | 0.60 | | | 1.33 | 3.0 | 2.5 | | 4.2 | | 0.85 | | |
| | 8 | | | | | | 0.50 | 0.42 | | | | | | | | 0.20 | 0.33 |
| | 8-9 | | 8.0 | | 6.7 | 0.25 | | | 0.84 | 2.17 | | 2.1 | | 3.5 | 0.50 | | |
| | 9 | | | | | | 0.20 | 0.17 | | | | | | | | 0.15 | 0.25 |
| | 9-10 | 11.0 | | 9.2 | | 0.45 | | | 0.84 | 2.17 | 1.7 | | 2.8 | | 0.50 | | |
| | | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY | | |
| NOTES | | | | | | | | | | | | | | | | | |

FIGURE 608.1-4 Portion of a typical tabulation of results for frequency and voltage regulation, stability and transient response test.

METHOD 608.2b

FREQUENCY AND VOLTAGE STABILITY TEST
(LONG-TERM)

608.2.1 General. The power system must be capable of maintaining constant voltage and frequency for constant loads over long periods of time. Frequency stability describes the tendency of the frequency to remain at a constant value at a constant load. Generally, the instantaneous value of frequency is not constant but varies randomly above and below a mean value. Stability may be described as either short-term or long-term stability depending upon the length of time that the frequency is observed. This Method defines the long-term stability to be based on four hours. Another term, bandwidth, describes the limits of these variations. Bandwidth is expressed as a percentage of rated frequency of the power system. Voltage stability is described similarly.

FIGURE 608.2-1 is a diagrammatic representation of the above terms.

608.2.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. If power system stabilization is to be determined through the temperature of the oil (see 608.2.3.2a), use instrumentation for measuring the oil temperature in the oil sump as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

608.2.3 Procedure.

608.2.3.1. Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

b. Record the following items on both the data sheets and file(s):

1. The date.

2. The serial number(s) of the recording meter(s).

3. Power system identification.

4. The data reading number (indexing).

c. Place all instrumentation referred to in 608.2.2 in operation.

608.2.3.2. Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 608.2-2) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 608.2.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 608.2.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. After step a above, make no further adjustments to the voltage or frequency controls or control systems for the remainder of this test.

c. Operate the power system at rated load for a four hour period. During this period record all instrument readings.

d. Immediately after the long-term stability period, step c, reduce the load to zero. Stabilize the power system at no load per 608.2.3.2a.

e. Immediately after the power system has stabilized at no load, repeat step c except at no load.

f. Immediately after step e, apply the following load conditions to the power system. Each load condition shall last for 60 seconds. Make no adjustments to the power system before or during this portion of the Method.

1. Rated load
2. No load
3. Rated load
4. No load
5. Rated load
6. No load

g. Repeat steps a through f for each voltage connection and frequency specified in the procurement document.

608.2.4 Results.

a. To determine the observed short-term or long-term stability voltage bandwidth as a percentage:

1. Determine the highest ($B_H$) and lowest ($B_L$) voltage during each of the following:

   a. The first 30 seconds at rated load.

   b. The rest of the four hour period at rated load.

   c. The first 30 seconds at no load.

   d. The rest of the four hour period at no load.

2. Take half the difference between the highest and lowest voltage and divide it by the rated voltage and multiply it by 100. Calculate the observed stability voltage bandwidth (B) as a percentage as follows:

$$B = \frac{B_H - B_L}{2 * (Rated\ Voltage)} * 100$$

b. Determine the following as per METHOD 608.1:

1. Maximum overshoot/undershoot voltage and frequency at each transient as a percentage of its rated voltage and frequency.

2. Recovery time after each transient.

3. Regulation as a percentage for all transients.

c. Compare the tabulated results with the requirements of the procurement document.

608.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable long-term voltage stability bandwidth or deviation in percent of rated voltage.

b. Maximum allowable long-term frequency stability bandwidth or deviation in percent of rated frequency.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

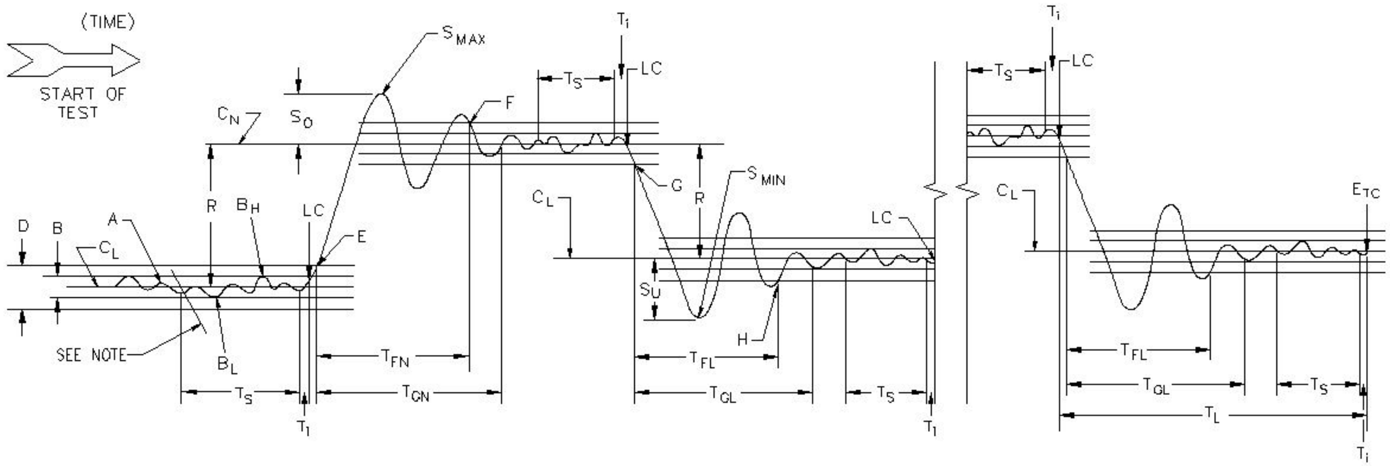
d. Length of time for the long term stability runs, if other than four hours at rated load and four hours at no load.

e. Maximum overshoot/undershoot requirement for voltage and frequency.

f. Recovery time requirement for voltage and frequency.

g. Voltage and frequency regulation requirements.

TRACE AND DEFINITIONS APPLY TO EITHER FREQUENCY OR RMS VOLTAGE




Note: Chart marked at start of test.

A Actual trace of frequency or RMS voltage.

B Observed short-term stability bandwidth (two lines parallel to the axis of chart movement, one each passing through the center points of maximum ($B_H$) and minimum ($B_L$) trace excursion respectively during the prescribed short-term stability period, $T_S$).

$C_L$ Mean value at selected load.

$C_N$ Mean value at no load.

D Prescribed short-term stability bandwidth.

E Point at which trace initially leaves prescribed load bandwidth under condition of decrease in load.

$E_{TC}$ End of transient cycle.

F Point at which trace enters and remains within prescribed no load bandwidth.

G Point at which trace initially leaves prescribed no load bandwidth.

H Point at which trace enters and remains within prescribed load bandwidth.

LC Point at which load change is triggered.

R Regulation between any two loads.

$S_{MAX}$ Maximum excursion during transient from load to no load.

$S_{MIN}$ Maximum excursion during transient from no load to load.

$S_O$ Surge, frequency overshoot or voltage overshoot.

$S_U$ Surge, frequency undershoot or voltage undershoot.

$T_{FL}$ Observed recovery time, no load to load.

$T_{FN}$ Observed recovery time, load to no load.

$T_{GL}$ Maximum allowable recovery time – no load to load.

$T_{GN}$ Maximum allowable recovery time – load to no load.

$T_i$ 0.2 - 0.3 seconds, Interim time between end of $T_S$ and LC.

$T_L$ 60 seconds, Time between load changes, LC.

$T_S$ Prescribed short-term time for determining stability.

FIGURE 608.2-1 Diagrammatic representation of regulation, stability and transient response terms.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120V, SINGLE PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21076<br><br>**REF.** MIL-STD-705/608.2 | **PHILADELPHIA REGION<br>DEFENSE CONTRACT ADMINISTRATION<br>SERVICE**<br><br>FREQUENCY AND VOLTAGE STABILITY TEST<br>(LONG-TERM) | **TEST NO.** 11<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 201 | | 113 | | 476 | | 819 | | 194 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | | | | | | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | STARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0805 | 120.0 | | 2.63 | 105 | 0.252 | 10.1 | | .80 | | 60.0 | | | | | | 73 |
| | 0810 | 120.2 | | 2.65 | 106 | 0.254 | 10.2 | | .80 | | 59.6 | | | | | | 74 |
| | 0815 | ADJUSTED LOAD, VOLTAGE AND FREQUENCY TO RATED VALUES | | | | | | | | | | | | | | | |
| | 0820 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0825 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0830 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 74 |
| | 0835 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0840 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0845 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0850 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0855 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0900 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.1 | | | | | | 75 |
| | 0905 | POWER SYSTEM STABLE – START RATED LOAD STABILITY TEST. | | | | | | | | | | | | | | | |
| | 0910 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 74 |
| | 0915 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 59.9 | | | | | | 73 |
| | 0920 | 120.1 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0925 | 120.1 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0930 | 120.1 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| **NOTES** | RECORDING METER NO 038<br>LINE CURRENT MEASURED USING C.T. NO 1377 | | | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY |

FIGURE 608.2-2 Portion of a typical test record for frequency and voltage stability (long-term).

METHOD 608.3

VOLTAGE AND FREQUENCY DRIFT TEST

608.3.1 General. The power system must be capable of maintaining constant voltage and frequency for constant loads over long periods of time and with changing temperature ranges. Frequency stability describes the tendency of the frequency to remain at a constant value at a constant load. Generally, the instantaneous value of frequency is not constant but varies randomly above and below a mean value. Stability may be described as either short-term or long-term stability depending upon the length of time that the frequency is observed. Another term, bandwidth, describes the limits of these variations. Bandwidth is expressed as a percentage of rated frequency of the power system. Voltage stability is described similarly.

608.3.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. If power system stabilization is to be determined through the temperature of the oil (see 608.2.3.2a), use instrumentation for measuring the oil temperature in the oil sump as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the temperatures with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.2.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

608.3.3 Procedure.

608.3.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

b. Record the following items on both the data sheets and file(s):

  1. The date.

  2. Serial number of recording meter(s).

  3. Power system identification.

  4. The data reading number (indexing).

c. Place all instrumentation referred to in 608.3.2 in operation.

608.3.3.2 Test. Perform the test in accordance with METHOD 608.2 as follows:

a. Stabilize the power system at rated load, frequency and voltage per 608.2.3.2a at any temperature such that during the course of the test, the temperature shall not be outside the defined ambient temperature range of the power system.

b. Operate the power system at rated load for eight hours while gradually raising the temperature at a rate not to exceed 5.5ºC (10ºF) per hour until the power system has been raised 33ºC (60ºF). During this period, record all readings per METHOD 203.1 (see FIGURE 608.3-1).

c. Drop load and turn off power system.

**NOTE**: This test may be performed while the power system is being warmed from a cold temperature test (METHOD 701.1, METHOD 701.2, METHOD 701.3, or METHOD 701.4).

608.3.4 Results. Determine the voltage drift as follows:

$$Voltage\ drift = \frac{V_{maximum} - V_{minimum}}{(Rated\ Voltage)} * 100$$

Where:

$V_{maximum}$ is the maximum voltage reading over the 8 hour period.

$V_{minimum}$ is the minimum voltage reading over the 8 hour period.

Determine the frequency drift in the same manner.

608.3.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The maximum allowable voltage drift.

b. The maximum allowable frequency drift.

**DESCRIPTION:** 10 KW, 60 HZ
120V, SINGLE PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 21076

**REF.** MIL-STD-705/608.3

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE AND FREQUENCY DRIFT TEST

**TEST NO.** 11

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 201 | | 113 | | 476 | | 819 | | 194 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | | | | | | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | STARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0805 | 120.0 | | 2.63 | 105 | 0.252 | 10.1 | | .80 | | 60.0 | | | | | | 73 |
| | 0810 | 120.2 | | 2.65 | 106 | 0.254 | 10.2 | | .80 | | 59.6 | | | | | | 74 |
| | 0815 | ADJUSTED LOAD, VOLTAGE AND FREQUENCY TO RATED VALUES | | | | | | | | | | | | | | | |
| | 0820 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0825 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0830 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 74 |
| | 0835 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0840 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0845 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0850 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0855 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 75 |
| | 0900 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.1 | | | | | | 75 |
| | 0905 | POWER SYSTEM STABLE – START TEST. | | | | | | | | | | | | | | | |
| | 0910 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 74 |
| | 0915 | 120.0 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 59.9 | | | | | | 73 |
| | 0920 | 120.1 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0925 | 120.1 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0930 | 120.1 | | 2.60 | 104 | 0.250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| **NOTES** | RECORDING METER NO 038 | | | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY |
| | LINE CURRENT MEASURED USING C.T. NO 1377 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 608.3-1 Portion of a typical test record for voltage and frequency drift test.

# METHOD 610.1b

## VOLTAGE AND FREQUENCY DROOP TEST

| |
|---|
| **NOTE**: Method 610.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C. |

610.1.1 General. In a generator set in which the generator is equipped with a voltage regulator, the voltage regulator must be capable of maintaining a terminal voltage that falls within specified limits throughout the load range of the generator. The engine governor also must be capable of maintaining speed within the specified range, under the same conditions. Terminal voltage and speed will vary as load is applied but shall not vary more than the specified limits.

610.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705.

610.1.3 Procedure.

610.1.3.1. Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10.

b. Disconnect or otherwise render inoperative the cross current compensator, if provided.

610.1.3.2. Test.

a. Start and operate the generator and allow the set to stabilize at rated load, voltage and frequency. During this period record all instrument readings including ambient temperature at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and frequency. Adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage and frequency adjust devices. On sets utilizing a droop-type frequency control system as the prime speed control, the frequency and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the procurement document. Adjustments to the load, voltage or frequency controls shall be recorded on the data sheet at the time of adjustment. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when four consecutive voltage and current recordings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage or frequency has been made.

b. After temperatures have stabilized, apply and drop the load a number of times (three should be sufficient) to insure that the voltage regulator and engine governor return the terminal voltage and frequency to their rated values at rated load.

c. Reapply rated load. Adjust the voltage regulator and engine governor to obtain rated values of terminal voltage and frequency. After governor adjustments, the frequency regulation shall be checked for compliance with the requirements of the procurement document.

**NOTE**: No further adjustments shall be made to the voltage regulator or engine governor.

d. Starting at rated load, rated voltage, and rated frequency, reduce the load to no load in one step and record all instrument readings.

e. Gradually increase the load at rated power factor in approximately 10 percent steps, recording all instrument readings at each load step until the load reaches the specified overload condition. Then gradually decrease the load in approximately 10 percent steps until no load is reached recording all instrument readings at each step.

f. On ac generator sets repeat step e above with a unity power factor load.

610.1.4 Results.

a. Plot voltage-droop and frequency-droop curves. The voltage-droop curve shall be plotted with the vertical axis as the "terminal voltage" and the horizontal axis as the total kilowatt load. The frequency-droop curve shall be plotted with the vertical axis as the "frequency" and the horizontal axis as the total kilowatt load.

b. Compare these results with the requirements of the procurement document.

610.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum voltage droop allowed.

b. Maximum frequency droop allowed.

c. Maximum overload condition at which this method shall be performed.

d. Short-term frequency stability requirement.

e. Maximum frequency regulation allowed.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60HZ<br>120V, SINGLE-PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 4087<br><br>**REF.** MIL-STD-705/610.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>VOLTAGE AND FREQUENCY DROOP TEST | **TEST NO.** 17<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** FEBRUARY 9, 1971<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 1077 | | 963 | | 212 | | 1308 | | 1328 | | 1016 | 1068 | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | EXCITER FIELD | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | - | | HZ | VOLTS | AMPS | | | | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1410 | STABILIZATION COMPLETE | | | | | | | | | | | | | | | |
| | 1412 | | 122.2 | 0 | 0 | 0 | 0 | | - | | 61.6 | 18.2 | 0.85 | | | | 77 |
| | 1415 | | 122.0 | 0.26 | 10.2 | 0.025 | 1.0 | | 0.80 | | 61.4 | 18.6 | 0.87 | | | | |
| | 1420 | | 121.5 | 0.51 | 20.4 | 0.050 | 2.0 | | 0.80 | | 61.3 | 19.2 | 0.89 | | | | |
| | 1425 | | 121.5 | 0.77 | 30.8 | 0.075 | 3.0 | | 0.80 | | 61.1 | 19.6 | 0.92 | | | | |
| | 1430 | | 121.3 | 1.03 | 41.2 | 0.100 | 4.0 | | 0.80 | | 61.0 | 19.8 | 0.96 | | | | |
| | 1435 | | 121.1 | 1.29 | 51.7 | 0.125 | 5.0 | | 0.80 | | 60.8 | 20.0 | 1.00 | | | | |
| | 1440 | | 120.8 | 1.55 | 62.0 | 0.150 | 6.0 | | 0.80 | | 60.6 | 20.5 | 1.05 | | | | |
| | 1445 | | 120.6 | 1.61 | 72.5 | 0.175 | 7.0 | | 0.80 | | 60.4 | 21.0 | 1.15 | | | | |
| | 1450 | | 120.4 | 2.07 | 83.0 | 0.200 | 8.0 | | 0.80 | | 60.3 | 21.5 | 1.20 | | | | |
| | 1455 | | 120.2 | 2.33 | 93.3 | 0.225 | 9.0 | | 0.80 | | 60.1 | 22.0 | 1.25 | | | | |
| | 1500 | | 120.0 | 2.60 | 104.0 | 0.250 | 10.0 | | 0.80 | | 60.0 | 23.0 | 1.35 | | | | 77 |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING CURRENT TRANSFORMER NO. 1305 | | | | | | | | | | | | | | | | |
| | EXCITER FIELD CURRENT MEASURED USING 2A, 50mV SHUNT NO. 712 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 610.1-I Typical test record for voltage and frequency droop test.

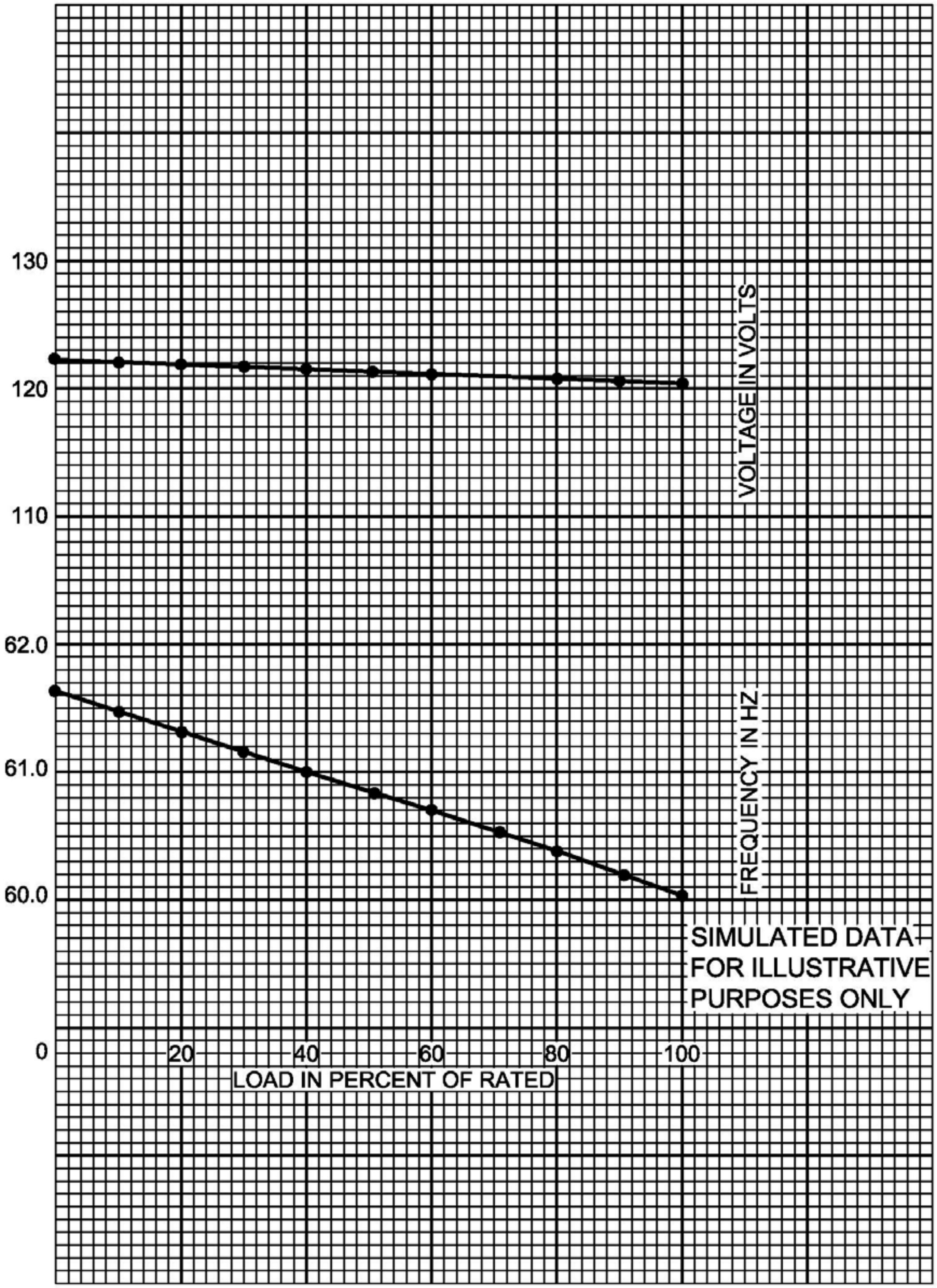



FIGURE 610.1- II Voltage and frequency droop curves for increasing load.

METHOD 611.1b

INHERENT VOLTAGE DROOP TEST

**NOTE**: Method 611.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

611.1.1 General. The inherent voltage droop of the generator is used by design engineers as an aid in the selection of a suitable voltage regulator and as a check to compare production generators with the preproduction generator.

611.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705. In addition, a variable dc source for external excitation shall be required.

611.1.3 Procedure.

611.1.3.1 Preparation for test.

a. Provide the external excitation supply to the generator (disconnect the voltage regulator, if applicable).

b. Connect the load and field instrumentation in accordance with the applicable figure MIL-HDBK-705, method 205.1, paragraph 205.1.10 for one voltage connection and speed specified in the procurement document.

**CAUTION**: **When operating the generator under manual voltage control, care must be exercised in going from rated load to no load. The terminal voltage may rise to as much as 150 percent of rated terminal voltage and exceed the voltage ratings of test instruments connected in the circuit.**

611.1.3.2 Test.

a. Start and operate the generator set and allow it to stabilize at rated load, rated voltage and rated speed. During this period record all instrument readings at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and speed may be made to maintain rated load at rated voltage and speed. Adjustments to the voltage and speed shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or speed adjust devices. On sets utilizing a droop type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and speed control system shall be made unless permitted by the procurement document. Adjustments to load, voltage or speed controls shall be recorded on the data sheet at the time of adjustment. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage or speed has been made.

b. After stabilization has occurred apply and drop rated load several times (3 should be sufficient) to assure that the no load and rated load voltage and speed values are repeatable and that the speed regulation is within the limits specified in the procurement document. If any adjustments are necessary step a above must be repeated.

c. Adjust the excitation voltage, if necessary, to obtain the rated terminal voltage at rated load. No further adjustments of the field rheostat shall be made during the test except as permitted under certain conditions of no load, as described in e below.

d. Starting with rated load (or specified overload) operation, reduce the load gradually to no load and record the instrument readings at approximately each 10 percent of rated load value (see FIGURE 611.1-I).

e. At no load operation, adjust the terminal voltage to its rated value.

f. Gradually increase the load to rated current (or specified overload current) operation and record instrument readings at approximately each 10 percent of rated current value.

611.1.4 Results.

a. Plot voltage droop curves. The vertical axis shall be "terminal voltage", and the horizontal axis shall be "load current". For each of these curves, the maximum deviation from rated voltage shall be noted (see FIGURE 611.1-II).

b. Compare the maximum deviation from rated voltage with the procurement document requirements.

611.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Allowable inherent voltage droop.

b. Voltage connection(s) and speed(s) at which this method is to be performed.

c. Maximum overload current, if applicable.

**DESCRIPTION:** 15KW, DC 120V, 3600RPM GENERATOR SET

**MFGR:** ENGENSETS, INC

**MODEL NO.** DC-15.0

**SERIAL NO.** 0001

**REF.** MIL-STD-705/611.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

INHERENT VOLTAGE DROOP TEST

**TEST NO.** 12

**SHEET:** 1 OF 1

**DATE:** MARCH 22, 1971

**RECORDER:** L WRIGHT

**PROJ. ENGR** J. J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 103 | | 212 | | CAL | | 617 | | 112 | 316 | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | SPEED | | EXCITER FIELD | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | | AMPS | | KW | | RPM | VOLTS | AMPS | | | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0810 | STARTED SET APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0830 | | 120.0 | | 125 | | 15.0 | | 3600 | 15.6 | 1.81 | | | | | | 71 |
| | 0840 | | 120.0 | | 125 | | 15.0 | | 3600 | 15.6 | 1.81 | | | | | | 71 |
| | 0850 | | 120.0 | | 125 | | 15.0 | | 3600 | 15.6 | 1.81 | | | | | | 71 |
| | 0900 | | 120.0 | | 125 | | 15.0 | | 3600 | 15.6 | 1.81 | | | | | | 71 |
| | 0900 | DROPPED AND APPLIED RATED LOAD SEVERAL TIMES | | | | | | | | | | | | | | | |
| | 0910 | | 120.0 | | 125 | | 15.0 | | 3600 | 15.6 | 1.81 | | | | | | 71 |
| | | | 121.7 | | 113 | | 13.5 | | 3600 | 15.6 | 1.81 | | | | | | 72 |
| | | | 123.2 | | 100 | | 12.0 | | 3600 | 15.6 | 1.81 | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | | 72 |
| | | | 125.0 | | 87 | | 10.5 | | 3600 | 15.6 | 1.81 | | | | | | 72 |
| | | | 126.1 | | 75 | | 9.0 | | 3600 | 15.6 | 1.81 | | | | | | 72 |
| | | | 127.2 | | 62 | | 7.5 | | 3600 | 15.6 | 1.81 | | | | | | 72 |
| | | | 128.0 | | 50 | | 6.0 | | 3600 | 15.6 | 1.81 | | | | | | 72 |
| | | | 128.6 | | 38 | | 4.5 | | 3625 | 15.6 | 1.81 | | | | | | 72 |
| | | | 128.8 | | 25 | | 3.0 | | 3650 | 15.6 | 1.81 | | | | | | 72 |
| | | | 129.0 | | 13 | | 1.5 | | 3650 | 15.6 | 1.81 | | | | | | 72 |
| | 0925 | | 129.0 | | 0 | | 0 | | 3675 | 15.6 | 1.81 | | | | | | 72 |
| **NOTES** | LINE CURRENT MEASURED USING CURRENT A 200A, 50mV SHUNT NO. 1723 | | | | | | | | | | | | | | | | |

FIGURE 611.1-I Typical test record for inherent voltage droop test.

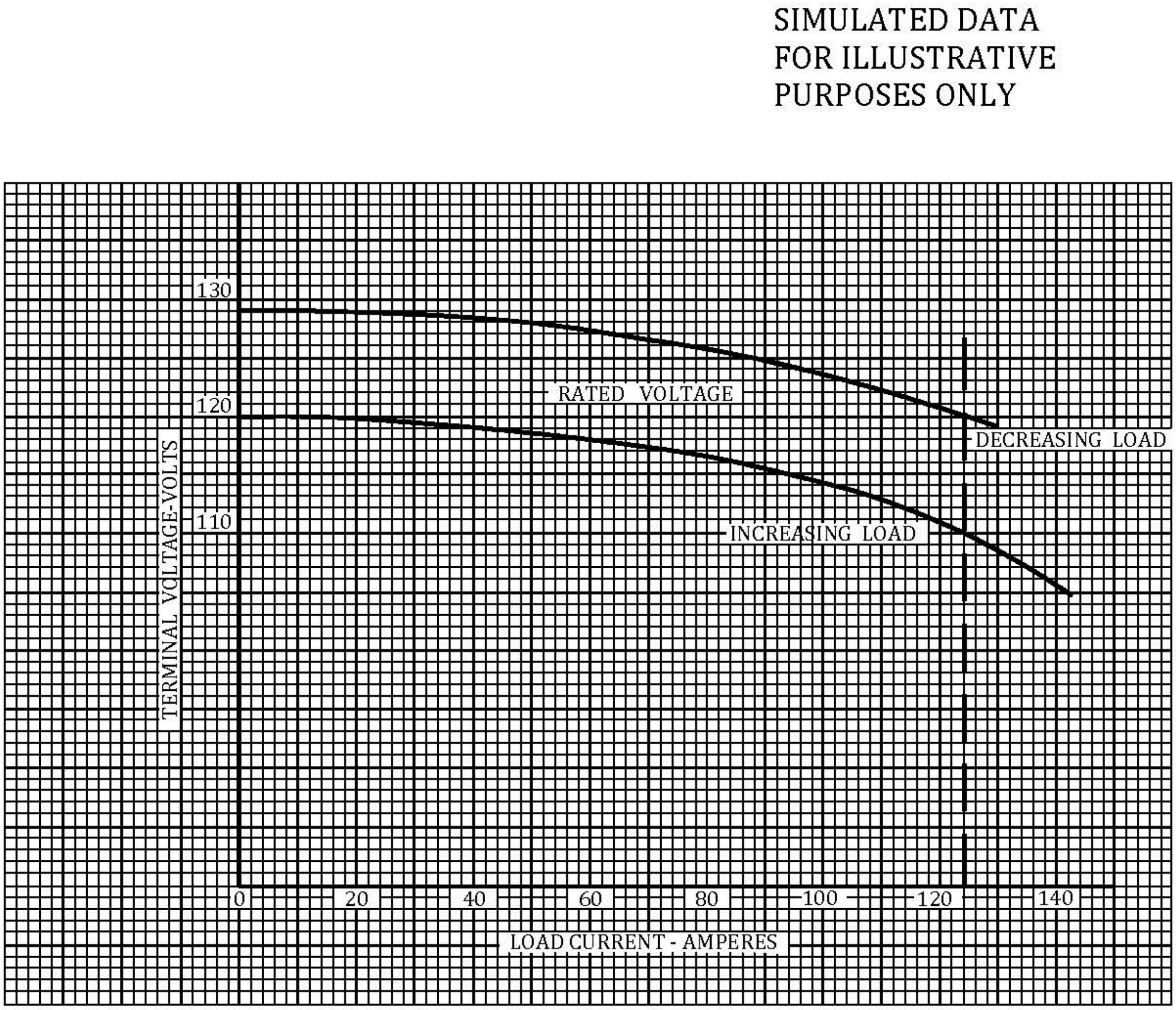



FIGURE 611.1-II Typical curve for inherent voltage droop test.

# METHOD 614.1b

## VOLTAGE AND FREQUENCY REGULATION TEST (FOR GENERATOR SETS)

**NOTE**: Method 614.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

614.1.1 General. The frequency regulation (sometimes referred to as droop) of a generator set is the maximum difference between the no load value of frequency and the value at any load up to and including rated load. This difference is expressed as a percentage of the rated load frequency of the generator set. The voltage regulation is expressed similarly except that the rms value of voltage is used. Frequency stability describes the tendency of the frequency to remain at a constant value at a constant load. Generally, the instantaneous value of frequency is not constant but varies randomly above and below a mean value. Stability may be described as either short-term or long-term depending upon the length of time that the frequency is observed. Another term, bandwidth, describes the limits of these variations. Bandwidth is expressed as a percentage of the rated frequency of the generator set. Voltage stability is described similarly.

614.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705.

614.1.3 Procedure.

614.1.3.1 Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for one voltage connection and frequency specified in the procurement document.

b. Disconnect or otherwise render inoperative the cross current compensation circuits, if provided.

614.1.3.2 Test.

a. Start and operate the generator set at rated voltage. Adjust the engine governor so that the frequency regulation is within the specified limits.

b. Operate the generator set and allow the set to stabilize at rated load, voltage and frequency. During this period record all instrument readings including ambient temperature at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and frequency. Adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage and frequency adjust devices. On sets utilizing a droop-type frequency control system as the prime speed control, the frequency and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the procurement document. Adjustments to the load, voltage or frequency controls shall be recorded on the data sheet at the time of adjustment. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage or frequency has been made.

c. Starting with the rated load, voltage and frequency record all instrument readings. Then, reduce the load to zero in one step.

d. Record all instrument readings. Then, reapply rated load in one step.

e. Repeat steps c and d above two additional times.

f. Repeat 614.1.3 above, for ac sets only, using a rated kilowatt and unity power factor load.

614.1.3.3 Repeat procedure. Repeat 614.1.3 for all other voltage connections and frequencies specified in the procurement document.

614.1.4 Results.

614.1.4.1 Voltage regulation.

a. Obtain the average of the no-load and rated-load voltages individually. Do this for both line-to-line and line-to-neutral voltages.

Sample Computations
From data sheet - FIGURE 614.1-I

Rated Load

| | Reading No. 116 | Reading No. 118 | Reading No. 120 |
|---|---|---|---|
| $L_1$-$L_2$ (volts) | 208 | 208 | 208 |
| $L_2$-$L_3$ (volts) | 208 | 208 | 208 |
| $L_1$-$L_3$ (volts) | 208 | 208 | 208 |
| Total | 624 | 624 | 624 |

$$Average\ of\ three\ trials = \frac{624 + 624 + 624}{9} = 208 = V_{rl}$$

| | Reading No. 116 | Reading No. 118 | Reading No. 120 |
|---|---|---|---|
| $L_1$-$L_0$ (volts) | 120.4 | 120.4 | 120.4 |
| $L_2$-$L_0$ (volts) | 120.1 | 120.0 | 120.0 |
| $L_3$-$L_0$ (volts) | 120.2 | 120.2 | 120.2 |
| Total | 360.7 | 360.6 | 360.6 |

$$Average\ of\ three\ trials = \frac{360.7 + 360.6 + 360.6}{9} = 120.2 = V_{rl}$$

No Load

| | Reading No. 117 | Reading No. 119 | Reading No. 121 |
|---|---|---|---|
| $L_1$-$L_2$ (volts) | 210 | 211 | 212 |
| $L_2$-$L_3$ (volts) | 210 | 211 | 212 |
| $L_3$-$L_1$ (volts) | 210 | 211 | 212 |
| Total | 630 | 633 | 636 |

$$Average\ of\ three\ trials = \frac{630 + 633 + 636}{9} = 211 = V_{nl}$$

| | Reading No. 117 | Reading No. 119 | Reading No. 121 |
|---|---|---|---|
| $L_1$-$L_0$ (volts) | 121.4 | 121.8 | 122.2 |
| $L_2$-$L_0$ (volts) | 121.4 | 121.6 | 122.2 |
| $L_3$-$L_0$ (volts) | 121.6 | 122.0 | 122.4 |
| Total | 364.4 | 365.4 | 366.8 |

$$Average\ of\ three\ trials = \frac{364.4 + 365.4 + 366.8}{9} = 121.8 = V_{nl}$$

b. Substitute the average values of the three trials in the following formula:

$$Voltage\ regulation\ (in\ percent) = \frac{(V_{nl} - V_{rl})}{V_{rl}} * 100$$

Where:

$V_{n1}$ is the average voltage at no load.

$V_{r1}$ is the average voltage at rated load.

Sample Computation Line-to-Line:

$$Average\ voltage\ regulation = \frac{(211 - 208)}{208} * 100 = \frac{3}{208} * 100 = 1.44\%$$

Sample Computation Line-to-Line

$$Average\ voltage\ regulation = \frac{(121.8 - 120.2)}{120.2} * 100 = \frac{1.6}{120.2} * 100 = 1.33\%$$

614.1.4.2 Frequency (speed) regulation.

a. Obtain the average of the no-load speeds individually. On ac generator sets, frequency may be used instead of speed.

Sample Computation

| Reading No. | Frequency |
|---|---|
| 116 | 399.4 |
| 118 | 400.0 |
| 120 | 400.0 |

$$Average\ of\ three\ trials = \frac{1199.4}{3} = 399.8 = X_{rl}$$

| Reading No. | Frequency |
|---|---|
| 117 | 408.5 |
| 119 | 408.0 |
| 121 | 408.0 |

$$Average\ of\ three\ trials = \frac{1224.5}{3} = 408.2 = X_{nl}$$

b. Substitute the average values in the following formula:

$$Frequency\ (speed) regulation\ (in\ percent) = \frac{X_{nl} - X_{rl}}{X_{rl}} * 100$$

Where:

$X_{n1}$ is the average frequency (speed) at no load

$X_{r1}$ is the average frequency (speed) at rated load

Sample Computation

$$Average\ frequency\ (speed) regulation = \frac{408.2 - 399.8}{399.8} * 100 = \frac{8.4}{399.8} * 100 = 2.10\%$$

Compare the results of the computations with the values given in the procurement document.

614.1.5 <u>Procurement document requirements</u>. The following items must be specified in the individual procurement document:

a. Allowable voltage regulation.

b. Allowable frequency regulation.

c. The voltage connection(s) and frequency(ies) at which this method shall be performed.

| | | |
|---|---|---|
| **DESCRIPTION:** 30 KW, 400 HZ<br>120/208V 3 PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** HF-30.0-MD<br><br>**SERIAL NO.** RA-8038<br><br>**REF.** MIL-STD-705/614.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>VOLTAGE AND FREQUENCY REGULATION | **TEST NO.** 12<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** FEBRUARY 9, 1971<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 1756 | | | | | | 1532 | | | 314 | | | 196 | 1315 | 1406 | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | | | | LINE CURRENT | | | OUTPUT POWER | | | FREQ | EXCITER FIELD | | AVG AMB |
| | | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | $L_1$-$L_0$ | $L_2$-$L_0$ | $L_3$-$L_0$ | $L_1$ | $L_2$ | $L_3$ | $L_1$ | $L_2$ | $L_3$ | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | KW | KW | KW | ---- | VOLTS | AMPS | TEMP |
| **SYM** | | | | | | | | X40 | X40 | X40 | X40 | X40 | X40 | | | | °F |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0900 | STARTED UNIT – REGULATION OK – APPLIED RATED LOAD | | | | | | | | | | | | | | | 74 |
| 110 | 0910 | 208 | 208 | 208 | 120 | 120 | 120 | 2.60 | 2.60 | 2.60 | 0.250 | 0.250 | 0.250 | 400.0 | 11.0 | .50 | 73 |
| 111 | 0920 | 209 | 208 | 210 | 121 | 121 | 121 | 2.62 | 2.62 | 2.63 | 0.251 | 0.251 | 0.251 | 400.3 | 10.9 | .49 | 72 |
| | | ADJUSTED LOAD, VOLTAGE AND FREQUENCY TO RATED LOAD | | | | | | | | | | | | | | | |
| 112 | 0930 | 208 | 208 | 208 | 120 | 120 | 120 | 2.60 | 2.60 | 2.60 | 0.250 | 0.250 | 0.250 | 400.0 | 11.1 | .51 | 72 |
| 113 | 0940 | 208 | 208 | 208 | 120 | 120 | 120 | 2.60 | 2.60 | 2.60 | 0.250 | 0.250 | 0.250 | 400.0 | 11.1 | .51 | 72 |
| 114 | 0950 | 208 | 208 | 208 | 120 | 120 | 120 | 2.60 | 2.60 | 2.60 | 0.250 | 0.250 | 0.250 | 400.0 | 11.1 | .51 | 72 |
| 115 | 1000 | 208 | 208 | 208 | 120 | 120 | 120 | 2.60 | 2.60 | 2.60 | 0.250 | 0.250 | 0.250 | 400.0 | 11.1 | .51 | 72 |
| | | | | | | | | | | | | | | | | | |
| | | TRIAL #1 | | | | | | | | | | | | | | | |
| 116 | 1015 | 208 | 208 | 208 | 120.4 | 120.1 | 120.2 | 2.60 | 2.60 | 2.60 | 0.250 | 0.250 | 0.250 | 400.0 | 11.1 | .51 | 72 |
| 117 | | 210 | 210 | 210 | 121.4 | 121.4 | 121.6 | 0 | 0 | 0 | 0 | 0 | 0 | 408.5 | 6.1 | .27 | 72 |
| | | TRIAL #2 | | | | | | | | | | | | | | | |
| 118 | | 208 | 208 | 208 | 120.4 | 120.0 | 120.2 | 2.60 | 2.60 | 2.60 | 0.250 | 0.250 | 0.250 | 400.0 | 10.6 | .48 | 72 |
| 119 | | 211 | 211 | 211 | 121.8 | 121.6 | 122.0 | 0 | 0 | 0 | 0 | 0 | 0 | 408.0 | 6.1 | .28 | 72 |
| | | TRIAL #3 | | | | | | | | | | | | | | | |
| 120 | | 208 | 208 | 208 | 120.4 | 120.0 | 120.2 | 2.60 | 2.60 | 2.60 | 0.250 | 0.250 | 0.250 | 400.0 | 10.6 | .48 | 72 |
| 121 | 1425 | 212 | 212 | 212 | 122.2 | 122.2 | 122.4 | 0 | 0 | 0 | 0 | 0 | 0 | 408.0 | 6.1 | .28 | 72 |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. N0. 1305-$L_1$; 1306-$L_2$; 1307-$L_3$ | | | | | | | | | | | | | | | | |
| | EXCITER FIELD CURRENT MEASURED USING 1A, 50mV, SHUNT NO. 113 | | | | | | | | | | | | | | | | |

FIGURE 614.1-I Typical test record for voltage and frequency regulation test.

# METHOD 615.1b

## INHERENT VOLTAGE REGULATION TEST

**NOTE**: Method 615.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

615.1.1 General. The inherent voltage regulation is used by design engineers to aid in the selection of the voltage regulator and overvoltage safety equipment. It is important that the inherent voltage regulation of production generator(s) remains approximately the same as the regulation for the first article generator(s).

615.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705. In addition a variable dc source for external excitation shall be required. If this method is not performed as a set test, a prime mover capable of meeting the speed requirements as specified in the procurement document will be required.

615.1.3 Procedure.

615.1.3.1 Preparation for test.

a. Connect the load and field instrumentation in accordance with the applicable figure on MIL-HDBK-705, method 205.1, paragraph 205.1.10 for one voltage connection and speed specified in the procurement document and provide the external excitation supply to the generator.

**CAUTION: When operating the generator under manual voltage control care must be exercised in going from rated load to no load. The terminal voltage may rise to 150 percent of rated terminal voltage and exceed the voltage ratings of test instruments connected in the circuit.**

615.1.3.2 Test.

a. Start and operate the generator set and allow it to stabilize at rated load, rated voltage and rated speed. During this period record all instrument readings at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and speed may be made to maintain rated load at rated voltage and speed. On sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and speed control systems shall be made unless permitted by the procurement document. Adjustments to load, voltage or speed controls shall be recorded on the data sheet at the time of adjustment. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variation about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage or speed has been made.

b. After stabilization has occurred apply and drop rated load several times (3 should be sufficient) to assure that the no load and rated load voltage and speed values are repeatable and that the voltage and speed regulation is within the limits specified in the procurement document. If any adjustments are necessary, step a must be repeated. Reapply rated load. No further adjustments of the field voltage shall be made for the remainder of this method.

c. Starting with rated load, obtain the following load conditions in one step from the previous load step. During each step record all instrument readings (see FIGURE 615.1-I).

1. Rated load
2. No load
3. Rated load
4. No load
5. Rated load
6. No load

d. Repeat steps a through c above for all other voltage connection(s) and frequency(ies) specified in the procurement document.

615.1.4 Results.

a. Obtain the average of the three no load voltage readings and the average of the three rated load voltage readings.
b. Substitute the averages obtained in step a above in the following formula to obtain the inherent voltage regulation:

$$Inherent\ voltage\ regulation\ (in\ percent) = \frac{(V_{nl} - V_{rl})}{V_{rl}} * 100$$

Where:

$V_{n1}$ is the average no load voltage.

$V_{r1}$ is the average rated load voltage.

c. Compare the computed inherent voltage regulation with the procurement document requirements.

615.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Upper and lower limits of acceptable inherent voltage regulation in percent of rated voltage.

b. Voltage connection(s) and speed(s) at which this method is to be performed.

c. Allowable speed regulation.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60HZ<br>120V, SINGLE-PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 17765<br><br>**REF.** MIL-STD-705/615.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>INHERENT VOLTAGE REGULATION TEST | **TEST NO.** 16<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** MARCH 17, 1971<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 316 | | 077 | | 108 | | 417 | | 288 | | 312 | 055 | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | EXCITER FIELD | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | - | | HZ | VOLTS | AMPS | | | | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0815 | STARTED SET-APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0825 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.1 | 1.32 | | | | 76 |
| | 0835 | | 119.8 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.1 | 1.32 | | | | 76 |
| | 0845 | | 119.5 | 2.55 | 102 | .248 | 9.8 | | .80 | | 60.1 | 16.1 | 1.30 | | | | 78 |
| | 0855 | ADJUSTED VOLTAGE AND FREQ. TO RATED | | | | | | | | | | | | | | | |
| | 0905 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.4 | 1.32 | | | | 77 |
| | 0915 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.4 | 1.32 | | | | 77 |
| | 0925 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.4 | 1.32 | | | | 77 |
| | 0935 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.4 | 1.32 | | | | 77 |
| | 0940 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.4 | 1.32 | | | | 77 |
| | 0941 | | 181.7 | 0 | 0 | 0 | 0 | | - | | 61.6 | 16.4 | 1.32 | | | | 77 |
| | 0942 | | 120.2 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.4 | 1.32 | | | | 77 |
| | 0943 | | 181.7 | 0 | 0 | 0 | 0 | | - | | 61.6 | 16.4 | 1.32 | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | 77 |
| | 0944 | | 120.2 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 16.4 | 1.32 | | | | 77 |
| | 0945 | | 181.7 | 0 | 0 | 0 | 0 | | - | | 61.6 | 16.4 | 1.32 | | | | 77 |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C. T. NO. 1305 | | | | | | | | | | | | | | | | |
| | EXCITER FIELD CURRENT MEASURED USING 2A, 100mV SHUNT NO. 1785 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 615.1-I Typical test record for inherent voltage regulation test.

METHOD 619.1e

VOLTAGE DIP FOR LOW POWER FACTOR LOADS TEST

619.1.1 General. Voltage data from the sudden application of low power factor loads indicates the ability of a power system to start motors.

619.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. If power system stabilization is to be determined through the temperature of the oil (see 619.1.3.2a), use instrumentation for measuring the oil temperature in the oil sump as described in METHOD 110.1. Use a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter (unless otherwise specified in the procurement document). Also use a voltage-linear, non-saturating reactive load of 0.4 (or less) power factor lagging.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

619.1.3 Procedure.

619.1.3.1 Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figures of 205.1.10, the data recorder manufacturer's instructions and the instructions given in this Method for one voltage connection and frequency specified in the procurement document.

b. Unless otherwise specified, connect the data recorder to any line-to-neutral (phase) connection which provides the input to the voltage regulator sensing circuit. Make this connection at the power system output terminals.

c. If the power system contains an internal load bank, disconnect it. If a voltage regulator reactive droop compensator is installed on the power system, make it inoperative.

619.1.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 619.1-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 619.1.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, the power system must be shutdown. Failure to do so may cause personal injury or death.**

   a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

   b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 619.1.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. Immediately after the power system has stabilized, reduce the load to zero.

c. Adjust the terminal voltage and frequency to their rated values (power system nameplate values at the voltage connection and frequency used).

**CAUTION: Do not maintain the low power factor load on the power system longer than 1 minute. Failure to do so may cause damage to the power system.**

d. Apply the 0.4 or less power factor load (or as specified) for a duration not to exceed 1 minute and adjust this load to draw twice rated current (this will be a 1/2 per unit (P.U.) load impedance at the rated voltage connection used in step b above). Use a balanced three phase reactive load for three phase machines. If, while the applied load is drawing twice rated current, the power system output voltage as measured on RMS meter differs by more than two percent from the rated value, readjust the reactive load to compensate for this voltage difference.

**NOTE:** Several trial runs and readjustments may be necessary to insure that the equation is satisfied for the measured values of $I_{ZPF}$ and $E_{ZPF}$.

Calculate the new equivalent load current from the following equation:

$$I_{ZPF} = \frac{2\,I_R * E_{ZPF}}{E_R}$$

Where:

$I_{ZPF}$ = New equivalent load current.

$E_{ZPF}$ = Resultant voltage at the low power factor load coincident with $I_{ZPF}$.

$I_R$ = Rated current (from the generator nameplate data at the specified voltage connection).

$E_R$ = Rated voltage (at the specified voltage connection).

e. Reduce the load to zero.

f. Record the steady-state readings per METHOD 203.1 (see FIGURE 619.1-1).

g. Apply the low power factor load in one step. After allowing the voltage and frequency to return to steady-state conditions after the transient period, record the steady-state readings.

h. Repeat steps e through g above two additional times allowing the voltage and frequency to return to steady-state conditions after each load application.

i. Repeat steps a through h above for each additional voltage connection and frequency specified in the procurement document.

619.1.4 Results.

a. From the data, check to insure that the load reactance was not saturated and introducing excessive harmonics by determining that the ratios of the peak-to-peak voltage to the peak-to-peak current remain constant from the instant the reactive load is first applied until steady-state conditions are reached.

b. Using the data and the corresponding voltage readings, determine the voltage dip in percent using the following equation:

$$Voltage\ Dip, in\ percent = \frac{V_{NL} - V_D}{V_{Rated}} * 100$$

Where:

$V_{NL}$ = Voltage reading at no load prior to applying load.

$V_{RATED}$ = Rated voltage for which the generator is connected.

$V_D$ = Calculated voltage dip during the transient period where:

$$V_D = \frac{V_{Transient} * V_L}{V_{Steady-State}}$$

$V_L$ = Steady-state voltage reading after application of load.

$V_{Transient}$ = Minimum peak-to-peak voltage during the transient period following load application.

$V_{Steady\text{-}State}$ = Peak-to-peak steady-state voltage after load application.

c. Calculate the minimum voltage, in percent of rated voltage, during the transient period after the application of the low power factor load by subtracting the voltage dip, in percent, obtained in step b above from 100 percent.

d. From the data, determine the recovery time (no load to load) to the nearest 0.01 second. The recovery time is the time from the application of load until the voltage reaches the voltage value specified in the procurement document.

e. Compare these results with the requirements of the procurement document.

619.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Allowable voltage dip (no load to load), in percent of rated voltage or the minimum value of voltage, in percent of rated voltage, permitted during the transient period.

b. Required recovery time (no load to load) and the voltage value to which it is to be measured.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Load conditions, if other than 1/2 P.U. impedance at 0.4, or less, power factor lagging (twice rated current).

e. Phase connections for voltage measurement, if other than as specified herein.

**DESCRIPTION:** 5 KW, 60HZ 120V SINGLE-PHASE POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-5.0-MD

**SERIAL NO.** 10776

**REF.** MIL-STD-705/619.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE DIP FOR LOW POWER FACTOR LOADS TEST

**TEST NO.** 16

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 117 | | 227 | | 336 | | 445 | | 554 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | | | | | | °F |
| **SYM** | | | | X25 | X1 | X25 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1300 | | STARTED POWER SYSTEM, APPLIED RATED LOAD | | | | | | | | | | | | | | |
| | 1305 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1310 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1315 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1320 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1325 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1330 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1335 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1340 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1345 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1350 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.0 | | | | | | 77 |
| | 1355 | | 120.0 | 4.16 | 104 | .20 | 5.0 | | 0.40 | | 60.0 | | | | | | |
| | 1400 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.1 | | | | | | |
| | 1405 | | 120.0 | 4.16 | 104 | .20 | 5.0 | | 0.40 | | 60.0 | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 1410 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.1 | | | | | | |
| | 1415 | | 120.0 | 4.16 | 104 | 2.0 | 5.0 | | 0.40 | | 60.1 | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | C.T. #1101 | | | | | | | | | | | | | | | | |
| | SHUNT #1310, 1A, 50mV | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 619.1-1 Typical test record for voltage dip for low power factor loads test.

METHOD 619.2d

VOLTAGE DIP AND RISE FOR RATED LOAD TEST

619.2.1 General. Voltage data from the sudden application and removal of load enables the voltage transient response of a power system to be determined.

619.2.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. If power system stabilization is to be determined through the temperature of the oil (see 619.2.3.2a), use instrumentation for measuring the oil temperature in the oil sump as described in METHOD 110.1. Use a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter (unless otherwise specified in the procurement document).

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

619.2.3 Procedure.

619.2.3.1 Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figure of 205.1.10, the data recorder manufacturer's instructions and the instructions given in this Method for one voltage connection and frequency specified in the procurement document.

b. Unless otherwise specified, connect the data recorder across any line-to-neutral connection which provides the input to the voltage regulator sensing circuit. Make this connection at the generator output terminals.

c. If the power system contains an internal load bank, disconnect it. Make the voltage regulator reactive droop compensator inoperative, if applicable.

619.2.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 619.2-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 619.2.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

   a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

   b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 619.2.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. After the stabilization has occurred record all instrument readings per METHOD 203.1 (see FIGURE 619.2-1).

c. Reduce the load to zero in one step (do not use power system circuit breaker to remove load). After allowing the voltage and frequency to return to steady state conditions after the transient period, record all instrument readings.

d. Reapply the load in one step and allow the voltage and frequency to return to steady state conditions. Record all instrument readings.

e. Repeat steps c and d above a sufficient number of times to obtain the data of 3 voltage dips and 3 voltage rises.

f. Repeat steps a through e above for each additional voltage connection and frequency specified in the procurement document.

g. Repeat steps a through f above for any other load conditions specified in the procurement document.

619.2.4 Results.

a. From the data, check to insure that the load reactance was not saturated and introducing excessive harmonics by determining that the ratios of the peak-to-peak voltage to the peak-to-peak current remain constant from the instant the load is first applied until steady-state conditions are reached. (For AC generators only - see FIGURE 619.2-1).

b. Using the no load to load data and the corresponding voltage readings, determine the voltage dip in percent using the following equation:

$$Voltage\ Dip, in\ percent = \frac{V_{NL} - V_D}{V_{Rated}} * 100$$

Where:

$V_{NL}$ = Voltage reading at no load prior to applying load.

$V_{Rated}$ = Rated voltage for which the generator is connected.

$V_D$ = Calculated voltage dip during the transient period where:

$$V_D = \frac{V_{Transient} * V_L}{V_{Steady-State}}$$

$V_L$ = Steady-state voltage reading after application of load.

$V_{Transient}$ = Minimum peak-to-peak AC voltage during the transient period following load application. (For DC power systems use the minimum voltage from the zero reference line).

$V_{Steady-State}$ = Peak-to-peak AC steady-state voltage after load application.

c. Calculate the minimum voltage, in percent, during the transient period after the application of the load by subtracting the voltage dip, in percent, obtained in step b above from 100 percent.

d. From the data, determine the recovery time (no load to load) to the nearest 0.01 second. The recovery time is the time from the application of load until the voltage reaches the stable voltage value as specified in the procurement document.

e. Using the load to no load data and the corresponding voltmeter readings determine the voltage rise in percent using the following equation:

$$Voltage\ Rise, in\ percent = \frac{V_R - V_L}{V_{Rated}} * 100$$

Where:

$V_R$ = Calculated voltage rise during the transient period where

$$V_R = \frac{V_{Transient} * V_{NL}}{V_{Steady-State}}$$

$V_{Transient}$ = Peak-to-peak AC voltage during the transient period following load removal. (For DC power systems use the maximum voltage from the zero reference line).

$V_{Steady-State}$ = Peak-to-peak AC steady-state voltage after removing load.

$V_{NL}$ = Steady-state voltage reading after removing load.

$V_{Rated}$ = Rated voltage for which the generator is connected.

$V_L$ = Steady-state voltage reading prior to removing load.

f. Calculate the maximum voltage in percent, during the transient period after removal of load by adding the voltage rise, in percent, obtained in step e above to 100 percent.

g. From the data, determine the recovery time (load to no load) to the nearest 0.01 second. The recovery time is the time from the removal of load until the voltage reaches the stable voltage value as specified in the procurement document.

h. Compare these results with the requirements of the procurement document.

619.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Allowable voltage dip, no load to rated load, in percent of rated voltage, or the minimum value of voltage, in percent of rated voltage, permitted during the transient period after applying load.

b. Required recovery time, no load to rated load, and the stable voltage value, in percent of rated voltage, to which it is measured.

c. Allowable voltage rise, rated load to no load, in percent of rated voltage or the maximum value of voltage, in percent of rated voltage permitted during the period after removal of load.

d. Required recovery time, rated load to no load, and the stable voltage value to which it is to be measured, if different from item b above.

e. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

f. Load conditions, if other than rated load.

g. Additional transient response requirements in addition to those above, if any.

**DESCRIPTION:** 5KW, 60 HZ
120V SINGLE - PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC.

**MODEL NO.** SF-5.0-MD

**SERIAL NO.** 10776

**REF.** MIL-STD-705/619.2

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE DIP AND RISE FOR RATED LOAD TEST

**TEST NO.** 16

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 117 | | 227 | | 336 | | 445 | | 554 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | | | | | | °F |
| **SYM** | | | | X25 | X1 | X25 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1300 | | STARTED POWER SYSTEM, APPLIED RATED LOAD | | | | | | | | | | | | | | |
| | 1305 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1310 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1315 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1320 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1325 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1330 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1335 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1340 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1345 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1350 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.0 | | | | | | 77 |
| | 1355 | | 120.0 | 2.88 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | |
| | 1400 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.1 | | | | | | |
| | 1405 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 1410 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.1 | | | | | | |
| | 1415 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.1 | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | C.T. #1101 | | | | | | | | | | | | | | | | |
| | SHUNT # 1310, 1A, 50mV | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 619.2-1 Typical test record for voltage dip and rise for rated load test.

# METHOD 619.3

## VOLTAGE UNDERSHOOT FOR LOW POWER FACTOR LOADS TEST (RMS METHOD)

619.3.1 General. The observance of the output voltage during the sudden application of low power factor loads indicates the ability of a power system to start motors.

619.3.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. If power system stabilization is to be determined through the temperature of the oil (see 619.3.3.2a), use instrumentation for measuring the oil temperature in the oil sump as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

Also use a voltage-linear, non-saturating reactive load of 0.4 (or less) power factor lagging.

619.3.3 Procedure.

619.3.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

b. Record the following items on both data sheets and file(s):

1. The date.

2. The serial number(s) of the recording meter(s).

3. Power system identification.

4. The data reading number (indexing).

(Refer to FIGURE 619.3-2)

c. Place all instrumentation referred to in 619.3.2 in operation.

d. If the power system contains an internal load bank, disconnect it. If a voltage regulator reactive droop compensator is installed on the power system, make it inoperative.

619.3.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 619.3-2) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 619.3.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 619.3.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. After stabilization has occurred, reduce the load to zero.

**CAUTION: Do not maintain the low power factor load on the power system longer than 1 minute. Failure to do so may cause damage to the power system.**

c. Apply the 0.4 or less power factor load (or as specified) for a duration not to exceed 1 minute and adjust this load to draw twice rated current (this will be a 1/2 per unit (P.U.) load impedance). A balanced three phase reactive load is required for three phase machines. If, while the applied load is drawing twice rated current, the power system output voltage as measured on RMS instrumentation differs by more than two percent from the rated value, the reactive load shall be readjusted to compensate for this voltage difference.

**NOTE:** Several trial runs and readjustments may be necessary to insure that the equation is satisfied for the measured values of $I_{ZPF}$ and $E_{ZPF}$.

Calculate the new equivalent load current from the following equation:

$$I_{ZPF} = \frac{2\, I_R * E_{ZPF}}{E_R}$$

Where:

$I_{ZPF}$ = New equivalent load current.

$E_{ZPF}$ = Resultant voltage at the low power factor load coincident with $I_{ZPF}$.

$I_R$ = Rated current (from the generator nameplate data at the specified voltage connection).

$E_R$ = Rated voltage (at the specified voltage connection).

**NOTE**: Several trial runs and readjustments may be necessary to insure that the equation is satisfied for the measured values of $I_{ZPF}$ and $E_{ZPF}$.

d. Reduce the load to zero. Maintain no load for 60 seconds to collect stability data prior to transient event.

e. Using $I_{ZPF}$ determined above, apply the same low power factor load and allow the voltage and frequency to return to steady-state conditions. Record all readings.

f. Repeat steps d and e above two additional times allowing the voltage and frequency to return to steady-state conditions after each load application.

g. Repeat steps a through f above for any other voltage connection(s) and frequency(ies) specified in the procurement document.

619.3.4 Results. Prepare a data sheet for all voltage connection(s) similar to FIGURE 619.3-2 giving for each transient the short-term stability bandwidth, the maximum voltage undershoot, and the recovery time.

a. To determine the observed short-term stability voltage bandwidth as a percentage (referring to
b. FIGURE 619.3-1, bandwidth B):

1. Determine the highest and lowest voltage during each constant load. See $B_H$ and $B_L$ of
2. FIGURE 619.3-1, respectively.

3. Take half the difference between the highest and lowest voltage and divide it by the rated voltage and multiply it by 100. This is the observed short-term stability voltage bandwidth as a percentage. For example, using
4. FIGURE 619.3-1 calculate the observed short-term stability voltage bandwidth (B) as follows:

$$B = \frac{B_H - B_L}{2 * (Rated\ Voltage)} * 100$$

c. To determine the location of the prescribed short-term stability voltage bandwidth (referring to
d. FIGURE 619.3-1, bandwidth D):

1. Take the mean of all voltage readings during each short term time for determining stability, $T_S$. This is the observed short-term stability voltage for the constant load. See $C_L$ or $C_N$ of
2. FIGURE 619.3-1.

3. To calculate the prescribed short-term stability voltage bandwidth: multiply the short-term stability voltage found in step 1 by half the allowable bandwidth in percentage according to the procurement document (see 619.3.5).

$$D_{Limit} = C_L * \frac{(Allowable\ Bandwidth)}{2}$$

4. Add the value found in step 2 to the short-term stability voltage found in step 1 to get the upper bandwidth voltage. Subtract the value found in step 2 from the short-term stability voltage to get the lower bandwidth voltage. This range is the prescribed short-term stability voltage bandwidth. For example, see prescribed short-term stability bandwidth D from
5. FIGURE 619.3-1.

$$D_{High} = C_L + D_{Limit}$$

$$D_{Low} = C_L - D_{Limit}$$

e. To determine the maximum undershoot voltage at each transient as a percentage of its rated voltage:

1. From the data, calculate the difference between the maximum undershoot voltage (see $S_U$ of
2. FIGURE 619.3-1) and the new observed steady-state voltage following the transient.

$$S_U = C_L - S_{MIN}$$

3. Divide the voltage determined in step 1 by the rated voltage of the power system, then multiply by 100 to convert to percentage. This is the maximum undershoot voltage as a percentage of its rated voltage.

$$Maximum\ Undershoot = \frac{S_U}{(Rated\ Voltage)} * 100$$

| |
|---|
| **NOTE:** Do not use the constant operating voltage at each load as the divisor in the computation. Use only the rated voltage of the power system. |

f. To determine the recovery time required to restore stable voltage conditions after each transient:

1. For each transient, determine the time at which the voltage leaves the prescribed short-term stability bandwidth. For example, see point G on
2. FIGURE 619.3-1.

3. For each transient, determine the time at which the voltage enters and remains within the new prescribed short-term stability bandwidth. For example, see point H on
4. FIGURE 619.3-1.

5. The recovery time is the duration of time between the beginning of the transient (step 1) and the end of the transient (step 2). For example, see $T_{FL}$ on
6. FIGURE 619.3-1.

g. Compare the results tabulated above with the requirements of the procurement document.

619.3.5 Procurement document requirements. The following items must be specified in the individual procurement document:

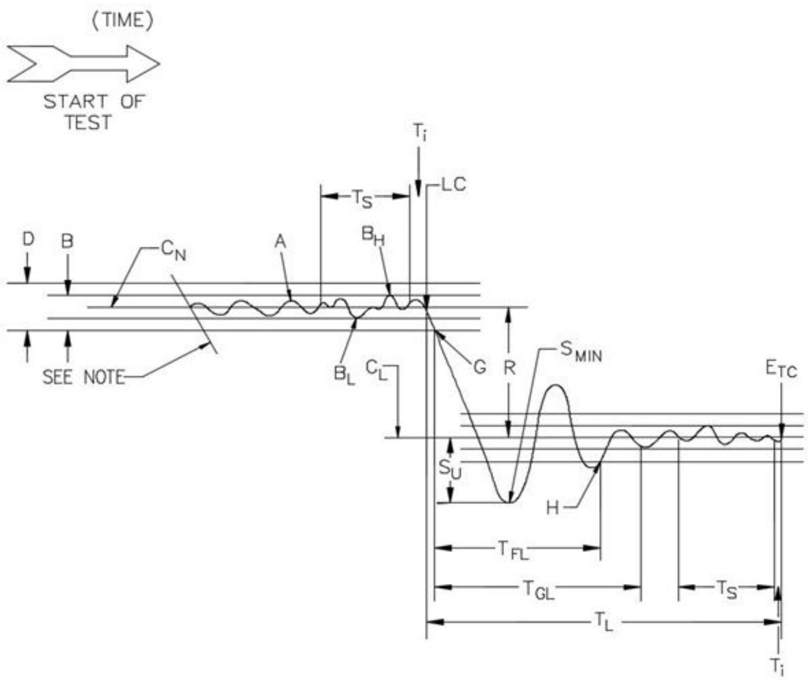
a. Maximum allowable voltage recovery time.

b. Maximum allowable voltage undershoot.

c. Maximum allowable short-term stability bandwidth or deviation in percent of rated voltage.

d. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

e. The short-term time for determining stability, if not based on 30 seconds.




Note: Chart marked at start of test.

A Actual trace of RMS voltage.

B Observed short-term stability bandwidth (two lines parallel to the axis of chart movement, one each passing through the center points of maximum ($B_H$) and minimum ($B_L$) trace excursion respectively during the prescribed short-term stability period $T_S$).

$C_L$ Mean value at selected load.

$C_N$ Mean value at no load.

D Prescribed short-term stability bandwidth.

$E_{TC}$ End of transient cycle.

G Point at which trace initially leaves prescribed no load bandwidth.

H Point at which trace enters and remains within prescribed load bandwidth.

LC Point at which load change is triggered.

R Regulation between any two loads.

$S_{MIN}$ Maximum excursion during transient from no load to load.

$S_U$ Surge, voltage undershoot.

$T_{FL}$ Observed recovery time, no load to load.

$T_{GL}$ Maximum allowable recovery time – No load to load.

$T_i$ 0.2-0.3 seconds, Interim time between end of Ts and LC.

$T_L$ 60 seconds, Time between load changes, LC.

$T_S$ Prescribed short-term time for determining stability.

FIGURE 619.3-1 Diagrammatic representation of voltage regulation, stability and transient response terms.

**DESCRIPTION:** 5 KW, 60HZ
120V SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-5.0-MD

**SERIAL NO.** 10776

**REF.** MIL-STD-705/619.3

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE UNDERSHOOT FOR LOW POWER FACTOR LOADS TEST (RMS METHOD)

**TEST NO.** 16

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J.JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 117 | | 227 | | 336 | | 445 | | 554 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | | | | | | °F |
| **SYM** | | | | X25 | X1 | X25 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1300 | | STARTED POWER SYSTEM, APPLIED RATED LOAD | | | | | | | | | | | | | | |
| | 1305 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1310 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1315 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1320 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1325 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1330 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1335 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1340 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1345 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1350 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.0 | | | | | | 77 |
| | 1355 | | 120.0 | 4.16 | 104 | .20 | 5.0 | | 0.40 | | 60.0 | | | | | | |
| | 1400 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.1 | | | | | | |
| | 1405 | | 120.0 | 4.16 | 104 | .20 | 5.0 | | 0.40 | | 60.0 | | | | | | |
| | 1410 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.1 | | | | | | |
| | 1415 | | 120.0 | 4.16 | 104 | 2.0 | 5.0 | | 0.40 | | 60.1 | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | C.T. #1101 | | | | | | | | | | | | | | | | |
| | SHUNT #1310, 1A, 50mV | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

FIGURE 619.3-2 Typical test record for voltage undershoot for low power factor loads test (RMS Method).

# METHOD 619.4

## VOLTAGE UNDERSHOOT AND OVERSHOOT FOR RATED LOAD TEST (RMS METHOD)

619.4.1 General. Voltage transient response describes the reaction of the voltage to a sudden change in some condition; such as, a load change on a power system. This response consists of the amount of excursion beyond the mean of the new operating band, and the recovery time. The recovery time is the interval beginning at the point where the voltage leaves the original prescribed operating band and ending at the point where it enters and remains within the new prescribed operating band. The amount of surge is expressed as a percentage of the rated voltage of the power system. The recovery time is expressed in seconds.

FIGURE 619.4-1 is a diagrammatic representation of the above terms.

619.4.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. If power system stabilization is to be determined through the temperature of the oil (see 619.4.3.2a), use instrumentation for measuring the oil temperature in the oil sump as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

619.4.3 Procedure.

619.4.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

b. Record the following items on both data sheets and file(s):

    1. The date.

    2. The serial number(s) of the recording meter(s).

    3. Power system identification.

    4. The data reading number (indexing).

(Refer to FIGURE 619.4-2)

c. Place all instrumentation referred to in 619.4.2 in operation.

d. If the power system contains an internal load bank, disconnect it. If a voltage regulator reactive droop compensator is installed on the power system, make it inoperative.

619.4.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see

b.

c. FIGURE 619.4-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 619.4.5) after the last adjustment to load, voltage, and frequency has been made.

    1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, the power system must be shutdown. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 619.4.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

d. After stabilization has occurred, operate the power system at each of the following load conditions (one step) for 60 seconds. During each load condition record all instrument readings except thermal instrumentation. For three-phase power systems do not record line-to-line voltages. Each load condition shall be applied to the power system in one step at the end of the short-term stability period for the previous load condition. Process, analyze, and present each transient in the data report. The load conditions are:

1. Maintain Rated Load (RL) for 60 seconds to collect stability data prior to first transient event.

| |
|---|
| **NOTE:** 60 seconds is used throughout this Method to ensure the transients have recovered after the required 30 second steady-state stability. |

a. Transient 1 – RL to No Load (NL).
b. Transient 2 – NL to RL.
c. Transient 3 – RL to NL.
d. Transient 4 – NL to RL.
e. Transient 5 – RL to NL.
f. Transient 6 – NL to RL.

e. Repeat steps a and b for any other voltage connection(s) and frequency(ies) specified in the procurement document.

619.4.4 Results. Prepare a data sheet for all voltage connection(s) similar to FIGURE 619.4-2 giving for each transient the short-term stability bandwidth, the maximum overshoot or undershoot, the recovery time, and regulation.

a. To determine the observed short-term stability voltage bandwidth as a percentage (referring to
b.
c. FIGURE 619.4-1, bandwidth B):

1. Determine the highest and lowest voltage during each constant load. See $B_H$ and $B_L$ of
2.
3. FIGURE 619.4-1, respectively.

4. Take half the difference between the highest and lowest voltage and divide it by the rated voltage and multiply it by 100. This is the observed short-term stability voltage bandwidth as a percentage. For example, using
5.
6. FIGURE 619.4-1 calculate the observed short-term stability voltage bandwidth (B) as follows:

$$B = \frac{B_H - B_L}{2 * (Rated\ Voltage)} * 100$$

d. To determine the prescribed short-term stability voltage bandwidth (referring to
e.
f. FIGURE 619.4-1, bandwidth D):

1. Take the mean of all voltage readings during each short term time for determining stability, $T_S$. This is the observed short-term stability voltage for the constant load. See $C_L$ or $C_N$ of
2. 
3. FIGURE 619.4-1.

4. To calculate the prescribed short-term stability voltage bandwidth: multiply the short-term stability voltage found in step 1 by half the allowable bandwidth in percentage according to the procurement document (see 619.4.5).

$$D_{Limit} = C_L * \frac{(Allowable\ Bandwidth)}{2}$$

5. Add the value found in step 2 to the short-term stability voltage found in step 1 to get the upper bandwidth voltage. Subtract the value found in step 2 from the short-term stability voltage to get the lower bandwidth voltage. This range is the prescribed short-term stability voltage bandwidth. For example, see prescribed short-term stability bandwidth D from
6. 
7. FIGURE 619.4-1.

$$D_{High} = C_L + D_{Limit}$$

$$D_{Low} = C_L - D_{Limit}$$

g. To determine the maximum overshoot/undershoot voltage at each transient as a percentage of its rated voltage:

1. From the data, calculate the difference between the maximum overshoot/undershoot voltage (see $S_O$ or $S_U$ of
2. 
3. FIGURE 619.4-1) and the new observed steady-state voltage following the transient.

$$S_O = S_{MAX} - C_N$$

$$S_U = C_L - S_{MIN}$$

4. Divide the voltage determined in step 1 by the rated voltage of the power system, then multiply by 100 to convert to percentage. This is the

maximum overshoot/undershoot voltage as a percentage of its rated voltage.

$$Maximum\ Overshoot\ = \frac{S_O}{(Rated\ Voltage)} * 100$$

$$Maximum\ Undershoot = \frac{S_U}{(Rated\ Voltage)} * 100$$

**NOTE:** Do not use the constant operating voltage at each load as the divisor in the computation. Use only the rated voltage of the power system.

h. To determine the recovery time required to restore stable voltage conditions after each transient:

1. For each transient, determine the time at which the voltage leaves the prescribed short-term stability bandwidth. For example, see point E on
2. 
3. FIGURE 619.4-1.

4. For each transient, determine the time at which the voltage enters and remains within the new prescribed short-term stability bandwidth. For example, see point F on
5. 
6. FIGURE 619.4-1.

7. The recovery time is the duration of time between the beginning of the transient (step 1) and the end of the transient (step 2). For example, see $T_{FN}$ on
8. 
9. FIGURE 619.4-1.

Compare the results tabulated in 619.4.4 with the requirements of the procurement document.

619.4.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable voltage recovery time.

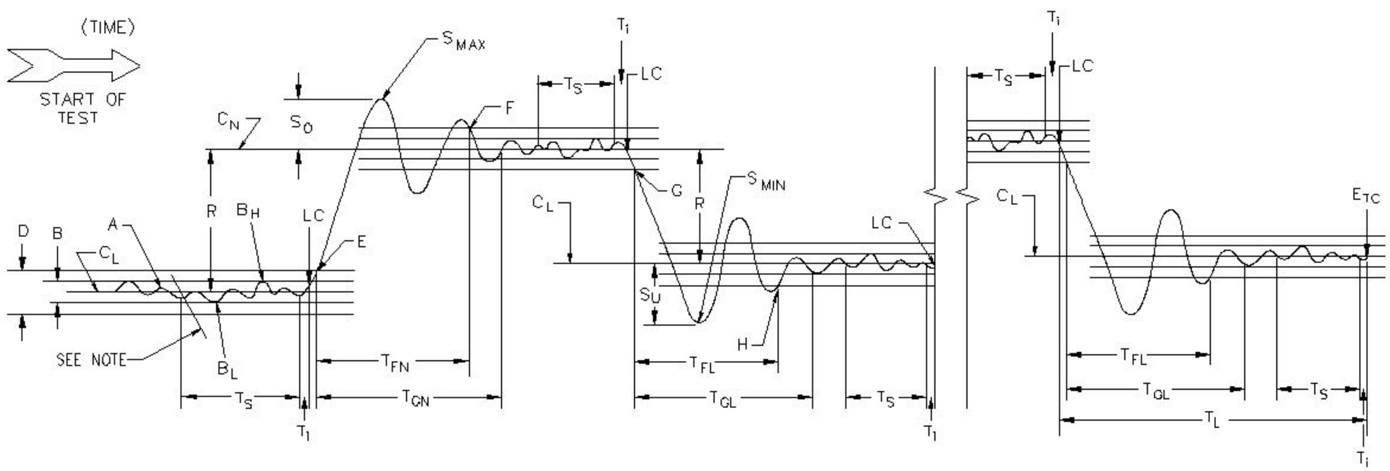
b. Maximum allowable voltage overshoot and undershoot.

c. Maximum allowable short-term stability bandwidth or deviation in percent of rated voltage.

d. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

e. The short-term time for determing stability, if not based on 30 seconds.

TRACE AND DEFINITIONS APPLY TO EITHER FREQUENCY OR RMS VOLTAGE




Note: Chart marked at start of test.

- A — Actual trace of frequency or RMS voltage.
- B — Observed short-term stability bandwidth (two lines parallel to the axis of chart movement, one each passing through the center points of maximum ($B_H$) and minimum ($B_L$) trace excursion respectively during the prescribed short-term stability period, $T_S$).
- $C_L$ — Mean value at selected load.
- $C_N$ — Mean value at no load.
- D — Prescribed short-term stability bandwidth.
- E — Point at which trace initially leaves prescribed load bandwidth under condition of decrease in load.
- $E_{TC}$ — End of transient cycle.
- F — Point at which trace enters and remains within prescribed no load bandwidth.
- G — Point at which trace initially leaves prescribed no load bandwidth.
- H — Point at which trace enters and remains within prescribed load bandwidth.
- LC — Point at which load change is triggered.
- R — Regulation between any two loads.
- $S_{MAX}$ — Maximum excursion during transient from load to no load.
- $S_{MIN}$ — Maximum excursion during transient from no load to load.
- $S_O$ — Surge, frequency overshoot or voltage overshoot.
- $S_U$ — Surge, frequency undershoot or voltage undershoot.
- $T_{FL}$ — Observed recovery time, no load to load.
- $T_{FN}$ — Observed recovery time, load to no load.
- $T_{GL}$ — Maximum allowable recovery time – no load to load.
- $T_{GN}$ — Maximum allowable recovery time – load to no load.
- $T_i$ — 0.2 - 0.3 seconds, Interim time between end of $T_S$ and LC.
- $T_L$ — 60 seconds, Time between load changes, LC.
- $T_S$ — Prescribed short-term time for determining stability.

FIGURE 619.4-1 Diagrammatic representation of voltage regulation, stability and transient response terms.

| | | |
|---|---|---|
| **DESCRIPTION:** 5KW, 60 HZ<br>120V SINGLE - PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-5.0-MD<br><br>**SERIAL NO.** 10776<br><br>**REF.** MIL-STD-705/619.4 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>VOLTAGE UNDERSHOOT AND OVERSHOOT FOR RATED LOAD TEST (RMS METHOD) | **TEST NO.** 16<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 117 | | 227 | | 336 | | 445 | | 554 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | | | | | | °F |
| **SYM** | | | | X25 | X1 | X25 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1300 | | STARTED POWER SYSTEM, APPLIED RATED LOAD | | | | | | | | | | | | | | |
| | 1305 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1310 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1315 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1320 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1325 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1330 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1335 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1340 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1345 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | 77 |
| | 1350 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.0 | | | | | | 77 |
| | 1355 | | 120.0 | 2.88 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | |
| | 1400 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.1 | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 1405 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.0 | | | | | | |
| | 1410 | | 121.2 | 0 | 0 | 0 | 0 | | -- | | 61.1 | | | | | | |
| | 1415 | | 120.0 | 2.08 | 52 | .20 | 5.0 | | 0.80 | | 60.1 | | | | | | |
| **NOTES** | C.T. #1101 | | | | | | | | | | | | | | | | |
| | SHUNT # 1310, 1A, 50mV | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 619.4-2 Typical test record for voltage undershoot and overshoot for rated load test (RMS method).

# METHOD 620.1c

## VOLTAGE UNBALANCE WITH UNBALANCED LOAD TEST (LINE-TO-NEUTRAL LOAD)

620.1.1 General. A power system must have the capability to maintain a reasonably balanced voltage among the phases when an unbalanced load is applied. Line-to-line voltage unbalance has a serious effect on polyphase motor loads. The negative sequence voltages cause heating of the windings and loss of torque. Line-to-neutral voltage deviations from rated voltage affect single phase loads. Lights and single phase motors may have either too low or too high a voltage impressed on them for either efficient or safe operation.

620.1.2 Apparatus. Use instrumentation for measuring load conditions and ambient temperature as described and illustrated in the 100 series methods, as applicable. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4. The voltmeter used shall have an accuracy in accordance with 4.2.

620.1.3 Procedure.

620.1.3.1 Preparation for test. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for one voltage connection and frequency specified in the procurement document.

620.1.3.2 Test.

a. Start and operate the power system at rated voltage, no load, rated frequency, and under control of the voltage regulator. Record all instrument readings per METHOD 203.1 (see FIGURE 620.1-1).

b. Apply the specified load between terminals $L_1$-N, $L_2$-N, and $L_3$-N in turn. Record all instrument readings at each line-to-neutral condition.

c. Repeat 620.1.3 for each of the other specified voltage connection(s) and frequency(ies).

620.1.4 Results.

a. Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

b. Compare the largest differences expressed in percent with the maximum allowable difference specified in the procurement document.

620.1.4.1 Sample calculations.

$L_1$-N = 115.1 volts

$L_2$-N = 117.0 volts
$L_3$-N = 121.1 volts

Maximum difference = 5.0 volts

Rated Voltage = 120.0 volts

$$\frac{5.0}{120.0} * 100 = 4.17\ percent$$

620.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Load(s) to be applied as unbalanced loads in percent of rated line-to-neutral load.

b. Maximum acceptable values of line-to-line voltage unbalance expressed as percent of rated voltage.

c. Maximum acceptable values of line-to-neutral voltage unbalance expressed as a percent of rated voltage.

d. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

**DESCRIPTION:** 10KW, 60 HZ 120/208V 3-PHASE POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 10761

**REF.** MIL-STD-705/620.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE UNBALANCE WITH UNBALANCED LOAD TEST
(LINE – TO – NEUTRAL LOAD)

**TEST NO.** 24

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 7284 | | | | | | 1528 | | | 1476 | 319 | 216 | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | | | | LINE CURRENT | | | OUTPUT POWER | POWER FACTOR | FREQ | DIFFERENCE | | | AVG AMB TEMP |
| | | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | $L_1$-N | $L_2$-N | $L_3$-N | $L_1$ | $L_2$ | $L_3$ | | | | L-L | L-N | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | KW | -- | HZ | % | % | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | | | | | | | | | | | | | | | | | |
| | 1000 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1010 | 208.0 | 208.0 | 208.1 | 120.0 | 120.0 | 120.1 | 0 | 0 | 0 | 0 | -- | 60.0 | -- | -- | | 76 |
| | | 200.0 | 198.5 | 207.0 | 115.1 | 117.0 | 121.1 | 8.6 | 0 | 0 | .83 | .80 | 60.0 | 4.1 | 5.0 | | |
| | | | | | | | | | | | | | | | | | |
| | | 208.0 | 208.0 | 208.1 | 120.0 | 120.0 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | -- | -- | | |
| | | 207.0 | 200.0 | 198.5 | 121.1 | 115.1 | 117.0 | 0 | 8.6 | 0 | .83 | .80 | 60.0 | 4.1 | 5.0 | | |
| | | | | | | | | | | | | | | | | | |
| | | 208.0 | 208.0 | 208.1 | 120.0 | 120.0 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | -- | -- | | |
| | | 198.5 | 207.0 | 200.0 | 117.0 | 121.1 | 115.1 | 0 | 0 | 8.6 | .83 | .80 | 60.0 | 4.1 | 5.0 | | 77 |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

SAMPLE CALCULATION =

$$\frac{121.1-115.1}{120} \text{ X } 100 = \frac{6}{120} \text{ X } 100 = 5.0\%$$

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

**NOTES** LINE CURRENT MEASURED USING C.T. NOs. $L_1$ - 1305, $L_2$ - 1306, $L_3$ - 1307

FIGURE 620.1-1 <u>Typical test record for voltage unbalance with unbalanced load test</u>.

METHOD 620.2c

VOLTAGE UNBALANCE WITH UNBALANCED LOAD TEST
(LINE-TO-LINE)

620.2.1 General. A power system must have the capability to maintain a reasonably balanced voltage among the phases when an unbalanced load is applied. Line-to-line voltage unbalance has a serious effect on polyphase motor load. The negative sequence voltages cause heating of the windings and loss of torque.

620.2.2 Apparatus. Use instrumentation for measuring load conditions and ambient temperature as described and illustrated in the 100 series methods, as applicable. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4. The voltmeter shall have an accuracy in accordance with 4.2.

620.2.3 Procedure.

620.2.3.1 Preparation for test. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for a specified voltage and frequency condition. Use only one voltmeter to measure the line-to-line voltages.

620.2.3.2 Test.

a. Start and operate the power system at rated voltage, no load, rated frequency, and under control of the voltage regulator. Record all instrument readings per METHOD 203.1 (see FIGURE 620.2-1).

b. Apply the specified load between terminals $L_1$-N, $L_2$-N and $L_3$-N in turn. Record all instrument readings at each line-to-line condition.

c. Repeat 620.2.3 for each of the other specified voltage connection(s) and frequency(ies).

620.2.4 Results.

a. Express the difference between any of the maximum and minimum line-to-line voltages as a percent of rated line-to-line voltages.

b. Compare the largest differences expressed in percent with the maximum allowable difference specified in the procurement document.

620.2.4.1 Sample calculations.

Reading No. 222 $L_1$-$L_2$ = 200 volts
$L_2$-$L_3$ = 203 volts
$L_3$-$L_1$ = 210 volts

Maximum line-to-line difference = 10 volts
Rated line-to-line voltage = 208 volts

$$\frac{10}{208} * 100 = 4.81\ percent$$

620.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Load(s) to be applied as unbalanced load in percent of rated line-to-line load.

b. Maximum acceptable values of line-to-line voltage unbalance expressed as a percent of rated voltages.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

**DESCRIPTION:** 10 KW, 400HZ
120/208 V 3-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** HF-10.0-MD

**SERIAL** NO. 01415

**REF.** MIL-STD-705/620.2

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

VOLTAGE UNBALANCE WITH UNBALANCED LOAD TEST (LINE-TO-LINE)

**TEST NO.** 23

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 7284 | | | 1584 | | | 1476 | 319 | 216 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | LINE CURRENT | | | OUTPUT POWER | POWER FACTOR | FREQ | | MAXIMUM LINE TO LINE DIFFERENCE | | | | | AVG AMB TEMP |
| | | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | $L_1$ | $L_2$ | $L_3$ | | | | | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | KW | -- | HZ | | VOLTS | % | | | | °F |
| **SYM** | | | | | X2 | X2 | X2 | X2 | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 950 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1000 | 206.0 | 206.0 | 207.0 | 0 | 0 | 0 | 0 | -- | 412 | | 1 | 0.481 | | | | 83 |
| | 1010 | 200.0 | 198.5 | 207.0 | 4.34 | 4.34 | 0 | 0.865 | 1.00 | 410 | | 8.5 | 4.08 | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1015 | 207.0 | 207.0 | 207.0 | 0 | 0 | 0 | 0 | -- | 412 | | 0 | 0 | | | | |
| | 1025 | 209.0 | 219.0 | 212.0 | 4.48 | 0 | 4.48 | 0.950 | 1.00 | 410 | | 10 | 4.81 | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1030 | 207.0 | 207.0 | 207.0 | 0 | 0 | 0 | 0 | -- | 412 | | 0 | 0 | | | | |
| | 1035 | 211.0 | 209.0 | 202.5 | 0 | 4.36 | 4.36 | 0.890 | 1.00 | 410 | | 8.5 | 4.08 | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING CURRENT TRANSFORMERS $L_1$ – NO 1304 | | | | | | | | | | | | | | | | |
| | $L_2$ – NO 1305 | | | | | | | | | | | | | | | | |
| | $L_3$ – NO 1306 | | | | | | | | | | | | | | | | |

FIGURE 620.2-1 Typical test record for voltage unbalance with unbalanced load test (line-to-line).

# METHOD 620.4c

## VOLTAGE UNBALANCE TEST (THREE WIRE, SINGLE PHASE)

620.4.1 General. A power system must have the capability to maintain balanced voltages when an unbalanced load is applied. Voltage deviations from rated voltage affect single phase loads. Lights and single phase motors may have either too low or too high a voltage impressed on them for either efficient or safe operation.

620.4.2 Apparatus. Use instrumentation for measuring load conditions and ambient temperature as described and illustrated in the 100 series methods, as applicable. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4. The voltmeter used shall have an accuracy in accordance with 4.2.

620.4.3 Procedure.

620.4.3.1 Preparation for test. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for one voltage connection and frequency specified in the procurement document.

620.4.3.2 Test.

a. Start and operate the power system at rated voltage, no load, rated frequency, and under control of the voltage regulator. Record all instrument readings per METHOD 203.1 (see FIGURE 620.4-1).

b. Apply the specified load between terminals $L_1$-N, $L_2$-N and $L_1$-N in turn. Record all instrument readings at each load condition.

620.4.4 Results.

a. Express the greatest difference between the two line-to-neutral voltages as a percent of rated line-to-neutral voltage.

b. Compare this difference expressed in percent with the maximum allowable difference specified in the procurement document.

620.4.4.1 Sample calculations.

$L_1$-N = 118.0 volts

$L_2$-N = 122.0 volts

Voltage Difference = 4.0 volts

Rated Line to Neutral Voltage = 120.0 volts

$$\frac{4.0}{120.0} * 100 = 3.33\ percent$$

620.4.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Load(s) to be applied as unbalanced load in percent of rated line-to-neutral load.

b. Maximum acceptable value of line-to-neutral voltage unbalance in percent of rated voltage.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

| **DESCRIPTION:** 10KW, 60HZ 120/240V, SINGLE-PHASE POWER SYSTEM<br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SF-10.0-MD<br>**SERIAL NO.** 10776<br>**REF.** MIL-STD-705/620.4 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>VOLTAGE UNBALANCE TEST<br>(THREE WIRE, SINGLE PHASE) | **TEST NO.** 99<br>**SHEET:** 1 OF 1<br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** J. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST→** | | 312 | | | 212 | | 316 | | 618 | | 406 | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | VOLTAGE DIFFERENCE | | | | AVG AMB TEMP |
| | | $L_1$-$L_2$ | $L_1$-N | $L_2$-N | | | | | | | | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | VOLTS | % | | | °F |
| **SYM** | | | | | X5 | | X5 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| | 0805 | 240 | 120.0 | 120.0 | | 0 | | 0 | | -- | | 60.0 | 0 | 0 | | | 72 |
| | | | | | | | | | | | | | | | | | |
| $L_1$-N | 0810 | 239.6 | 118.3 | 121.3 | 2.60 | 13.0 | .25 | 1.25 | | .80 | | 60.0 | 3.0 | 2.5 | | | |
| | | | | | | | | | | | | | | | | | |
| $L_2$-N | 0815 | 240.0 | 122.0 | 118.0 | 2.60 | 13.0 | .25 | 1.25 | | .80 | | 60.0 | 4.0 | 3.33 | | | |
| | | | | | | | | | | | | | | | | | |
| $L_1$-$L_2$ | 0820 | 238.0 | 119.0 | 119.0 | 2.60 | 13.0 | .50 | 2.50 | | .80 | | 60.0 | 0 | 0 | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

| **NOTES** | LINE CURRENT MEASURED USING C.T. #1308 |
|---|---|

FIGURE 620.4-1 Typical test record for voltage unbalance test (three wire, single phase).

# METHOD 621.1b

## UNBALANCED LOAD HEATING TEST

**NOTE**: Method 621.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

621.1.1 General. The generator set must be capable of withstanding without damage unbalanced loads for long periods of time.

621.1.2 Apparatus. Instrumentation for measuring load conditions, field conditions, field voltage and current, temperature of the generator windings and ambient temperature shall be as described and illustrated in MIL-HDBK-705.

621.1.3 Procedure.

621.1.3.1 Preparation for test.

a. Connect the load and field instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for one voltage connection and frequency specified in the procurement document.

b. Connect switch(es) to the generator armature winding(s) for which the temperature rise is to be determined, such that the winding(s) may be isolated for resistance measurements (if rapid access is available to isolate the individual winding(s) this step may be omitted).

c. Attach the necessary thermal instrumentation in accordance with MIL-HDBK-705, method 202.1 and make the necessary winding resistance measurements in accordance with MIL-STD-705, method 401.1

621.1.3.2 Test.

a. Start and operate the generator set at rated voltage, no load, rated frequency, and under control of the voltage regulator.

b. Apply the specified unbalanced load.

c. Add balanced load at rated power factor, until rated current is recorded at one or the other of the two terminals to which the single phase load is connected.

**NOTE**: The current will not be the same in the lines to which the single phase load is applied, if the power factor of the three phase load is other than unity. As soon as the current at either terminal is at rated value, discontinue adding three phase load.

d. Allow the generator set to stabilize at the above conditions. During this period record all instrument readings including ambient temperature at minimum intervals of 10 minutes. If necessary adjustments to the voltage and frequency may be made to maintain rated conditions. Adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage and frequency adjust devices. On sets utilizing a droop type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the procurement document. Adjustments to the voltage and frequency controls shall be recorded on the data sheets at the time of adjustment. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the voltage or frequency has been made (see FIGURE 621.1-I).

e. After stabilization has occurred, stop the set so that temperatures of rotating components and windings may be taken. For application of the contact method to rotating parts, or the resistance method to the armature coils (see MIL-HDBK-705, methods 110.1 and 202.1); a quick shutdown of the set is mandatory.

**CAUTION: Do not connect bridges, meters or temperature measuring equipment for measuring resistance or temperature to circuits which may still be energized, e.g., during the time that the set is coming to a stop.**

f. Immediately after the shutdown, start to record the resistance bridge readings of the windings and the temperature of the components, where the contact method of measuring temperature rise is used. Readings of resistance measurements shall be recorded in accordance with instructions given in MIL-HDBK-705, method 110.1. The first thermocouple reading shall be taken and recorded within 30 seconds after shutdown and additional readings taken and recorded at approximately 30 second intervals until one reading has been recorded after the temperature has begun to decrease, or three minutes has elapsed since set shutdown, whichever is longer, being certain that the maximum temperature reached by each component has been recorded. Continuous or multipoint temperature recorder(s) may be used to record component temperatures as long as the above time requirements are met.

g. Repeat steps a through f above for each of the windings specified in the procurement document.

621.1.4 Results. Compare the temperature rise(s) with the procurement document requirements.

621.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Allowable temperature rise for the windings, giving the method of measurement.

b. Unbalanced load to be applied, in percent of rated phase load.

c. Voltage connection(s) and frequency (ies) at which this method is to be performed.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120/208V 3 PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 107671<br><br>**REF.** MIL-STD-705/621.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>UNBALANCED LOAD HEATING TEST | **TEST NO.** 96<br><br>**SHEET:** 1 OF 2<br><br>**DATE:** MARCH 26, 1971<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 107 | | | | | | 312 | | | 418 | | | 210 | 156 | 372 | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | | | | LINE CURRENT | | | OUTPUT POWER | | | FREQ | EXCITER FIELD | | AVG AMB TEMP |
| | | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | $L_1$-$L_0$ | $L_2$-$L_0$ | $L_3$-$L_0$ | $L_1$ | $L_2$ | $L_3$ | $L_1$ | $L_2$ | $L_3$ | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | KW | KW | KW | HZ | VOLTS | AMPS | |
| **SYM** | | | | | | | | X10 | X10 | X10 | X10 | X10 | X10 | | | | °F |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1100 | STARTED UNIT | | | | | | | | | | | | | | | |
| | 1102 | 208.0 | 208.0 | 208.0 | 120.0 | 120.0 | 120.0 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 8.3 | 0.91 | 72 |
| | 1105 | APPLIED SINGLE PHASE LOAD TO $L_1$-$L_2$ | | | | | | | | | | | | | | | |
| | 1107 | 207.0 | 209.0 | 209.0 | 119.0 | 119.0 | 121.0 | .87 | .87 | 0 | .072 | .072 | 0 | 60.0 | 10.1 | 1.02 | 72 |
| | 1110 | APPLIED SYMETRICAL THREE PHASE LOAD | | | | | | | | | | | | | | | |
| | 1120 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.0 | 1.51 | 72 |
| | 1130 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.3 | 1.51 | 72 |
| | 1140 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.3 | 1.51 | 72 |
| | 1150 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.3 | 1.51 | 72 |
| | 1200 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.3 | 1.51 | 72 |
| | 1212 | SHUT DOWN SET FOR RESISTANCE READING $T_1$-$T_4$ | | | | | | | | | | | | | | | |
| | 1220 | RESTARTED SET – APPLIED UNBALANCED LOAD | | | | | | | | | | | | | | | |
| | 1230 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.1 | 1.51 | 72 |
| | 1240 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.3 | 1.51 | 72 |
| | 1250 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.3 | 1.51 | 72 |
| | 1300 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.3 | 1.51 | 72 |
| | 1310 | 207.0 | 208.5 | 208.5 | 119.0 | 119.5 | 121.0 | 3.47 | 3.40 | 2.61 | 3.33 | .326 | .250 | 60.0 | 16.3 | 1.51 | 72 |
| | 1312 | SHUT DOWN SET FOR RESISTANCE READING $T_2$-$T_5$ | | | | | | | | | | | | | | | |
| | 1320 | RESTARTED SET – APPLIED UNBALANCED LOAD | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. N0s. $L_1$-1305; $L_2$-1306; $L_3$-1307 | | | | | | | | | | | | | | | | |
| | EXCITER FIELD CURRENT MEASURED USING 2A, 50mV, SHUNT NO. 008 | | | | | | | | | | | | | | | | |

FIGURE 621.1-I Portion of typical test record for unbalanced load heating test.

METHOD 625.1e

SHORT CIRCUIT TEST
(MECHANICAL STRENGTH)

625.1.1 General. The mechanical design of the power system must be adequate to withstand the stresses caused by abnormal operating conditions including sustained short circuits.

625.1.2 Apparatus. Use instrumentation for measuring load conditions and ambient temperature as described and illustrated in the 100 series methods, as applicable. Use a shorting switch and a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter (unless otherwise specified in the procurement document).

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

**WARNING:**

**The shorting switch used must be able to withstand the short circuit currents. Failure to use a proper switch may cause personal injury or death.**

**CAUTION: Do not close any load switches or circuit interrupters until specifically directed to do so. Closing the load switches or circuit interrupters at any other time may damage both the equipment and the test apparatus.**

625.1.3 Procedure.

625.1.3.1 Preparation for test.

a. Deactivate the circuit interrupter.

b. Connect the load and instrumentation in accordance with the applicable figure of 205.1.10 for one voltage connection and frequency specified in the procurement document.

c. Connect the data recorder in accordance with the data recorder manufacturer's instructions and the shorting switch directly to the specified line terminals in order to measure the short circuit current.

625.1.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 625.1-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 625.1.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

| **WARNING:** |
| --- |
| **If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.** |

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 625.1.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

| **NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency. |
| --- |

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. After stabilization occurs apply the short circuit(s) for the time specified in the procurement document. Record all instrument readings including the steady-state short-circuit current for each short circuit condition.

c. Repeat steps a and b above for all other voltage connections and frequencies specified in the procurement document.

d. Inspect the power system, its sub-systems and control devices (as applicable) for damage incurred during the short-circuit event. List any damage on the data sheet. Sub-systems can include those for regulating voltage and frequency; energy storage components, wiring harnesses, stator windings and any others.

625.1.4 Results. Calculate the sustained short-circuit current as a percent of rated current and compared with the value given in the procurement document. Any damage to the power system constitutes failure of this test.

625.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Type(s) of short circuit to be applied.

b. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

c. Length of time short circuit is to be applied.

d. Minimum acceptable value of sustained short-circuit current.

e. Definition of damage.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 400 HZ<br>120V SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** HF-10.0-MD<br>**SERIAL NO.** 01417<br>**REF.** MIL-STD-705/625.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>SHORT CIRCUIT TEST<br>(MECHANICAL STRENGTH) | **TEST NO.** 37<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |

| **INST→** | | 1013 | | 918 | | 672 | | 498 | | 311 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | SHORT CIRCUIT CURRENT | | AVG. AMB TEMP. |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | | | | AMPS | AMPS | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | X100 | X1 | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1300 | STARTED POWER SYSTEM APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1305 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1310 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1315 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1320 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1325 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1330 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1335 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1340 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1345 | | 120.0 | 2.60 | 104 | 0.250 | 10.0 | | 0.80 | | 400.0 | | | | | | 77 |
| | 1350 | APPLIED SHORT CIRCUIT FOR 10 SEC. | | | | | | | | | | | | | 4.15 | 415 | |
| | 1355 | APPLIED SHORT CIRCUIT FOR 10 SEC. | | | | | | | | | | | | | 4.15 | 415 | |
| | 1400 | APPLIED SHORT CIRCUIT FOR 10 SEC. | | | | | | | | | | | | | 4.15 | 415 | |
| | 1405 | APPLIED SHORT CIRCUIT FOR 10 SEC. | | | | | | | | | | | | | 4.15 | 415 | |
| | 1410 | APPLIED SHORT CIRCUIT FOR 10 SEC. | | | | | | | | | | | | | 4.15 | 415 | |
| | 1415 | APPLIED SHORT CIRCUIT FOR 10 SEC. | | | | | | | | | | | | | 4.15 | 415 | |
| | 1420 | APPLIED SHORT CIRCUIT FOR 10 SEC. | | | | | | | | | | | | | 4.15 | 415 | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

| | | |
|---|---|---|
| **NOTES** | LINE CURRENT MEASURED USING C.T. NO. 1305<br>SHORT CIRCUIT CURRENT MEASURED USING C.T. NO. 1306 | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY |

FIGURE 625.1-1 Typical test record for short circuit test (mechanical strength).

METHOD 630.1e

PARALLEL OPERATING TEST

630.1.1 General. It is sometimes necessary to connect two or more power systems (which are designed for parallel operation) in parallel to supply power requirements greater than the rating of an individual power system. Power systems may also be connected in parallel to assure an uninterrupted supply of power if it becomes necessary for one power system to be shutdown for maintenance or service. When two or more power systems are connected in parallel, the capability should exist for supplying power equal to their combined ratings without overloading any one of the individual units. Thus, the power systems must divide the load in proportion to their individual power ratings and minimize the power exchange between the parallel-connected power systems. Power exchange is the difference between the maximum and minimum power output delivered by each power system given a constant total load.

630.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

630.1.3 Procedure.

630.1.3.1 Test instrumentation setup.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

b. Record the following items on both data sheets and file(s):

1. The date.

2. The serial number(s) of the recording meter(s).

3. Power system identification.

4. The data reading number (indexing).

(Refer to FIGURE 630.1-1 and FIGURE 630.1-2.)

c. Place all instrumentation referred to in 630.1.2 in operation.

**CAUTION: Do not close any load switches or circuit interrupters until specifically directed to do so. Closing the load switches or circuit interrupters at any other time may damage both the equipment and the test apparatus.**

630.1.3.2 Preparation for test. The following instructions are for paralleling two power systems of the same power (and frequency) rating. For paralleling more than two power systems of different power ratings, this method may be followed by extension of the procedure.

a. Connect the power systems to be paralleled for one of the voltage connections and frequencies specified in the procurement document.

b. Connect each of the power systems, through individual load switches, to a common system load using the proper phase sequence (like output terminal numbers on each power system are connected together on the same line). Connect the individual power system instrumentation and system load instrumentation in accordance with the applicable figure in 205.1.10. Record the active power (watts) delivered by one power system.

c. Prepare the power systems for paralleling in accordance with technical manual or manufacturer's instructions.

630.1.3.3 Test.

a. Perform METHOD 507.1, Phase Sequence Test (Rotation) only at the voltage connection under test on each power system. If any failure occurs, stop test and record failure.

b. Open all circuit interrupters and load switches.

c. Operate the power systems at rated voltage, rated frequency and at no load.

d. Parallel the two power systems in accordance with the technical manual or manufacturer's instruction.

e. Apply the minimum total load specified in the procurement document.

f. With the power systems operating in parallel, and with each power system loaded to the minimum load value specified in the procurement document, make small adjustments to the governors (by means of the frequency adjust device only) to equally divide the kW load between the power systems. Make small adjustments to the voltage regulators (by means of the voltage adjust device only) to obtain a minimum and equal current, thereby dividing the reactive load equally between the power systems.

g. For power systems with real and reactive load sharing controls, increase the total load in small increments and balance this load between each power system using the real and reactive load sharing controls until each power system is carrying rated load. Make no further adjustments to either the load sharing controls or the voltage and frequency adjust devices for the remainder of this test unless specifically directed otherwise.

h. In one step, reduce the total load to the minimum value specified in the procurement document. Operate the power systems at this load condition for one hour. Record the load instrumentation readings for each power system and the total load at 15 minute intervals per METHOD 203.1 (see FIGURE 630.1-1).

i. Increase the total load in four approximately equal steps until the combined rating of the power systems is applied. At each of the four load steps operate the power systems for one hour taking readings and recordings as in step h above. At each of the four load steps, take data to determine the long-term voltage and frequency stability per METHOD 608.2, Frequency and Voltage Stability Test (Long-Term).

j. After the four load steps and with each power system operating at rated load, perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short-Term) except the stabilization of 608.1.3.2a is not required.

k. On power systems having a reverse power protective device, slowly adjust the frequency adjust device on one of the power systems in such a manner as to increase the load on that power system until the circuit interrupter on the other power system opens or the specified value of reverse power is exceeded. Record the value of reverse power at which the circuit interrupter opens or record that the specified value of reverse power was attained without the circuit interrupter opening. Record the indication of the malfunction indicator as applicable.

l. Parallel the two power systems in accordance with the technical manual or manufacturer's instruction.

m. On power systems having permissive paralleling provisions, do the following:

1. Verify that two power systems shall not parallel until the voltage difference of the same phase is less than the value specified in the procurement document.

2. Verify that the permissive paralleling device shall not be damaged or falsely operate when: either of its AC terminals is raised to a voltage over ground specified by the procurement document; or when the voltage across the AC input terminals is at any value between 0 and the voltage over ground specified by the procurement document.

3. Repeat steps 1 and 2 above except hold the circuit interrupter actuating switch on one power system closed until the circuit interrupter actually closes. Record whether or not the circuit interrupters on either power system opened and any indication of the malfunction indicator, as applicable.

4. Repeat step 3 above using the other power system.

n. Repeat steps a through m above for each of the other voltage connections and frequencies specified in the procurement document.

630.1.4 Results.

630.1.4.1 Active power division.

a. Using the individual power system load instrumentation data, determine the kilowatt output for each power system, in percent of its nameplate rating, at each load condition. This is the active power division for each power system.

b. Determine the difference in the percentage of kilowatt load carried by each power system by subtracting the values calculated in step a at each of the load conditions.

630.1.4.2 Active power exchange.

a. From the data, determine at each load condition the maximum and minimum values of active power carried by one power system.

b. Subtract the minimum value from the maximum value, divide by the nameplate rating of the power system and multiply by 100. This is the active power exchange in percent of the nameplate rating of the individual power system.

630.1.4.3 Reactive power division.

a. Using the individual power system load instrumentation data, determine the kVAR output for each power system at each load condition. This is the reactive power division for each power system.

b. Determine the difference in the reactive power by subtracting the values calculated in step a above for each load condition. Divide the remainder by the individual power system's kVAR rating. This is the percent unbalance in the reactive power division.

630.1.4.4 Load current pulsation.

a. From the data, determine at each load condition the maximum and minimum values of load current carried by one power system.

b. Subtract the minimum value from the maximum value, divide by the nameplate current rating of the power system and multiply by 100. This is the load current pulsation in percent of the nameplate rating of the individual power system.

630.1.4.5 Voltage and frequency stability and transient response.

a. From the data, determine the voltage and frequency stability bandwidths for each load condition of 630.1.3.3, steps h and i. Refer to METHOD 608.2.

b. For each of the load transients performed in 630.1.3.3, step j, determine the following (refer to METHOD 608.1):

1. Recovery times.

2. The overshoot.

3. The undershoot.

4. The regulation for voltage and frequency.

630.1.4.6 Compare these results with the procurement document requirements.

630.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Voltage connection(s) and frequency(ies) at which the Method is to be performed.

b. Minimum and maximum total load values.

c. Voltage and frequency droop control settings at which this Method is to be performed, if applicable.

d. Maximum load transient, if other than specified in this Method.

e. Active (kilowatt) power difference allowed, in percent of individual power system rating.

f. Reactive power difference allowed, in percent of individual power system rating.

g. Maximum active power exchange allowed, in percent of individual power system rating.

h. Maximum load current pulsation exchange in percent of individual power system rating, if applicable.

i. Maximum value of reverse power at which the circuit interrupter is to operate if applicable.

j. Malfunction indicator requirements, if applicable.

k. Maximum allowable long-term voltage stability bandwidth or deviation in percent of rated voltage.

l. Maximum allowable long-term frequency stability bandwidth or deviation in percent of rated frequency.

m. Maximum allowable short-term voltage stability bandwidth or deviation in percent of rated voltage.

n. Maximum allowable short-term frequency stability bandwidth or deviation in percent of rated frequency.

o. Maximum allowable voltage recovery time.

p. Maximum allowable frequency recovery time.

q. Maximum allowable voltage overshoot and undershoot, if applicable.

r. Maximum allowable frequency overshoot and undershoot.

s. Maximum allowable voltage regulation.

t. Maximum allowable frequency regulation.

u. Maximum voltage difference in the same phase to permit paralleling, if applicable.

v. Maximum AC terminal voltage of the permissive paralleling device, if applicable.

| **DESCRIPTION:** 60KW, 60HZ 120/208V 3-PHASE POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SF-60.0-MD<br>**SERIAL NO.** 0087<br>**REF.** MIL-STD-705/630.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>PARALLEL OPERATING TEST<br><br>#0087 PARALLELED WITH #0103 | **TEST NO.** 61<br><br>**SHEET:** 1 OF 3<br><br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST→** | | 11038 | | | 1081 | | | | | | 534 | | 671 | | 422 | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM. VOLTAGE | | | LINE CURRENT | | | | | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | AVG AMB TEMP |
| | | $L_1$-N | $L_2$-N | $L_3$-N | $L_1$ | $L_1$ | $L_2$ | $L_2$ | $L_3$ | $L_3$ | | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | AMPS | AMPS | AMPS | KW | KW | | -- | | HZ | °F |
| **SYM** | | | | | X80 | X1 | X80 | X1 | X80 | X1 | X80 | X1 | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1340 | APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1345 | 119.5 | 120.0 | 119.8 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 83 |
| | 1350 | 119.5 | 120.0 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 83 |
| | 1355 | 119.6 | 120.1 | 119.9 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 83 |
| | 1400 | 119.6 | 120.1 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 84 |
| | 1405 | 119.6 | 120.1 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 83 |
| | 1410 | 119.6 | 120.1 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 83 |
| | 1415 | 119.6 | 120.1 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 83 |
| | 1420 | 119.6 | 120.1 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 83 |
| | 1435 | 119.6 | 120.1 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | 83 |
| | | TRANSIENT RESPONSE | | | | | | | | | | | | | | | |
| | 1440 | 120.1 | 120.3 | 120.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | - | | 60.1 | |
| | | 119.6 | 120.0 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | |
| | | 120.0 | 120.2 | 120.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | - | | 60.1 | |
| | | 119.7 | 120.0 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | |
| | | 120.1 | 120.2 | 120.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | - | | 60.1 | |
| | | 119.6 | 120.0 | 120.0 | 2.66 | 212.8 | 2.64 | 211.2 | 2.65 | 212.0 | .750 | 60.0 | | 0.78 | | 60.0 | |
| | | REVERSE POWER PROTECTIVE DEVICE CHECK | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 1445 | | | | | | | | | | .160 | 12.8 | | | | | |
| | | DEVICE ACTUATED – REVERSE POWER MALFUNCTION INDICATOR ON – POWER SYSTEM DROPPED OFF LINE | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. # $L_1$ – 1307 | | | | | | | | | | | | | | | | |
| | # $L_2$ – 1308 | | | | | | | | | | | | | | | | |
| | # $L_3$ – 1309 | | | | | | | | | | | | | | | | |

FIGURE 630.1-1 Portion of a typical test record for parallel operating test.

| **DESCRIPTION:** 60 KW, 60 HZ<br>120/208V, 3-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SE-60.0-MD<br>**SERIAL NO.** 0087 & 0103<br>**REF.** MIL-STD-705/630.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>PARALLEL OPERATING TEST<br>RESULTS | **TEST NO.** 61<br><br>**SHEET:** 1 OF 2<br><br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST→** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO↓** | | | | | | NOM. SYSTEM LOAD | S/N 0087 | | S/N 0103 | | % DIFFERENCE | | | | | | |
| **UNITS** | | | | | | % | | % | | % | | % | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | ACTIVE POWER DIVISION | | | | | 50 | | 47 | | 53 | | 6 | | | | | |
| | | | | | | 62.5 | | 60 | | 65 | | 5 | | | | | |
| | | | | | | 75 | | 73 | | 77 | | 4 | | | | | |
| | | | | | | 87.5 | | 88 | | 87 | | 1 | | | | | |
| | | | | | | 100 | | 100 | | 100 | | 0 | | | | | |
| | | | | | | | MAX. | MIN. | MAX. | MIN. | | | | | | | |
| | ACTIVE POWER EXCHANGE | | | | | | KW | KW | KW | KW | | | | | | | |
| | | | | | | 50 | 28.8 | 27.6 | 32.4 | 31.2 | | 2 | | | | | |
| | | | | | | 62.5 | 36.6 | 35.4 | 39.5 | 38.3 | | 2 | | | | | |
| | | | | | | 75 | 44.3 | 43.1 | 46.7 | 45.5 | | 2 | | | | | |
| | | | | | | 87.5 | 53.2 | 52.1 | 52.7 | 51.5 | | 2 | | | | | |
| | | | | | | 100 | 60.6 | 59.4 | 60.6 | 59.4 | | 2 | | | | | |
| | | | | | | | | | | | | | | | | | |
| | REACTIVE POWER DIVISION | | | | | | | KVAR | | KVAR | | %UNBAL | | | | | |
| | | | | | | 50 | | 22.0 | | 23.4 | | 3 | | | | | |
| | | | | | | 62.5 | | 28.0 | | 28.9 | | 2 | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | 75 | | 34.0 | | 35.6 | | 3 | | | | | |
| | | | | | | 87.5 | | 39.3 | | 40.2 | | 2 | | | | | |
| | | | | | | 100 | | 45.0 | | 46.1 | | 2 | | | | | |
| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 630.1-2 Portion of typical results for parallel operating test.

METHOD 640.1e

MAXIMUM POWER TEST
(FOR GASOLINE AND DIESEL POWER SYSTEMS)

640.1.1 General. The maximum power of a power system is a function of the ambient conditions (temperature and altitude) and the power system's condition at any particular time.

640.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. Use instrumentation for measuring pressures as described in METHOD 112.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

640.1.3 Procedure.

**CAUTION: This procedure subjects the power systems to a severe overload which may be damaging if maintained for too long a period of time.**

640.1.3.1 Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figure of 205.1.10 for one voltage connection and frequency specified in the procurement document.

b. Install appropriate thermocouples to measure the following temperatures:

**NOTE**: Not all power systems require instrumentation of all of the listed items. The list contains items normally instrumented. However, some power systems may require additional thermal instrumentation.

1. Engine coolant (engine outlet and inlet).
2. Spark plug(s).
3. Exhaust gas(es) [the exhaust manifold(s) shall be drilled and tapped as close as possible to the combustion chamber(s).]
4. Lubricating oil sump.
5. Engine combustion air in (located at the inlet of the intake manifold).

c. Install appropriate pressure instrumentation to measure the following items:

   1. Exhaust pressure (combined exhaust gases in exhaust manifold).

   2. Intake air manifold pressure (between air filters and manifold).

d. Obtain and record the barometric and water vapor pressures (see METHOD 220.2).

e. On power systems having more than one power output system; e.g. high voltage AC and low voltage DC (disregard the battery charging system) or two AC systems of different frequencies, maintain the system with the lowest power rating at rated load for all parts of this test. Then vary the load in the power output system with the highest power rating as indicated below to determine the maximum power of the power system.

f. Bypass the power system circuit interrupter if required.

g. Connect the power system to a source of fuel containing a specified fuel required by the procurement document.

640.1.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 640.1-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 640.1.5) after the last adjustment to load, voltage, and frequency has been made.

   1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

   2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 640.1.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. Perform this test using resistive load only (on AC power systems remove reactive load after stabilization).

c. For power systems with droop-type governors (except turbocharged engine-driven power systems):

1. Alternately increase the load, voltage and frequency in small increments until the fuel system controls are in the maximum flow rate as permitted by the governor and the voltage and frequency are within 1 percent of their rated values. Do not exceed a maximum load of 125 percent of rated load.

**NOTE:** Small increments should be taken to avoid passing the maximum power at the rated voltage and frequency point and to avoid racing or bogging the engine.

2. Hold the conditions in step 1 above for two minutes. However, if the voltage and frequency cannot be maintained within 1 percent of their rated values, adjust the load to the point at which the voltage and frequency can be maintained within 1 percent of their rated values for two minutes.

**CAUTION: It may be necessary to reduce the load to a value below the rated kilowatt load for a short period of time to prevent serious overheating or damage to the power system if the above conditions cannot be readily attained. Monitor instrumentation.**

3. During the two minute period record all instrument readings including thermal and pressure instrumentation per METHOD 203.1 (see FIGURE 640.1-1). On 3-phase power systems do not record line-to-line voltages.

4. Reduce the load to rated kilowatt load and allow the power system to cool for 10 minutes.

5. Repeat steps 1 through 4 above until three valid sets of maximum power data are obtained.

d. For power systems with isochronous-type governors (except for turbocharged engine-driven power systems), repeat step c above but do not adjust the frequency.

e. For turbocharged engine-driven power systems with droop-type governors:

1. Load the power system to 125 percent of rated load unless otherwise specified in the procurement document. Adjust the frequency to the rated value and maintain the load for 5 minutes unless otherwise specified in the procurement document.

2. Record all instrument readings including thermal and pressure instrumentation.

f. For turbocharged engine-driven power systems with isochronous-type governors, repeat step e above but do not adjust the frequency.

g. Repeat steps a through f above as applicable for all other voltage connections and frequencies specified in the procurement document.

h. Repeat steps a through g above as applicable for all fuels specified in the procurement document.

640.1.4 Results.

a. Average the three valid maximum power readings for each load, voltage, frequency and fuel type. This average is the observed maximum power value.

b. Except when performed as part of METHOD 720.1, Altitude Operation Test; correct the observed maximum power value to standard conditions using the procedure in 220.2.4 for the corrected maximum power value. Compare these results with the procurement document requirements.

**NOTE:** The observed maximum power value for supercharged engine-driven power systems, including turbocharged engines, is not to be corrected to standard conditions.

640.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Minimum value of maximum power required. For turbocharged engine-driven power systems: the value of load and length of time the power system is to be operated at this load if other than specified herein.

b. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

c. Fuel(s) to be used in performing this Method, if applicable.

**DESCRIPTION:** 10 KW, 60 HZ
120 V, SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-10.0-MD
**SERIAL NO.** 21067
**REF.** MIL-STD-705/640.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

MAXIMUM POWER TEST
(FOR GASOLINE AND DIESEL POWER SYSTEMS)

**TEST NO.** 12
**SHEET:** 1 OF 2
**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J.JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST→** | | 377 | 153 | | 217 | | 706 | 809 | | | 916 | | 981 | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ. | | | ENG. AIR IN | ENG. AIR OUT | PRESSURE EXHAUST | PRESSURE INTAKE AIR | PRESSURE BAROMETRIC | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | °F | °F | in HG | in HG | in HG | | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1000 | STARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1005 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | .80 | 60.0 | | | 77 | 92 | 70.0 | 29.2 | 29.2 | | 76 |
| | 1010 | 120.4 | 2.62 | 105 | 0.251 | 10.4 | .796 | 60.3 | | | 79 | 95 | 70.2 | 29.2 | 29.2 | | 77 |
| | 1015 | 120.4 | 2.62 | 105 | 0.251 | 10.4 | .796 | 60.3 | | | 79 | 95 | 70.4 | 29.2 | 29.2 | | 77 |
| | 1020 | 120.4 | 2.62 | 105 | 0.251 | 10.4 | .796 | 60.3 | | | 79 | 95 | 70.5 | 29.2 | 29.2 | | 77 |
| | 1025 | 120.4 | 2.62 | 105 | 0.251 | 10.4 | .796 | 60.3 | | | 79 | 95 | 71.0 | 29.2 | 29.2 | | 77 |
| | 1030 | 120.4 | 2.62 | 105 | 0.251 | 10.4 | .796 | 60.3 | | | 79 | 95 | 70.8 | 29.2 | 29.2 | | 77 |
| | 1035 | 120.4 | 2.62 | 105 | 0.251 | 10.4 | .796 | 60.3 | | | 79 | 95 | 70.9 | 29.2 | 29.2 | | 77 |
| | 1040 | 120.4 | 2.62 | 105 | 0.251 | 10.4 | .796 | 60.3 | | | 79 | 95 | 72.0 | 29.2 | 29.2 | | 77 |
| | 1045 | 120.4 | 2.62 | 105 | 0.251 | 10.4 | .796 | 60.3 | | | 79 | 95 | 71.8 | 29.2 | 29.2 | | 77 |
| | | ADJUSTED LOAD, VOLTAGE AND FREQUENCY | | | | | | | | | | | | | | | |
| | 1050 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | .80 | 60.0 | | | 80 | 98 | 71.6 | 29.2 | 29.2 | | 78 |
| | 1055 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | .80 | 60.0 | | | 81 | 98 | 71.5 | 29.2 | 29.2 | | 78 |
| | 1100 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | .80 | 60.0 | | | 81 | 98 | 72.0 | 29.2 | 29.2 | | 78 |
| | 1105 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | .80 | 60.0 | | | 81 | 98 | 71.5 | 29.2 | 29.2 | | 78 |
| | 1110 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | .80 | 60.0 | | | 81 | 98 | 72.0 | 29.2 | 29.2 | | 78 |
| | 1115 | 118.8 | 2.63 | 105 | 0.313 | 12.5 | 1.0 | 59.4 | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 1120 | 118.8 | 2.63 | 105 | 0.313 | 12.5 | 1.0 | 59.4 | | | | | | | | | |
| | 1130 | 118.8 | 2.63 | 105 | 0.313 | 12.5 | 1.0 | 59.4 | | | | | | | | | |
| | AVERAGE OBSERVED MAX POWER = 12.5 KW | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. NO. 1306 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 640.1-1 Portion of a typical test record for maximum power test (for gasoline and diesel power systems).

# METHOD 640.2e

## MAXIMUM POWER TEST
## (DETERMINATION OF REQUIREMENTS FOR PRODUCTION POWER SYSTEMS)

640.2.1 General. The maximum power of a power system is a function of the ambient conditions (temperature and altitude) and the power system's condition at any particular time.

640.2.2 Apparatus. None required. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

640.2.3 Procedure. Unless otherwise specified in the procurement document, the minimum acceptable corrected maximum power limit shall not be less than 95 percent of the average of the maximum power values of the first article (FA) power systems (taken prior to endurance test), corrected to standard conditions using the procedure in 220.2.4.

$$Min\ Acceptable\ Max.Power\ Limit = Avg.FA\ Power\ System\ Max.Power * 0.95$$

640.2.4 Results. Use the value obtained above as the minimum maximum power requirement in METHOD 640.4.

640.2.5 Procurement document requirement. The following item must be specified in the individual procurement document:

a. The minimum acceptable value of maximum power, if other than that specified herein.

METHOD 640.4b

# MAXIMUM POWER TEST FOR GASOLINE AND DIESEL, POWER SYSTEMS (PRODUCTION POWER SYSTEMS)

640.4.1 General. The maximum power of a power system is a function of the ambient conditions (temperature and altitude) and the power system's condition at any particular time.

640.4.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. Use instrumentation for measuring pressures as described in METHOD 112.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

640.4.3 Procedure.

**CAUTION: This procedure subjects the power system to a severe overload which may be damaging if maintained for too long a period of time.**

640.4.3.1 Preparation for test.

a. Connect the load and instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

b. Install appropriate thermocouples to measure the following temperatures.

    1. Lubricating oil sump.

    2. Engine combustion air in (located at the inlet of the intake manifold).

c. Obtain and record the barometric and water vapor pressures (see METHOD 220.2).

d. On power systems having more than one power output system, e.g., high voltage AC and low voltage DC (disregard the battery charging system) or two AC systems of different frequencies, maintain the system with the lowest power rating at rated load for all parts of this test. Then vary the load on the power output system with the highest power rating as indicated below to determine the maximum power of the power system.

e. Bypass the power system circuit interrupter if required.

f. Connect the power system to a source of fuel as required by the procurement document.

640.4.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 640.4-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 640.4.5) after the last adjustment to load, voltage, and frequency has been made.

    1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

    2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

        a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

        b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 640.4.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. Perform this test using resistive load only (on AC power systems remove the reactive portion of the load after stabilization).

c. For power systems with droop-type governors (except turbocharged engine-driven power systems):

1. Alternately increase the load, voltage and frequency in small increments until the fuel system controls are in the maximum position as permitted by the governor control linkage and the voltage and frequency are within 1 percent of their rated values. Do not exceed a maximum load of 125 percent of rated load.

**NOTE**: Small increments should be taken to avoid passing the maximum power at the rated voltage and frequency point and to avoid racing or bogging the engine.

2. Hold the conditions in step 1 above for two minutes. However, if the voltage and frequency cannot be maintained within 1 percent of their rated values, adjust the load to the point at which the voltage and frequency can be maintained within 1 percent of their rated values for two minutes.

**CAUTION: It may be necessary to reduce the load to a value below the rated kilowatt load for a short period of time to prevent serious overheating or damage to the power system if the above conditions cannot be readily attained. Monitor instrumentation.**

3. During the two minute period record all instrument readings including thermal instrumentation per METHOD 203.1 (see FIGURE 640.4-1).

4. Reduce the load to approximately rated kilowatt load and allow the power system to cool for 10 minutes.

5. Repeat steps 1 through 4 above until three valid sets of maximum power data are obtained.

d. For power systems with isochronous-type governors (except for turbocharged engine-driven power systems), repeat step c above, but do not adjust the frequency.

e. For turbocharged engine-driven power systems with droop-type governors:

1. Load the power system to 125 percent of rated load unless otherwise specified in the procurement document. Adjust the frequency to the rated value and maintain the load for 5 minutes unless otherwise specified in the procurement document.

2. Record all instrument readings including thermal instrumentation.

f. For turbocharged engine-driven power systems with isochronous-type governors, repeat step e above, but do not adjust the frequency.

640.4.4 Results.

a. Average the three valid maximum power readings. This average is the observed maximum power value.

b. Correct the observed maximum power value to standard conditions using the procedure in 220.2.4. This is the corrected maximum power value.

**NOTE:** The observed maximum power value for supercharged engine-driven power systems, including turbocharged engines, is not to be corrected to standard conditions.

c. Compare the corrected maximum power value to the procurement document requirements.

640.4.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Minimum value of maximum power required. For turbocharged power systems: the value of load and length of time the power system is to be operated at this load and length of time the power system is to be operated at this load if other than as specified herein. If no value is given, perform METHOD 640.2.

b. Voltage connection and frequency at which this Method is to be performed.

c. Fuel to be used in performing this Method.

**DESCRIPTION:** 10KW, 60 HZ
120V SINGLE PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 21069

**REF.** MIL-STD-705/640.4

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

MAXIMUM POWER TEST
(PRODUCTION POWER SYSTEMS)

**TEST NO.** 4

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 489 | 9172 | | 476 | | 211 | 2062 | 1377 | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLT. | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | LUBE OIL | | | | | | | | AVG AMG TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | - | HZ | °F | | | | | | | | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1400 | STARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | 70 |
| | 1420 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 154 | | | | | | | | 71 |
| | 1425 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 159 | | | | | | | | 71 |
| | 1430 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 162 | | | | | | | | 71 |
| | 1435 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 163 | | | | | | | | 71 |
| | 1440 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 163 | | | | | | | | 71 |
| | 1445 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 163 | | | | | | | | 71 |
| | 1450 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 163 | | | | | | | | 71 |
| | 1455 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 163 | | | | | | | | 71 |
| | 1500 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | 163 | | | | | | | | 71 |
| | 1515 | 118.8 | 2.63 | 105 | 0.313 | 12.5 | 1.0 | 594 | 177 | | | | | | | | 71 |
| | 1530 | 118.8 | 2.63 | 105 | 0.313 | 12.5 | 1.0 | 594 | 181 | | | | | | | | 71 |
| | 1545 | 118.8 | 2.63 | 105 | 0.313 | 12.5 | 1.0 | 594 | 181 | | | | | | | | 71 |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | OBSERVED MAX. POWER = 12.5 KW | | | | | | |
| | | | | | | | | | | | | | | | | | |

| | | |
|---|---|---|
| **NOTES** | BAROMETRIC PRESSURE: 29.85 IN HG | SIMULATED DATA FOR ILLUSTRATIVE PURPOSES ONLY |
| | LINE CURRENT MEASURED USING C.T. NO 1305 | |
| | WET BULB: 63°F, DRY BULB: 71°F | |

FIGURE 640.4-1 Typical test record for maximum power test (production power systems).

# METHOD 650.1b

## RIPPLE VOLTAGE TEST

650.1.1 General. The ripple voltage is the alternating component of the output voltage of a direct current generator. This alternating component is caused by the generator characteristics and may be large enough to cause the generator to be unsuitable for some applications.

650.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. In addition, use a low range true RMS sensing, AC voltmeter of suitable frequency rating and with an internal resistance of at least 1,000 ohms per volt and a blocking capacitor (non-electrolytic type) with a capacitance of 1 microfarad or greater.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

650.1.3 Procedure.

650.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10.

b. Connect the low range AC voltmeter in series with the blocking capacitor across the power system load terminals.

650.1.3.2 Test.

a. Start and operate the power system at rated frequency, rated voltage and at no load. Record all instrument readings.

b. Apply 25 percent; 50 percent; 75 percent; and 100 percent of rated load and adjust the voltage and frequency to rated values at each step. Record all instrument readings at each load condition per METHOD 203.1 (see FIGURE 650.1-1).

650.1.4 Results.

a. Read the ripple voltage directly on the low range AC voltmeter under all conditions of load. Convert the value of ripple voltage to percent of rated voltage using the following formula:

$$\frac{V_{rip}}{V_{rated}} * 100 = Percent\ of\ rated\ voltage$$

Where:

$V_{rip}$ = Observed ripple voltage

$V_{rated}$ = Rated voltage

b. Compare these readings with the maximum allowable ripple voltage specified in the procurement document.

650.1.5 Procurement document requirements. The following item must be specified in the individual procurement document:

a. Maximum allowable value of ripple voltage in percent of rated voltage.

**DESCRIPTION:** 3 KW
28 VOLTS DC
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** DC-3.0-MD

**SERIAL NO.** 1326

**REF.** MIL-STD-705/650.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

RIPPLE VOLTAGE TEST

**TEST NO.** 66

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J.JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 117 | | 210 | | 314 | | 106 | | | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | SPEED | | RIPPLE VOLTAGE | | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | | AMPS | | RPM | VOLTS | % | | | | | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1125 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | |
| | 1128 | | 28.0 | | 0 | | 3600 | 2.3 | 8.2 | | | | | | | | 76 |
| | 1130 | | 28.0 | | 26.7 | | 3600 | 2.1 | 7.5 | | | | | | | | 76 |
| | 1135 | | 28.0 | | 53.5 | | 3600 | 1.9 | 6.8 | | | | | | | | 76 |
| | 1140 | | 28.0 | | 80.2 | | 3600 | 1.8 | 6.4 | | | | | | | | 76 |
| | 1145 | | 28.0 | | 107 | | 3600 | 1.7 | 6.1 | | | | | | | | 76 |
| **NOTES** | LINE CURENT MEASURED USING A 200 AMP, 50mV SHUNT NO. 1309 | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

FIGURE 650.1-1 Typical test record for ripple voltage test.

# METHOD 651.1e

## JUDGING OF COMMUTATION TEST (AC POWER SYSTEMS)

651.1.1 General. Excessive sparking at the exciter commutator or generator slip rings will shorten the life of the brushes and will damage the commutator or slip rings.

651.1.2 Apparatus. Use instrumentation for measuring the load conditions as described and illustrated in METHOD 205.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

651.1.3 Procedure.

651.1.3.1 Preparation for test.

a. Examine the brushes for wear, pitting or other signs of unsatisfactory service. Record these conditions on the data sheet per METHOD 203.1 (see FIGURE 651.1-2).

b. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for one voltage connection and frequency specified in the procurement document.

651.1.3.2 Test.

a. Start and operate the power system at rated voltage, rated frequency and rated load for at least one hour.

b. Compare the observed sparking of each brush with the chart shown in FIGURE 651.1-1 using at least two observers.

c. Record the chart pattern number which most closely corresponds to the sparking observed at each brush per METHOD 203.1 (see FIGURE 651.1-2).

d. Repeat steps b and c above at each load voltage connection and frequency condition specified in the procurement document.

e. After shutdown, examine the commutator, slip rings, and brushes for wear, pitting, or other signs of unsatisfactory service. Record these conditions on the data sheet.

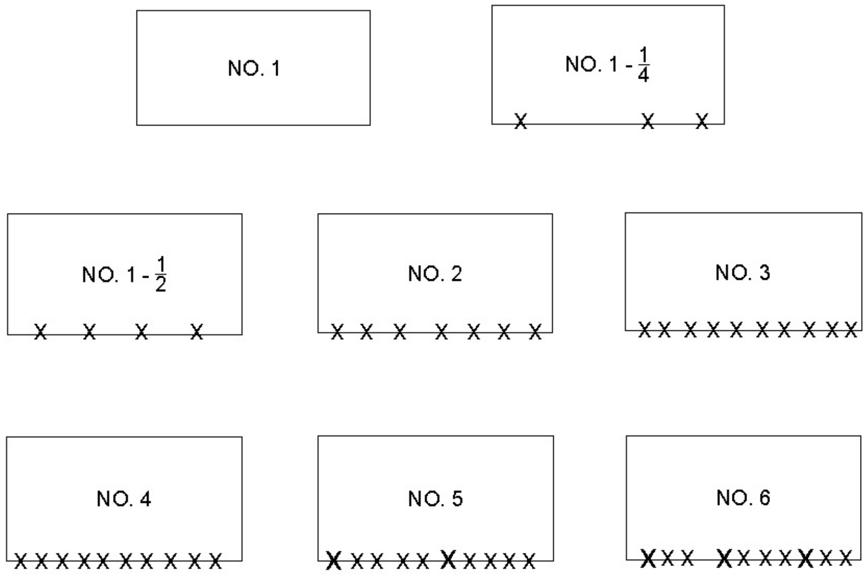
651.1.4 Results. Compare the results with the procurement document requirements.

651.1.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

b. Load conditions at which this Method is to be performed.

c. Acceptable values of sparking pattern (see FIGURE 651.1-1).




1 – BLACK WITH NO SPARK SHOWING

1 ¼ - SLIGHT INTERMITTENT SPARKING

1 ½ - SLIGHT CONTINUOUS SPARKING

2 – CONTINUOUS SPARKING HEAVIER THAN 1 ½ STREAMERS JUST BEGIN TO EXTEND FROM THE EDGE OF THE BRUSH

3 – SPARKS HEAVIER THAN 2

4 – SPARKS HEAVER THAN 3

5 – SPARKS HEAVER THAN 4

6 – SPARKS- ENTIRE BRUSH COVERED WITH CONTINUOUS HEAVY SPARKS

FIGURE 651.1-1 Sparking chart for use in judging of commutation.

| | | |
|---|---|---|
| **DESCRIPTION:** 60KW 400HZ 120/208V, THREE PHASE POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** AFC-400<br><br>**SERIAL NO.** 10701<br><br>**REF.** MIL-STD-705/651.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>JUDGING OF COMMUTATION TEST<br>(AC POWER SYSTEMS) | **TEST NO.** 18<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 101 | | | 202 | | | 303 | | | 404 | | 505 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | LINE CURRENT | | | OUTPUT POWER | | | POWER FACTOR | | FREQUENCY | | SPARKING NUMBER | | |
| | | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | $L_1$ | $L_2$ | $L_3$ | $L_1$ | $L_2$ | $L_3$ | | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | KW | KW | KW | | -- | | HZ | | | |
| **SYM** | | | | | X50 | X50 | X50 | X50 | X50 | X50 | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | BRUSH CONDITION – GOOD – NO SIGNS OF UNSATISFACTORY CONDITIONS | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 0830 | STARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0900 | 208 | 208 | 208 | 4.17 | 4.17 | 4.17 | .40 | .40 | .40 | | .80 | | 400 | | | |
| | 0930 | 208 | 208 | 208 | 4.17 | 4.17 | 4.17 | .40 | .40 | .40 | | .80 | | 400 | | | |
| | | BRUSH #1 POSITIVE | | | | | | | | | | | | | | 1 ½ | |
| | | BRUSH #2 NEGATIVE | | | | | | | | | | | | | | 3 | |
| | | BRUSH #3 POSITIVE | | | | | | | | | | | | | | 1 | |
| | | BRUSH #4 NEGATIVE | | | | | | | | | | | | | | 2 | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. NOs. $L_1$ - 1305; $L_2$ - 1306; $L_3$ - 1307 | | | | | | | | | | | | | | | | |

FIGURE 651.1-2 Typical test record for judging of commutation test (AC power systems).

METHOD 651.2e

JUDGING OF COMMUTATION TEST (DC POWER SYSTEMS)

651.2.1 General. Excessive sparking at the commutator will shorten the life of the brushes and will damage the commutator.

651.2.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in METHOD 205.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

651.2.3 Procedure.

651.2.3.1 Preparation for test.

a. Examine the brushes for wear, pitting, or other signs of unsatisfactory service. Record these conditions on the data sheet per METHOD 203.1 (see FIGURE 651.2-2).

b. Connect the load instrumentation in accordance with the applicable figure of 205.1.10.

651.2.3.2 Test.

a. Start and operate the power system at rated voltage, rated frequency and at rated load for at least 30 minutes.

b. Compare the observed sparking of each brush with the chart shown in FIGURE 651.2-1 using at least two observers.

c. Record the chart pattern number which most closely corresponds to the sparking observed at each brush.

d. Repeat steps b and c above at each load voltage connection and frequency condition specified in the procurement document.

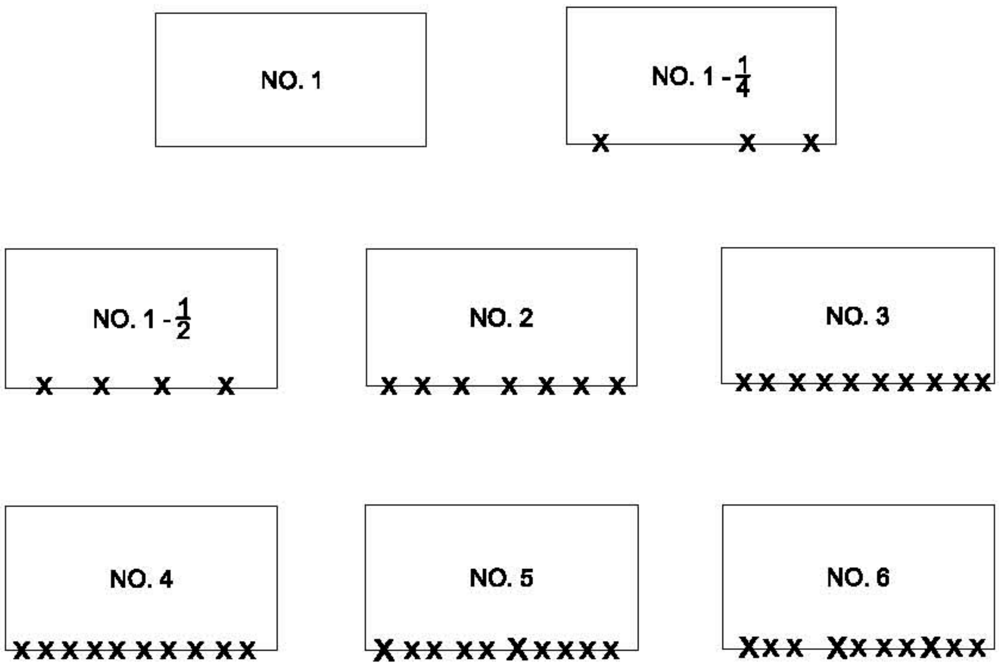
e. After shutdown, examine the commutator and brushes for wear, pitting, or other signs of unsatisfactory service. Record these conditions on the data sheet.

651.2.4 Results. Compare the results with the procurement document requirements.

651.2.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. Load conditions at which this Method is to be performed.

b. Acceptable values of sparking pattern (see FIGURE 651.2-1).




1 – BLACK WITH NO SPARK SHOWING

1 ¼ - SLIGHT INTERMITTENT SPARKING

1 ½ - SLIGHT CONTINUOUS SPARKING

2 – CONTINUOUS SPARKING HEAVIER THAN 1 ½ STREAMERS
JUST BEGIN TO EXTEND FROM THE EDGE OF THE BRUSH

3 – SPARKS HEAVIER THAN 2

4 – SPARKS HEAVER THAN 3

5 – SPARKS HEAVER THAN 4

6 – SPARKS- ENTIRE BRUSH COVERED WITH CONTINUOUS HEAVY SPARKS

FIGURE 651.2-1 Sparking chart for use in judging of commutation.

**DESCRIPTION:** 7.5 KW 3600 RPM
28 V, DIRECT CURRENT
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** 7.5 - DC

**SERIAL NO.** 108

**REF.** MIL-STD-705/651.2

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

JUDGING OF COMMUTATION TEST
(DC POWER SYSTEMS)

**TEST NO.** 20

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J.JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST→** | | 102 | | 203 | | CAL | | 411 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | SPEED | | SPARKING NUMBER | | | | | | | |
| **UNITS** | | | VOLTS | | AMPS | | KW | | RPM | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | BRUSH CONDITION GOOD | | | | | | | | | | | | | | | |
| | 0830 | STARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0830 | | 28.0 | | 268 | | 7.5 | | 3600 | | | | | | | | |
| | 0900 | | 28.0 | | 268 | | 7.5 | | 3600 | | | | | | | | |
| | | BRUSH # 1 | | | | | | | | | 1 1/2 | | | | | | |
| | | BRUSH # 2 | | | | | | | | | 1 | | | | | | |
| | | BRUSH # 3 | | | | | | | | | 2 | | | | | | |
| | | BRUSH # 4 | | | | | | | | | 2 | | | | | | |
| | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING 500 A, 50mV SHUNT 013 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 651.2-2 Typical test record for judging of communication test (DC power systems).

# METHOD 652.1b

# SHAFT CURRENT TEST

**NOTE**: Method 652.1b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

652.1.1 General. Presence of shaft current will damage the bearings of the generator.

652.1.2 Apparatus. Instrumentation for measuring load conditions shall be as described and illustrated in MIL-HDBK-705. In addition, a low resistance ac ammeter or dc millivoltmeter and low resistance loads (one with a probe for contacting the generator shaft, the other with a means of making a low resistance contact with the frame of bearing support) shall be required.

652.1.3 Procedure.

652.1.3.1 Preparation for test. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for one voltage connection and frequency specified in the procurement document.

652.1.3.2 Test.

a. Start and operate the generator set at rated voltage, rated frequency (speed) and at a load condition specified in the procurement document.

b. With the low resistance ac ammeter, or dc millivoltmeter, connected between the shaft and the frame or bearing support, record all instrument readings (see FIGURE 652.1-I).

c. Repeat steps a and b above for each specified load condition.

652.1.4 Results. Compare the results with the procurement document requirements.

652.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

b. Allowable shaft current for each specified load current.

| | | |
|---|---|---|
| **DESCRIPTION:** 10KW, 60HZ<br>120V, SINGLE-PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 11701<br><br>**REF.** MIL-STD-705/652.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>SHAFT CURRENT TEST | **TEST NO.** 47<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** APRIL 8, 1971<br><br>**RECORDER:** L WRIGHT<br><br>**PROJ. ENGR** J. J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST→** | | 107 | | 312 | | 418 | | 512 | | 210 | | 317 | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | SHAFT CURRENT | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | - | | HZ | | AMPS | | | | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1015 | STARED SET-APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1020 | | 120.0 | 2.60 | 104 | .25 | 10.0 | | .80 | | 60.0 | | 1.73 | | | | 74 |
| | 1022 | | 120.0 | 2.08 | 83 | .25 | 10.0 | | 1.00 | | 60.0 | | 1.53 | | | | |
| | 1025 | | 120.0 | 0 | 0 | 0 | 0 | | - | | 60.0 | | .76 | | | | |
| | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C. T. NO. 1305 | | | | | | | | | | | | | | | | |

FIGURE 652.1-I Typical test record for shaft current test.

METHOD 655.1b

DC CONTROL TEST

655.1.1 General. In certain instances, it may be necessary to operate a power system with a value of DC control voltage other than the nominal rated value.

655.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. In addition, use a data recorder with a 200kHz sample rate with a 30 kHz, 4 pole Butterworth type filter (unless otherwise specified in the procurement document) for AC voltage and current. In addition, use voltage and frequency recording type instrumentation to measure DC voltage. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

– Rise time for the frequency shall be 250 ms.

– Rise time for the voltage shall be 60 ms.

– Input shall be up to 500 volts RMS.

– Output shall be ±5 volts DC maximum.

– The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

655.1.3 Procedure.

655.1.3.1 Preparation for test.

a. Connect the load instrumentation using the data recorder in accordance with applicable figure of 205.1.10, the data recorder manufacturer's instructions, and the instructions given in this Method for one voltage connection and frequency specified in the procurement document. Unless otherwise specified, connect the signal input terminals of the data recorder directly to the output terminals of the power system.

b. Connect the DC voltage and current recording type instrumentation in accordance with the applicable figure of 205.1.10 at a point located in the DC bus which supplies the DC control power for the power system but does not read the starting solenoid current or the battery charging current.

**CAUTION: Make sure that the instrumentation does not read the starting motor solenoid current or the battery charging current as this would cause inaccurate readings and may cause instrumentation damage.**

c. Disconnect the power system batteries.

655.1.3.2 Test.

a. Using fully charged slave batteries and cable, start the power system. Record on the data sheet whether or not the power system started per METHOD 203.1 (see FIGURE 655.1-1).

b. Add rated load and operate the power system at rated voltage, rated frequency and rated load.

c. Record all line-to-neutral voltage waveforms. Record all voltage readings.

d. With the power system operating at rated load, remove the slave cable. Record whether or not the power system continues to operate without batteries.

e. With the power system operating without the slave batteries or internal batteries, reduce the load to zero in one step. Record the DC control voltage and current.

f. Apply rated load in one step using the power system circuit interrupter. Record the DC control voltage and current.

g. Repeat steps e and f two additional times. After that, record all readings.

h. With the power system operating at rated load, adjust the battery charging system voltage to the maximum operating value specified in the procurement document. On power systems with no alternator adjustment, ensure all batteries are disconnected and resistively load the battery charging system to achieve the desired voltage.

i. Repeat steps e through g above. After repeating steps e through g above, return battery charging system voltage to nominal value.

j. With the power system operating at rated load, adjust the battery charging system voltage to the minimum operating value specified in the procurement document.

k. Repeat steps e through g above. After repeating steps e through g above, return the battery charging system voltage to nominal value.

655.1.4 Results. The recorded data shall indicate, as a minimum, the following results:

a. Operation of the power system using the slave receptacle.

b. Operation at the nominal, maximum, and minimum DC control voltage as specified in the procurement document, and its effect on the operation of the power system.

c. Maximum DC control current at each of the conditions specified in 655.1.3.2 above.

d. Observed spikes or notches in the generator voltage waveform as determined from collected data.

e. Voltage and frequency steady state bandwidth. See METHOD 608.1 for method of calculation.

f. Compare these results with the procurement document requirements.

g. Examine data with and without battery to determine whether there was erratic governor or voltage regulator and if applicable inverter operation.

655.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum DC control current.

b. Nominal, maximum and minimum voltage limits for the DC control circuitry.

c. Allowable discontinuities (spikes or notches) in the generator voltage waveform, if any are allowable.

d. Maximum steady state voltage and frequency bandwidth.

**DESCRIPTION:** 15 KW, 60 HZ
120 V, SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-150-MD
**SERIAL NO.** 4166
**REF.** MIL-STD-705/655.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

DC CONTROL TEST

**TEST NO.** 86

**SHEET:** 1 OF 1
**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 377 | 153 | | 217 | | 706 | 809 | 342 | 067 | | | | | | | 912 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | D.C. CONTROL | | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | VOLTS | AMPS | | | | | | | |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | | | | | | | | | | | | | | | | | |
| | 1115 | STARTED POWER SYSTEM USING SLAVE BATTERIES | | | | | | | | | | | | | | | 75 |
| | 1118 | SHUTDOWN POWER SYSTEM | | | | | | | | | | | | | | | |
| | 1125 | ATTEMPED TO START POWER SYSTEM WITH BATTERY POLARITY REVERSED-POWER SYSTEM WOULD NOT CRANK | | | | | | | | | | | | | | | |
| | 1130 | CHECKED CONTROL PANEL FUSE – OK, NO REPLACEMENT NECESSARY | | | | | | | | | | | | | | | |
| | 1140 | STARTED POWER SYSTEM USING SLAVE BATTERIES WITH CORRECT POLARITY – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1145 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 27.6 | 1.30 | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | | 75 |
| | 1150 | NO SPIKES OR NOTCHES NOTED IN VOLTAGE WAVEFORM | | | | | | | | | | | | | | | |
| | 1200 | REMOVED SLAVE BATTERIES – NO NOTICABLE CHANGE IN POWER SYSTEM OPERATION | | | | | | | | | | | | | | | |
| | 1210 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 29.5 | 1.35 | | | | | | | |
| | 1211 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | 29.5 | 1.03 | REMOVED LOAD IN ONE STEP | | | | | | |
| | 1212 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 29.5 | 1.35 | APPLIED LOAD IN ONE STEP | | | | | | |
| | 1213 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | 29.5 | 1.03 | REMOVED LOAD IN ONE STEP | | | | | | |
| | 1214 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 29.5 | 1.35 | APPLIED LOAD IN ONE STEP | | | | | | |
| | 1215 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | 29.5 | 1.03 | REMOVED LOAD IN ONE STEP | | | | | | |
| | 1216 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 29.5 | 1..35 | APPLIED LOAD IN ONE STEP | | | | | | |
| | 1220 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 34.8 | 1.56 | ADJUSTED BATTERY CHARGING VOLTAGE TO MAX. | | | | | | |
| | 1221 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | 34.8 | 1.13 | REMOVED LOAD IN ONE STEP | | | | | | |
| | 1222 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 34.8 | 1.56 | APPLIED LOAD IN ONE STEP | | | | | | |
| **NOTES** | C.T. # 1377 | | | | | | | | | | | | | | | | |
| | T.I. # 016 | | | | | | | | | | | | | | | | |
| | DATA RECORDER # 870 | | | | | | | | | | | | | | | | |

FIGURE 655.1-1 Portion of a typical test record for DC control test.

METHOD 660.1e

INCLINED OPERATION TEST

660.1.1 General. A power system must be capable of normal operation including filling and draining liquids from the power system when it is placed in various inclined positions.

660.1.2 Apparatus. Use a means of measuring fuel capacity and a means of positioning the power system in various inclined positions. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

– Rise time for the frequency shall be 250 ms.

– Rise time for the voltage shall be 60 ms.

– Input shall be up to 500 volts RMS.

– Output shall be ±5 volts DC maximum.

– The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

660.1.3 Procedure.

660.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make the voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

b. Record the following items on both the data sheets and file(s):

    1. The date.

2. The serial number(s) of the recording meter(s).

3. Power system identification.

4. The data reading number (indexing).

660.1.3.2 Test.

| |
|---|
| **NOTE**: For power systems not equipped with an internal fuel tank(s), do not perform steps a, b, and e below. |

a. With the power system on a level surface and the fuel tank empty, determine the capacity of the fuel tank in gallons. Measure, either by volume or weight, the amount of fuel required to fill the tank until the fuel indicator of the power system indicates full or as defined in the technical manual or procurement document. Record on the data sheet the amount of fuel required to fill the tank per METHOD 203.1 (see FIGURE 660.1-1).

b. Drain the fuel tank.

c. With the power system on a level surface, check the level(s) of the lubricating oil and hydraulic oil (if used) and add or drain sufficient oil to bring the level(s) to the full mark as indicated by the dipstick(s).

d. Using blocks or ramps, raise the front end of the power system so that the angle between the horizontal and the power system base is at the maximum angle specified in the procurement document.

e. Determine and record the quantity of fuel required to fill the fuel tank with the power system in the inclined position.

f. Record the lubricating and hydraulic (if used) oil level(s). Record distance above or below the normal full mark within 1/16 inch.

g. Inspect the power system for excess oil around all fittings, tanks and seals. Wipe off any fuel and oil deposits found and note on the data sheet results of inspection.

h. Operate the recording instrumentation.

i. Using the power system fuel tank, start the power system and note and record whether or not it started normally. On power systems without an internal fuel tank use an external fuel source.

j. Unless otherwise specified in the procurement document, operate the power system at rated voltage, rated frequency and rated load for one hour. During this time inspect the power system every 15 minutes to see if engine lubrication is satisfactory (excessive noises in engine, etc.), that there is no leakage of lubricant and hydraulic oil (if used) from seals and that the fuel system functions satisfactorily and does not leak or spill over. Record the load instrumentation at the beginning and the end of the specified period of operation at the inclined position. Record any unusual modes of vibration.

k. Shutdown the power system and inspect it for leaks as in step g above.

l. Allow the power system to remain shutdown for a minimum of five minutes.

m. Restart the power system and note if the power system starts normally. Note on the data sheet any difficulty in starting.

n. Shutdown the power system.

o. Repeat steps b through n above except that the rear end of the power system is raised above the horizontal.

p. Repeat steps b through n above except that the left side of the power system is raised above the horizontal.

q. Repeat steps b through n above except that the right side of the power system is raised above the horizontal.

660.1.4 Results. Tabulate the the following items for each power system position:

a. Location of leaks.

b. Location of abnormal vibrations.

c. Excessive noises.

d. Abnormal starting.

e. Amount of fuel required to fill the power system fuel tank in each position.

f. Lubricating and hydraulic oil dipstick readings in each position.

g. Load instrumentation readings.

h. Maximum observed steady-state voltage and frequency bandwidth. See METHOD 608.2 for method of calculation.

i. Compare these results with the requirements of the procurement document.

j. Whether or not the power system operated for the specified time.

660.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Angle(s) of inclination from the horizontal at which this Method is to be performed.

b. Length of time for operation at each inclined position if other than one hour.

c. Voltage connection and frequency at which this Method is to be performed.

d. Maximum allowable long-term steady voltage and frequency bandwidth, if applicable.

e. Definition of full fuel tank, if applicable.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V SINGLE PHASE<br>0.8 POWER FACTOR POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 10076<br><br>**REF.** MIL-STD-705A/660.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>INCLINED OPERATION TEST<br>15° FROM HORIZONTAL | **TEST NO.** 6<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST.→** | | | FUEL | LUBE | | | 301 | 206 | | 112 | | 416 | 512 | | | | 918 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | INCLINA-TION | TO FILL TANK | OIL LEVEL | 1ST START | 2ND START | TERM. VOLT | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | NOTES | | | AVG AMB TEMP |
| **UNITS** | | | GAL | | | | VOLTS | X40 | AMPS | X40 | KW | -- | HZ | | | | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| 1 | 1030 | FRONT | 9.5 | ½" LOW | OK | | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | SLIGHT FUEL LEAK | | | 76 |
| 2 | 1130 | | | | | | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | AT FILLER NECK | | | 77 |
| 3 | 1135 | | | | | OK | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 4 | 1200 | REAR | 9.5 | ½" HI | OK | | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | NOTHING UNUSUAL | | | 77 |
| 5 | 1300 | | | | | | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | | 77 |
| 6 | 1305 | | | | | OK | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 7 | 1330 | L-SIDE | 8.0 | OK | OK | | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | TOOL BOX VIBRATING | | | 77 |
| 8 | 1430 | | | | | | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | SLIGHTLY | | | 77 |
| 9 | 1435 | | | | | OK | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 10 | 1500 | R-SIDE | 10.0 | OK | OK | | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | TOOL BOX VIBRATING | | | 77 |
| 11 | 1600 | | | | | | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | SLIGHTLY | | | 77 |
| 12 | 1605 | | | | | OK | | | | | | | SIMULATED DATA | | | | |
| | | | | | | | | | | | | | FOR ILLUSTRATIVE | | | | |
| | | | | | | | | | | | | | PURPOSE ONLY | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | ACTUAL FUEL TANK CAPACITY 10.0 GAL. | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | SET OPERATED FOR 1 HOUR IN EACH INCLINED POSITION. | | | | | | | | | | | | | | | | |

FIGURE 660.1-1 Typical test record for inclined operation test.

# METHOD 661.2d

# AUDIO NOISE TEST

661.2.1 General. The power system must satisfy audio noise requirements.

661.2.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in the 100 series methods, as applicable. Use audio noise test instrumentation per METHOD 115.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

661.2.3 Procedure.

661.2.3.1 Preparation for test.

a. Center the power system on a test site that is a uniform flat grass surface, free of ice, snow, or vegetation over 5.9 inches (0.15 meter) tall and free of reflecting surfaces such as buildings, trees, hillsides, or load bank(s) within a 164 foot (50 meter) radius. Do not perform the test if there is any precipitation or fog.

b. Position the sensing element of the microphone(s) parallel from the ground. Take the readings at the following positions unless otherwise specified by the procurement document:

    1. Take one reading perpendicular to the side of the power system where the control panel is located and at the halfway point of the control panel. Locate the microphone 2.3 feet (0.7 meters) from the control panel and at a height level with the operator’s station.

    2. Take four readings, one on each side of the power system. Take the readings perpendicular to its respective side of the power system and at the halfway point between the two corners of that side of the power system. Take these readings at a distance of 22.9 feet (7 meters) from the edge of the power system and at a height of 3.94 feet (1.2 meters) above ground.

    3. Take four readings, one on each corner of the power system and at a 45 degree angle from its respective corner. Take these readings at a distance of 22.9 feet (7 meters) from the corner of the power system and at a height of 3.94 feet (1.2 meters) above ground.

c. An anechoic or hemi-anechoic chamber may be substituted for outdoor measurements.

661.2.3.2 Test.

a. Record the following environmental conditions:

1. Ambient temperature, °F.

2. Wind speed, mph (km/h).

3. Barometric pressure, millimeters mercury (mm Hg).

4. Relative humidity, %.

5. Weather (i.e., cloudy, sunny).

b. Record the ambient sound pressure level (SPL) reading in dB and dB(A) with the power system off at all positions required in 661.2.3.1b per METHOD 203.1 (see FIGURE 661.2-1).

c. Open the control panel door(s) and secure it in the open position if applicable. Position all other door(s) in their normal operating positions. Start the power system and apply rated load. Record the SPL reading in dB and dB(A) at all positions required in 661.2.3.1b. If the background noise is not at least 10dB less than the noise source (power system), the test cannot be performed.

d. Operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. Stabilization for this Method shall be considered to have occurred after the power system has operated at rated load, rated voltage, and rated frequency for 10 minutes.

e. Take and record the nine readings in dB(A) as required by 661.2.3.1b.

f. Repeat steps d and e except at 75 percent rated load.

g. Repeat steps d and e except at 50 percent rated load.

h. Repeat steps d and e except at 25 percent rated load.

i. Repeat steps d and e except at no load.

j. Turn the power system off and repeat step b. If the ambient sound level is not at least 10dB less than the noise source (power system), the test was not valid.

661.2.4 Results. Compare the sound level measurements with the limits specified. Include the following:

a. Ambient noise levels versus octave band center frequency (dB and dB(A)).

b. A tabulation of the audio noise SPL versus octave band center for rated load and no load operation for each measurement (dB).

c. A tabulation of the of the SPL at each measurement (dB(A)).

d. A measurement of the SPL at the operator's station (dB(A)).

661.2.5 Procurement document requirements. The following details will be specified in the procurement document:

a. Weighting network.

b. Distance at which measurements are to be taken if other than as specified in this Method.

c. Position(s) of microphone and microphone height taken if other than as specified in this Method.

d. Position of doors if other than as specified in this Method.

e. Definition of location of operator's station.

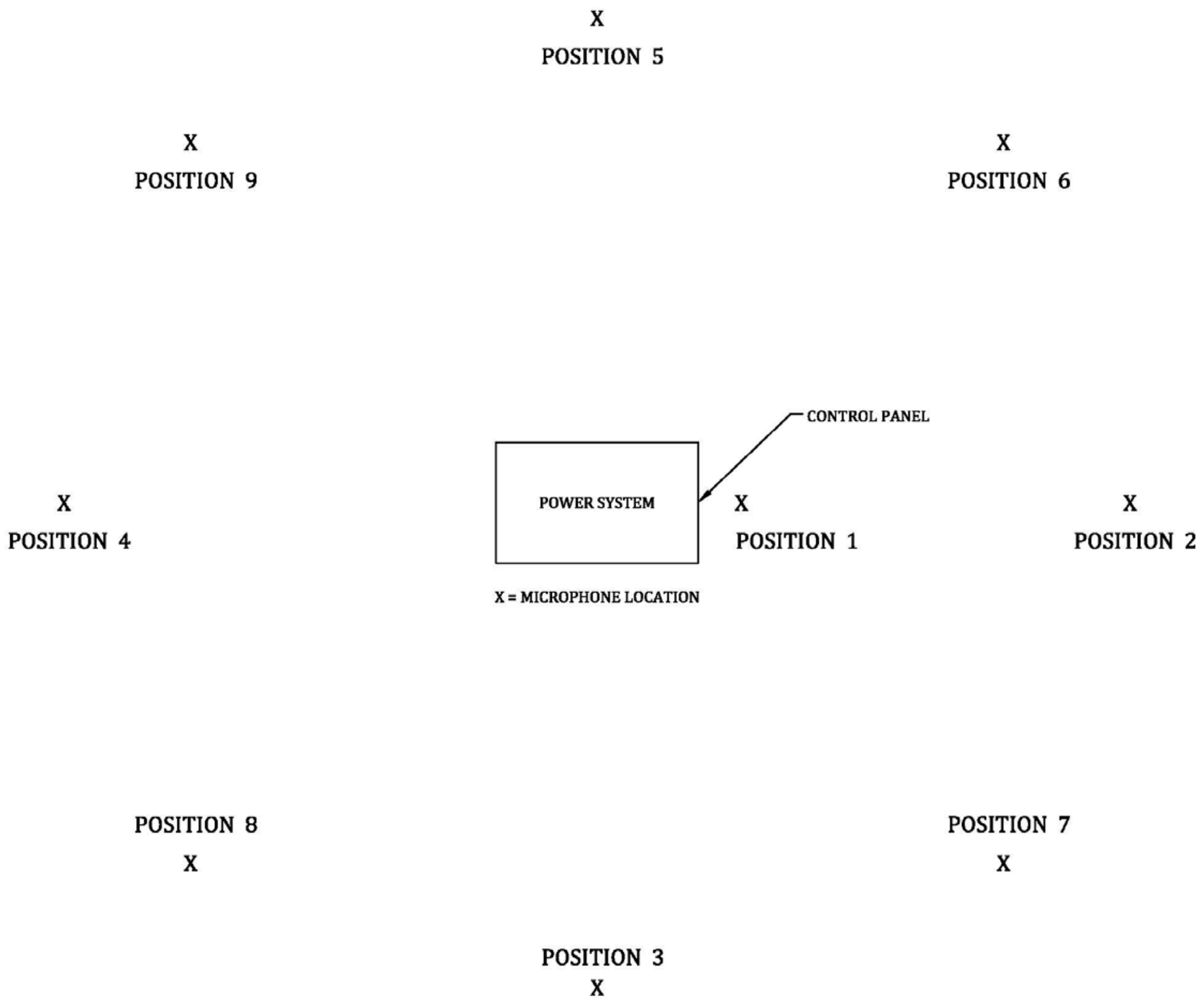



FIGURE 661.2-1 Typical layout for microphone locations for audio noise test (Page 1 of 2).

| POSITION | READING LOCATION | READING DISTANCE IN FEET (METERS) | READING HEIGHT IN FEET (METERS) LEVEL WITH OPERATOR'S STATION |
|---|---|---|---|
| 1 | PERPENDICULAR TO CONTROL PANEL | 2.3(0.7) | LEVEL WITH OPERATING STATION |
| 2 | SIDE OF POWER SYSTEM | 22.9(7) | 3.94(1.2) |
| 3 | | 22.9(7) | 3.94(1.2) |
| 4 | | 22.9(7) | 3.94(1.2) |
| 5 | | 22.9(7) | 3.94(1.2) |
| 6 | CORNER OF POWER SYSTEM | 22.9(7) | 3.94(1.2) |
| 7 | | 22.9(7) | 3.94(1.2) |
| 8 | | 22.9(7) | 3.94(1.2) |
| 9 | | 22.9(7) | 3.94(1.2) |

FIGURE 661.2-1 Typical layout for microphone locations for audio noise test (Page 2 of 2).

# METHOD 670.1c

## FUEL CONSUMPTION TEST (STEADY-STATE)

670.1.1 General. The length of time the power system will operate at rated load on a specific amount of fuel is vital logistics information. This time is also used to provide an indication of engine deterioration during an endurance run.

670.1.2 Apparatus. Use instrumentation for measuring load conditions, and ambient and fuel temperatures as described and illustrated in the 100 series methods, as applicable. In addition, provide the following apparatus.

Balance scale, platform scale or fuel flowmeter
Auxiliary fuel container
Auxiliary fuel lines
Stopwatch/timer
Means of accurately measuring the fuel tank capacity
Means of measuring the specific gravity of the fuel

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

670.1.3 Procedure.

670.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure in 205.1.10 for one voltage connection and frequency specified in the procurement document.

b. Depending upon which of the following procedures is used, provide the auxiliary fuel supply as directed: Balance scale (670.1.3.2.1), Platform balance (670.1.3.2.2), or Flowmeter (670.1.3.2.3).

c. Install the auxiliary fuel lines from the external fuel container directly to the engine fuel pump by bypassing the internal fuel system.

d. Install the temperature measuring devices in accordance with METHOD 110.1 to measure the ambient temperature and the fuel temperature.

e. If the flowmeter procedure is used, connect the flowmeter in the fuel supply line prior to starting the power system.

670.1.3.2 Test.

a. With the power system on a level surface and the fuel tank empty, determine the capacity of the fuel tank in pounds. Measure, by weight, the amount of fuel required to fill the tank until the fuel indicator of the power system indicates full or as defined in the technical manual or procurement document. Use the type of fuel required by the procurement document. Record this value on the data sheet per METHOD 203.1 (see FIGURE 670.1-1) as the fuel tank capacity in pounds.

b. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 670.1-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 670.1.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 670.1.3.2b. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

**NOTE**: Stabilization is not required if the flowmeter procedure is used.

c. Perform one of the following procedures.

670.1.3.2.1 Balance scale procedure.

a. Supply fuel from auxiliary container mounted on a platform balance or other scale.

b. After stabilization has occurred, set the balance weights at any convenient value slightly less than the total weight of the fuel and container.

c. Start the stopwatch/timer when the balance weights fall and record the total weight per METHOD 203.1 (see FIGURE 670.1-1).

d. Reduce the balance weight a convenient amount and record the amount of the weights removed.

e. Stop the stopwatch/timer when the balance weights fall and record the total weight and the elapsed time.

f. Repeat steps a through d above until the timed portion of the test exceeds the test duration in TABLE 670.1-I.

g. From the total elapsed time and total of the weights removed, determine the fuel consumption in terms of pounds per hour as follows:

$$Fuel\ Consumption = \frac{Pounds}{Hours}$$

h. Using the value obtained in step g above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$Pounds\ per\ kWH = \frac{Fuel\ Consumption\ (pounds\ per\ hour)}{kW\ Load}$$

i. Repeat 670.1.3.2 for each load condition specified in the procurement document.

j. For each specified load, compute the number of continuous hours the power system will operate on a full tank of fuel using the fuel tank capacity determined in 670.1.3.2a. The following formula shall be used.

$$Operating\ Hours = \frac{Fuel\ Tank\ Capacity\ (Pounds)}{Fuel\ Consumption\ (pounds\ per\ hour)}$$

670.1.3.2.2 Platform balance procedure.

a. Supply fuel from the auxiliary fuel container, mounted on a platform balance, or other weighing device.

b. After stabilization has occurred, record weight readings every one-half hour for the duration of the test as called for in TABLE 670.1-I.

c. Determine the average hourly fuel consumption rate in pounds per hour, as follows:

$$Fuel\ Consumption = \frac{Pounds}{Hours}$$

d. Using the average value obtained in step c above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$Pounds\ per\ kWH = \frac{Fuel\ Consumption\ (pounds\ per\ hour)}{kW\ Load}$$

e. Repeat 670.1.3.2 for each load condition specified in the procurement document.

f. For each specified load test, compute the number of continuous hours the power system will operate on a full tank of fuel using the fuel tank capacity determined in 670.1.3.2a. Use the following formula:

$$Operating\ Hours = \frac{Fuel\ Tank\ Capacity\ (Pounds)}{Fuel\ Consumption\ (pounds\ per\ hour)}$$

670.1.3.2.3 Flowmeter procedure.

**NOTE**: Flowmeters may be used to determine the fuel rate. They usually are calibrated in either gallons per hour, or pounds per hour, for a fuel of a definite specific gravity and temperature.

**NOTE**: Stabilization per 670.1.3.2b is not required if the flowmeter procedure is used.

a. Turn on the power system and operate it at rated load at rated voltage and current for a one hour period. During this period, take flowmeter readings every second.

b. Determine the average of the readings (corrected for fuel specific gravity and temperature) during the last twenty (20) minutes of the one hour period. This is the fuel consumption rate and convert it, if necessary, to pounds per hour.

c. Using the average value obtained in step b above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$Pounds\ per\ kWH = \frac{Fuel\ Consumption\ (pounds\ per\ hour)}{kW\ Load}$$

d. Repeat 670.1.3.2 for each load condition specified in the procurement document.

e. For each specified load test, compute the number of continuous hours the power system will operate on a full tank of fuel using the fuel tank capacity determined in 670.1.3.2a. Use the following formula:

$$Operating\ Hours = \frac{Fuel\ Tank\ Capacity\ (Pounds)}{Fuel\ Consumption\ (pounds\ per\ hour)}$$

670.1.4 Results. Compare the operating hours or the fuel consumption rate per kWH with the limits specified in the procurement document.

670.1.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. Load condition(s) and duration at which this Method is to be performed, if other than as specified in TABLE 670.1-I.

b. Number of hours power system must operate at specified load conditions when using power system fuel tank.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Types of fuel(s) to be used.

e. Definition of full fuel tank, if applicable.

TABLE 670.1-I. Duration of fuel consumption test.

| Power System Rated Load | Duration of Test |
|---|---|
| | |
| 0 – 3.0 kW | 2 hours |
| Greater than 3.0 kW through 15.0 kW | 4 hours |
| Greater than 15.0 kW | 6 hours |

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120 VOLT SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SF-10.0-MD<br>**SERIAL NO.** 13067<br>**REF.** MIL-STD-705/670.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>FUEL CONSUMPTION TEST (STEADY-STATE)<br><br>BALANCE SCALE PROCEDURE | **TEST NO.** 40<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J.JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |

| **INST.→** | | 2710 | 2210 | | 2112 | | 2411 | 2517 | | | SCALE: 1618 | | | | | 117 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ. | | | WEIGHT REMOVED | | TIME FOR WEIGHT TO FALL | | TOTAL TIME | FUEL TEMP | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | LBS | TOTAL | MIN | SECS | HRS | °F | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | LBS | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0815 | STARTED POWER SYSTEM APPLIED RATED LOAD | | | | | | | | | | | | | | | 75 |
| | 0900 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | | | | | | 76 | 76 |
| | 0910 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | | | | | | 76 | 76 |
| | 0920 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | | | | | | 76 | 76 |
| | 0930 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 5 | 26 | 17 | 0:26:17 | 76 | 76 |
| | 1000 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 10 | 25 | 57 | 0:52:15 | 76 | 77 |
| | 1030 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 15 | 26 | 05 | 1:18:27 | 76 | 76 |
| | 1100 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 20 | 26 | 30 | 1:44:57 | 76 | 76 |
| | 1130 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 25 | 26 | 21 | 2:11:18 | 76 | 75 |
| | 1200 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 30 | 25 | 46 | 2:37:04 | 76 | 76 |
| | 1230 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 35 | 26 | 12 | 3:03:16 | 76 | 76 |
| | 1300 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 40 | 25 | 56 | 3:29:12 | 76 | 77 |
| | 1330 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 45 | 26 | 12 | 3:55:24 | 76 | 77 |
| | 1400 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 50 | 25 | 51 | 4:21:15 | 76 | 77 |
| | 1430 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 55 | 26 | 00 | 4:47:15 | 76 | 76 |
| | 1500 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 60 | 25 | 52 | 5:13:07 | 76 | 76 |
| | 1530 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 65 | 26 | 07 | 5:39:14 | 76 | 76 |
| | 1600 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 70 | 25 | 53 | 6:05:07 | 76 | 76 |
| | 1628 | SHUTDOWN POWER SYSTEM | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. #1365<br>FUEL CONSUMPTION AT RATED LOAD = 1.16 LB/KWH | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |

FIGURE 670.1-1 Typical test record for fuel consumption test.

# METHOD 670.2

## FUEL CONSUMPTION TEST
## (LOAD PROFILE)

670.2.1 General. The length of time a power system will operate at various load conditions is vital logistics information.

670.2.2 Apparatus. Use instrumentation for measuring load conditions, and ambient and fuel temperatures as described and illustrated in the 100 series methods, as applicable. In addition, provide the following apparatus.

Balance scale, platform scale or fuel flowmeter
Auxiliary fuel container
Auxiliary fuel lines
Stopwatch/timer
Means of accurately measuring the fuel tank capacity
Means of measuring the specific gravity of the fuel

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

670.2.3 Procedure.

670.2.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure in 205.1.10 for one voltage connection and frequency specified in the procurement document.

b. Depending upon which of the following procedures is used, provide the auxiliary fuel supply as directed: Balance scale (670.2.3.2.1), Platform balance (670.2.3.2.2), or Flowmeter (670.2.3.2.3).

c. Install the auxiliary fuel lines from the external fuel container directly to the engine fuel pump by bypassing the internal fuel system.

d. Install the temperature measuring devices in accordance with METHOD 110.1 to measure the ambient temperature and the fuel temperature.

e. If the flowmeter procedure is used, connect the flowmeter in the fuel supply line prior to starting the power system.

670.2.3.2 Test.

a. With the power system on a level surface and the fuel tank empty, determine the capacity of the fuel tank in pounds. Measure, by weight, the amount of fuel required to fill the tank until the fuel indicator of the power system indicates full or as defined in the technical manual or procurement document. Use the type of fuel required by the procurement document. Record this value on the data sheet per METHOD 203.1 (see FIGURE 670.2-1) as the fuel tank capacity in pounds.

b. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 670.2-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 670.2.5) after the last adjustment to load, voltage, and frequency has been made.

   1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

   2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

      a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

      b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 670.2.3.2b. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

| |
|---|
| **NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency. |

| |
|---|
| **NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values. |

| |
|---|
| **NOTE**: Stabilization is not required if the flowmeter procedure is used. |

c. Perform one of the following procedures.

670.2.3.2.1 Balance scale procedure.

a. Supply fuel from auxiliary container mounted on a platform balance or other scale.

b. After stabilization has occurred, set the balance weights at any convenient value slightly less than the total weight of the fuel and container.

c. Start the stopwatch/timer when the balance weights fall and record the total weight per METHOD 203.1 (see FIGURE 670.2-1).

d. Reduce the balance weight a convenient amount and record the amount of the weights removed.

e. Stop the stopwatch/timer when the balance weights fall and record the total weight and the elapsed time.

f. Repeat steps a through d above until the timed portion of the test exceeds the test duration in TABLE 670.2- I.

g. From the total elapsed time and total of the weights removed determine the fuel consumption in terms of pounds per hour as follows:

$$Fuel\ Consumption = \frac{Pounds}{Hours}$$

h. Using the value obtained in step g above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$Pounds\ per\ kWH = \frac{Fuel\ Consumption\ (pounds\ per\ hour)}{kW\ Load}$$

**NOTE**: Pounds per kWH for no load is the pound per hour determined from the formula in 670.2.3.2.1g.

i. Repeat stabilization per 670.2.3.2b, then repeat 670.2.3.2.1 for each of the following load conditions:

1. No load.
2. 10% load.
3. 25% load.
4. 50% load.
5. 75% load.
6. 90% load.
7. 110% load, if applicable.

j. For each specified load, compute the number of continuous hours the power system will operate on a full tank of fuel using the fuel tank capacity determined in 670.2.3.2a. Use the following formula.

$$Operating\ Hours = \frac{Fuel\ Tank\ Capacity\ (Pounds)}{Fuel\ Consumption\ (pounds\ per\ hour)}$$

670.2.3.2.2 Platform balance procedure.

a. Supply fuel from the auxiliary fuel container, mounted on a platform balance, or other weighing device.

b. After stabilization has occurred, record weight readings every one-half hour for the duration of the test as called for in TABLE 670.2- I.

c. Determine the average hourly fuel consumption rate in pounds per hour, as follows:

$$Fuel\ Consumption = \frac{Pounds}{Hours}$$

d. Using the average value obtained in step c above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$Pounds\ per\ kWH = \frac{Fuel\ Consumption\ (pounds\ per\ hour)}{kW\ Load}$$

**NOTE**: Pounds per kWH for no load is the pounds per hour determined from the formula in 670.2.3.2.2c.

e. Repeat stabilization per 670.2.3.2b, then repeat 670.2.3.2.2 for each of the following load conditions:

1. No load.
2. 10% load.
3. 25% load.
4. 50% load.
5. 75% load.
6. 90% load.
7. 110% load, if applicable.

f. For each specified load test, compute the number of continuous hours the power system will operate on a full tank of fuel using the fuel tank capacity determined in 670.2.3.2a. Use the following formula:

$$Operating\ Hours = \frac{Fuel\ Tank\ Capacity\ (Pounds)}{Fuel\ Consumption\ (pounds\ per\ hour)}$$

670.2.3.2.3 Flowmeter procedure.

**NOTE**: Flowmeters may be used to determine the fuel rate. They usually are calibrated in either gallons per hour, or pounds per hour, for a fuel of a definite specific gravity and temperature.

**NOTE**: Stabilization per 670.2.3.2b is not required if the flowmeter procedure is used.

a. Turn on the power system and operate it at rated load at rated voltage and current for a one hour period. During this period, take flowmeter readings every second.

b. Determine the average of the readings (corrected for fuel specific gravity and temperature) for the last twenty (20) minutes of the one hour period. This is the fuel consumption rate and convert it, if necessary, to pounds per hour.

c. Using the average value obtained in step b above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$Pounds\ per\ kWH = \frac{Fuel\ Consumption\ (pounds\ per\ hour)}{kW\ Load}$$

**NOTE**: Pounds per kWH for no load is the pounds per hour determined from the formula in 670.2.3.2.2c.

d. Repeat steps a through c for each of the following load conditions:

1. No load.
2. 10% load.
3. 25% load.
4. 50% load.
5. 75% load.
6. 90% load.
7. 110% load, if applicable.

e. For each specified load test, compute the number of continuous hours the power system will operate on a full tank of fuel using the fuel tank capacity determined in 670.2.3.2a. Use the following formula:

$$Operating\ Hours = \frac{Fuel\ Tank\ Capacity\ (Pounds)}{Fuel\ Consumption\ (pounds\ per\ hour)}$$

670.2.4 Results. Compare the operating hours or the fuel consumption rate per kWH with the limits specified in the procurement document.

670.2.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. Load condition(s) and duration at which this Method is to be performed, if other than as specified in TABLE 670.2- I.

b. Number of hours power system must operate at specified load conditions when using power system fuel tank.

c. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

d. Types of fuel(s) to be used.

e. Definition of full fuel tank, if applicable.

TABLE 670.2- I. Duration of fuel consumption test.

| **Power System Rated Load** | **Duration of Test** |
|---|---|
| | |
| 0 – 3.0 kW | 2 hours |
| Greater than 3.0 kW through 15.0 kW | 4 hours |
| Greater than 15.0 kW | 6 hours |

**DESCRIPTION:** 10 KW, 60 HZ
120 VOLT SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-10.0-MD
**SERIAL NO.** 13067
**REF.** MIL-STD-705/670.2

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

FUEL CONSUMPTION TEST (LOAD PROFILE)

BALANCE SCALE PROCEDURE

**TEST NO.** 40

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J.JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 2710 | 2210 | | 2112 | | 2411 | 2517 | | | SCALE: 1618 | | | | | 117 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ. | | | WEIGHT REMOVED | | TIME FOR WEIGHT TO FALL | | TOTAL TIME | FUEL TEMP | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | LBS | TOTAL | MIN | SECS | HRS | °F | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | LBS | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0815 | STARTED POWER SYSTEM APPLIED RATED LOAD | | | | | | | | | | | | | | | 75 |
| | 0900 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | | | | | | 76 | 76 |
| | 0910 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | | | | | | 76 | 76 |
| | 0920 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | | | | | | 76 | 76 |
| | 0930 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 5 | 26 | 17 | 0:26:17 | 76 | 76 |
| | 1000 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 10 | 25 | 57 | 0:52:15 | 76 | 77 |
| | 1030 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 15 | 26 | 05 | 1:18:27 | 76 | 76 |
| | 1100 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 20 | 26 | 30 | 1:44:57 | 76 | 76 |
| | 1130 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 25 | 26 | 21 | 2:11:18 | 76 | 75 |
| | 1200 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 30 | 25 | 46 | 2:37:04 | 76 | 76 |
| | 1230 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 35 | 26 | 12 | 3:03:16 | 76 | 76 |
| | 1300 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 40 | 25 | 56 | 3:29:12 | 76 | 77 |
| | 1330 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 45 | 26 | 12 | 3:55:24 | 76 | 77 |
| | 1400 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 50 | 25 | 51 | 4:21:15 | 76 | 77 |
| | 1430 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 55 | 26 | 00 | 4:47:15 | 76 | 76 |
| | 1500 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 60 | 25 | 52 | 5:13:07 | 76 | 76 |
| | 1530 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 65 | 26 | 07 | 5:39:14 | 76 | 76 |
| | 1600 | 120.0 | 2.60 | 104 | 0.250 | 10.0 | 0.80 | 60.0 | | | 5 | 70 | 25 | 53 | 6:05:07 | 76 | 76 |
| | 1628 | SHUTDOWN POWER SYSTEM | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. #1365 | | | | | | | | | | | | | | | | |
| | FUEL CONSUMPTION AT RATED LOAD = 1.16 LB/KWH | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

FIGURE 670.2-1 Typical test record for fuel consumption test.

METHOD 680.1c

TEMPERATURE RISE TEST
(GENERATOR ONLY)

**NOTE**: Method 680.1c was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

680.1.1 General. Temperature rise tests are used by design engineers to assure each operating component is operating well within its rated temperature range and serve as a check on the manufacturing processes.

680.1.2 Apparatus. Instrumentation for measuring load conditions, generator and exciter field voltage and current, generator and ambient temperatures, and coil resistances shall be as described and illustrated in MIL-HDBK-705. In addition an electrical prime mover capable of driving the generator at rated output conditions shall be required.

680.1.3 Procedure.

680.1.3.1 Preparation for test.

a. Refer to the procurement document to determine which components have maximum temperature rises specified.

b. Attach the necessary thermal instrumentation for these components and the ambient temperature in accordance with MIL-HDBK-705, method 202.1 and make necessary winding resistance measurements in accordance with MIL HDBK-705, method 401.1.

c. Mechanically connect the generator to the prime mover. Be sure to shield the generator from air currents caused by the prime mover, adjacent machinery, belts or pulleys.

d. Connect the load and field instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for a voltage connection and frequency specified in the procurement document.

680.1.3.2 Test.

a. Start and operate the prime mover so that the generator is operating at rated voltage and rated frequency (speed) while under control of the voltage regulator. Apply rated load and allow the generator to stabilize at rated load, rated voltage and rated frequency. During this period record all instrument readings including thermal instrumentation at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and frequency. Adjustments to the voltage shall be limited to those adjustments that would normally be available to the operator when the generator is installed in the set configuration, specifically adjustments to the voltage adjust devices. No other adjustments to the voltage control system shall be make unless permitted by the procurement document. Adjustments to load, voltage or frequency controls shall be recorded on the data sheet at the time of adjustment. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when:

1. Three consecutive voltage and current readings of the field(s) remain unchanged after the last load, voltage and frequency adjustments has been made and,

2. The average ambient temperature has not been changed by more than 5 F° (2.73 C°) for the final six data readings.

b. After stabilization has occurred shut down the equipment so that temperatures of rotating components and windings may be taken. For application of contact method to rotating parts, or the resistance method to the armature coils (see MIL HDBK-705, method 110.1 and 202.1), a quick shutdown is mandatory.

**CAUTION: Do not connect bridges, meters of temperature measuring equipment for measuring resistance or temperature to circuits which may still be energized, e.g., during the time that the generator is coming to a stop.**

c. Immediately after the shutdown, start to record the resistance bridge readings of the coils and the temperature of the components where the contact method of measuring temperature rise is used. Readings of resistance measurements shall be recorded in accordance with instructions given in MIL-HDBK-705, method 110.1.

The first reading shall be taken and recorded within 30 seconds after shutdown and additional readings taken and recorded at approximately 30 second intervals until one reading has been recorded after the temperature has begun to decrease, or three minutes has elapsed since the generator shutdown, whichever is longer, being certain that the maximum temperature reached by each component has been recorded. Continuous or multipoint temperature recorder(s) may be used to record component temperatures as long as the above time requirements are met.

d. Repeat steps a through c above for each of the coils specified in the procurement document.

e. Repeat steps a through d above at each additional specified voltage connection, frequency, stabilization voltage, and load condition.

680.1.4 Results.

a. From the data obtained, compute the temperature rise of each specified component, in accordance with instructions given in MIL-HDBK-705, method 110.1.

> **NOTE**: To compute the temperature rise of a component, subtract the average ambient temperature of the air (immediately preceding shutdown) from the maximum temperature reached by each component.

b. Compare the temperature rise of every component, with the maximum temperature rise specified, for that component, in the procurement document.

680.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable temperature rise allowed for each component and class of insulation, for the method of measurement.

b. The voltage connection(s) and frequency(ies) at which this method is to be performed.

c. The stabilization voltage(s), if other than rated, at which this method is to be performed.

d. The load condition(s), if other than rated, at which this method is to be performed.

**DESCRIPTION:** 10 KW, 60 HZ
120 VOLT SINGLE-PHASE
GENERATOR ONLY

**MFGR:** ENGENSETS, INC.
**MODEL NO.** SF-10.0-MD
**SERIAL NO.** 21067
**REF.** MIL-STD-705/680.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

TEMPERATURE RISE TEST

**TEST NO.** 1

**SHEET:** 1 OF 1

**DATE:** FEBRUARY 11, 1971
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 201 | 113 | | 476 | | 194 | 819 | 348 | 106 | 342 | 118 | 810 | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | GENERATOR FIELD | | EXCITER FIELD | | GEN FRAME | GEN AIR IN | GEN AIR OUT | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | VOLTS | AMPS | VOLTS | AMPS | °F | °F | °F | | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | X.5 | | X.02 | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 08:50 | STARTED DRIVE MOTOR BROUGHT SET TO RATED SPEED VOLTAGE AND LOAD | | | | | | | | | | | | | | | |
| | 09:00 | 120.0 | 2.63 | 105 | 0.25 | 10.0 | 0.80 | 60.0 | 21.6 | 47.2 | 7.0 | 45.5 | 110 | 81 | 106 | | 80 |
| | 09:10 | 120.0 | 2.61 | 104 | 0.25 | 10.0 | 0.80 | 59.6 | 24.3 | 51.1 | 8.5 | 54.0 | 111 | 83 | 108 | | 82 |
| | 09:20 | ADJUSTED VOLTAGE AND FREQUENCY TO RATED | | | | | | | | | | | | | | | |
| | 09:30 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.6 | 50.1 | 8.2 | 53.6 | 111 | 83 | 107 | | 82 |
| | 09:40 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.8 | 50.4 | 8.3 | 54.0 | 111 | 83 | 108 | | 82 |
| | 09:50 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.8 | 50.4 | 8.3 | 54.0 | 111 | 83 | 108 | | 81 |
| | 10:00 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.8 | 50.4 | 8.3 | 54.0 | 111 | 83 | 107 | | 82 |
| | 10:00 | SHUTDOWN FOR RESISTANCE READING $T_1$ – $T_4$ | | | | | | | | | | | | | | | |
| | 10:05 | RESTARTED | | | | | | | | | | | | | | | |
| | 10:15 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.5 | 50.2 | 8.2 | 53.6 | 111 | 82 | 107 | | 81 |
| | 10:25 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.8 | 50.4 | 8.3 | 54.0 | 111 | 83 | 108 | | 82 |
| | 10:35 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.8 | 50.4 | 8.3 | 54.0 | 111 | 83 | 107 | | 82 |
| | 10:45 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.8 | 50.4 | 8.3 | 54.0 | 111 | 83 | 108 | | 82 |
| | 10:55 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.8 | 50.4 | 8.3 | 54.0 | 111 | 83 | 108 | | 82 |
| | 11:05 | 120.0 | 2.60 | 104 | 0.25 | 10.0 | 0.80 | 60.0 | 23.8 | 50.4 | 8.3 | 54.0 | 111 | 83 | 107 | | 82 |
| | 11:05 | SHUTDOWN FOR RESISTANCE READING $T_2$-$T_5$ | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | GENERATOR FIELD CURRENT MEASURED USING A 50 A, 50 mV SHUNT # 1067 | | | | | | | | | | | | | | | | |
| | EXCITER FIELD CURRENT MEASURED USING A 2 A, 50 mV SHUNT #1011 | | | | | | | | | | | | | | | | |
| | LINE CURRENT MEASURED USING C.T. # 1306 | | | | | | | | | | | | | | | | |

FIGURE 680.1-I Portion of a typical test record for temperature rise test (generator only).

# METHOD 680.2b

## TEMPERATURE RISE TEST
## (ALTERNATE LOADING METHOD)

**NOTE**: Method 680.2b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

680.2.1 General. Temperature rise tests are used by design engineers to assure each component is operating well within its rated temperature range and serve as a check on the manufacturing process.

680.2.2 Apparatus. Instrumentation for measuring load conditions, generator and exciter field voltage and current, generator and ambient temperatures, and coil resistances shall be as described and illustrated in MIL-HDBK-705. In addition, an electrical prime mover capable of driving the generator at the conditions specified herein shall be required.

680.2.3 Procedure.

680.2.3.1 Preparation for test.

a. Refer to the procurement document to determine which components have maximum temperature rises specified.

b. Attach the necessary thermal instrumentation in accordance with MIL-HDBK-705, method 202.1. Be sure to include the generator frame and bearing(s). Make the necessary winding resistance measurements in accordance with MIL-HDBK-705, method 401.1.

c. Mechanically connect the generator to the prime mover. Be sure to shield the generator from air currents caused by the prime mover, adjacent machinery, belts or pulleys.

d. Connect the load and field instrumentation in accordance with the applicable figure of this method.

e. From method 415.0, the Open Circuit Core Loss Test, determine the generator field current necessary to create a core loss equal to twice the rated voltage full load core loss of the generator.

f. Determine the value of the current that is to flow in the armature windings during the short-circuit period. The following formula shall be used:

$$I_t = 2I_a$$

Where:

$I_t$ is the short-circuit current in the armature during this method.

$I_a$ is the rated armature current.

This current will create twice the full-load copper loss in the armature.

680.2.3.2 Test.

a. Start and operate the prime mover such that the generator is at rated frequency (speed) with the field adjusted to the value determined in 680.2.3.1e and at no load for 30 minutes.

b. Decrease the field current to approximately zero and immediately apply the short-circuit and adjust the field current such that the armature current will be of the value determined in 680.2.3.1f above ($I_t$). Operate under the short–circuit conditions for 30 minutes.

c. During steps a and b above read and record all instrument readings at 15 minute intervals (see FIGURE 680.2-I).

d. Repeat steps a through c above until the temperature becomes stabilized as evidenced by frame and bearing temperatures remaining unchanged over a 1-hour period.

e. Repeat steps a and b above except that operating cycles shall be reduced to 15 minutes, until frame and bearing temperatures remain unchanged for 30 minutes. Record all instrument readings prior to each adjustment.

f. Repeat steps a and b above except that operating cycles shall be reduced to 5-minute periods, until frame and bearing temperatures remain unchanged for 30 minutes. Record all instrument readings prior to each adjustment.

g. After these procedures have been accomplished, the generator shall then be considered as having achieved temperature stabilization, provided the ambient temperature has not changed more than 5 F° (2.73 C°) during the last 30 minutes of operation.

h. As soon as the generator is considered stable, immediately shut down the equipment so that temperatures of rotating components and windings may be taken. For application of the contact method to rotating parts, or the resistance method to the armature coils (see MIL-HDBK-705, methods 110.1 and 202.1), a quick shutdown is mandatory.

**CAUTION: Do not connect bridges, meters or temperature measuring equipment for measuring resistance or temperature to circuits which may still be energized, e.g., during the time that the generator is coming to a stop.**

i. Immediately after the shutdown, start to record the resistance bridge readings of the coils and the temperature of the components where the contact method of measuring temperature rise is used. Readings of resistance measurements shall be recorded in accordance with instructions given in MIL-HDBK-705, method 110.1.

   The first thermocouple reading shall be taken and recorded within 30 seconds after shutdown and additional readings taken and recorded at approximately 30 second intervals until one reading has been recorded after the temperature has begun to decrease, or three minutes has elapsed since generator shutdown, whichever is longer, being certain that the maximum temperature reached by each component has been recorded. Continuous or multipoint temperature recorder(s) may be used to record component temperatures as long as the above time requirements are met.

j. Repeat steps a through i above for each of the coils specified in the procurement document.

k. Repeat steps a through j above for each additional specified voltage connection and frequency specified in the procurement document.

680.2.4 Results.

a. From the data obtained, compute the temperature rise of each specified component, in accordance with instructions given in MIL-HDBK-705, method 110.1.

**NOTE**: To compute the temperature rise of a component, subtract the average ambient temperature of the air (immediately preceding shutdown) from the maximum temperature reached by each component.

b. Compare the temperature rise of every component with the maximum temperature rise specified, for the component, in the procurement document.

680.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Maximum allowable temperature rise allowed for each component and class of insulation, for the method of measurement.

b. The voltage connection(s) and frequency(ies) at which this method is to be performed.

| **DESCRIPTION:** 500 KW 60 HZ 120/208V, THREE PHASE GENERATOR SET<br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SF-500.0<br>**SERIAL NO.** 113<br>**REF.** MIL-STD-705/680.2 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>TEMPERATURE RISE TEST<br>(ALTERNATE LOADING METHOD) | **TEST NO.** 17<br>**SHEET:** 1 OF 2<br>**DATE:** 22 NOVEMBER, 1971<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |
|---|---|---|

| **INST.→** | | 101 | | | 202 | | | 303 | | | 508 | 117 | 222 | 1013 | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | LINE CURRENT | | | OUTPUT POWER | | | FREQ | EXCITER FIELD | | GEN FRAME | GEN BEARING | GEN AIR IN | AVG AMB TEMP |
| | | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | $L_1$ | $L_2$ | $L_3$ | $L_1$ | $L_2$ | $L_3$ | | | | | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | KW | KW | KW | HZ | VOLTS | AMPS | °F | °F | °F | °F |
| **SYM** | | | | | X800 | X800 | X800 | X800 | X800 | X800 | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 11:00 | STARTED SET | | | | | | | | | | | | | | | |
| | 11:03 | 270 | 270 | 270 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 37.3 | 1.88 | 77 | 79 | 77 | 77 |
| | 11:18 | 270 | 270 | 270 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 37.3 | 1.88 | 78 | 79 | 77 | 77 |
| | 11:33 | 270 | 270 | 270 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 37.3 | 1.88 | 79 | 80 | 77 | 77 |
| | 11:33 | APPLIED SHORT CIRCUIT – ADJUSTED CURRENT TO TWICE RATED | | | | | | | | | | | | | | | |
| | 11:35 | 40 | 40 | 40 | 4.33 | 4.33 | 4.33 | .173 | .173 | .173 | 60.0 | 18.3 | .76 | 79 | 80 | 77 | 77 |
| | 11:50 | 40 | 40 | 40 | 4.33 | 4.33 | 4.33 | .173 | .173 | .173 | 60.0 | 18.3 | .76 | 83 | 85 | 77 | 77 |
| | 12:05 | 40 | 40 | 40 | 4.33 | 4.33 | 4.33 | .173 | .173 | .173 | 60.0 | 18.3 | .76 | 87 | 88 | 77 | 77 |
| | 12:06 | OPENED SHORT CIRCUIT ADJUST EXCITER FIELD CURRENT | | | | | | | | | | | | | | | |
| | 12:07 | 270 | 270 | 270 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 37.3 | 1.88 | 88 | 89 | 77 | 77 |
| | 12:22 | 270 | 270 | 270 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 37.3 | 1.88 | 90 | 92 | 77 | 77 |
| | 12:37 | 270 | 270 | 270 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 37.3 | 1.88 | 91 | 94 | 77 | 77 |
| | 12:39 | APPLIED SHORT | | | | | | | | | | | | | | | |
| | 12:40 | 40 | 40 | 40 | 4.33 | 4.33 | 4.33 | .173 | .173 | .173 | 60.0 | 18.3 | .76 | 91 | 94 | 77 | 77 |
| | 12:55 | 40 | 40 | 40 | 4.33 | 4.33 | 4.33 | .173 | .173 | .173 | 60.0 | 18.3 | .76 | 92 | 95 | 77 | 77 |
| | 13:10 | 40 | 40 | 40 | 4.33 | 4.33 | 4.33 | .173 | .173 | .173 | 60.0 | 18.3 | .76 | 92 | 95 | 77 | 77 |
| | 13:10 | OPENED SHORT | | | | | | | | | | | | | | | |
| | 13:11 | 270 | 270 | 270 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 37.3 | 1.88 | 92 | 95 | 77 | 77 |
| | 13:26 | 270 | 270 | 270 | 0 | 0 | 0 | 0 | 0 | 0 | 60.0 | 37.3 | 1.88 | 92 | 95 | 77 | 77 |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. Nos. $L_1$ – 11773; $L_2$-11774; $L_3$-11775 | | | | | | | | | | | | | | | | |
| | EXCITER FIELD CURRENT MEASURED USING 2A 50mV SHUNT NO 005 | | | | | | | | | | | | | | | | |

FIGURE 680.2-I Portion of a typical test record for temperature rise test (alternate loading method).

METHOD 690.1e

ENDURANCE TEST

690.1.1 General. The endurance test approximates, under controlled conditions, the wear and deterioration a power system receives in field service. The endurance test consists of operating the power system for a specified period of time and adhering to a specified schedule of maintenance. Prior to, during, and after the endurance run, certain performance checks are made.

690.1.2 Apparatus. Use instrumentation for measuring temperature in accordance with METHOD 110.1. Use instrumentation for measuring atmospheric pressure in accordance with METHOD 112.1. Use a stopwatch/timer. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

690.1.3 Procedure.

690.1.3.1 Preparation for test.

a. Unless otherwise specified in the procurement document, place the power system outdoors such that it is completely exposed to the weather on all sides; and directly on a level, solid reinforced concrete surface at least 3 inches thick. Do not restrain the power system in any manner. If the power system must be restrained to prevent "walking", indicate so in the test results.

b. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document. For power systems having more than one power output system (e.g., high voltage AC and low voltage DC, power system battery charging system not included, or two AC systems of different frequencies), separate loads and instrumentation are required for each output system.

c. Record the following items on both data sheets and file(s):

1. The date.
2. The serial number(s) of the recording meter(s).
3. Power system identification.
4. The data reading number (indexing).

d. Install appropriate thermocouples to measure the following temperatures:

**NOTE**: Not all power systems will require instrumentation of all of the listed items. The list contains items normally instrumented, however, additional thermal instrumentation may be required for the specified performance checks.

1. Engine coolant (inlet and outlet).
2. Spark plug(s).
3. Exhaust gas (combined exhaust gases in exhaust manifold or turbine tailpipe).
4. Lubricating oil sump and gallery for first article power systems (and sump only for production power systems).
5. Engine combustion air in (located at the inlet of the intake manifold).
6. Control panel cubicle (ambient air, inside).
7. Ambient temperature (in accordance with 202.1.4).
8. Generator stator frame (top and bottom, outside).
9. Generator cooling air (inlet and outlet).

10. Air entering power system.

690.1.3.2 Test.

690.1.3.2.1 Initial endurance performance tests. Within the first 24 hours of the endurance test, perform the following Methods:

a. METHOD 608.1, Frequency and Voltage Regulation Stability and Transient Response Test (Short Term).

b. METHOD 640.1, Maximum Power Test (for Gasoline and Diesel Power Systems).

c. METHOD 670.1, Fuel Consumption Test (Steady-State).

d. METHOD 651.1, Judging of Commutation Test (AC Power Systems) or METHOD 651.2, Judging of Commutation Test (DC Power Systems). These Methods are not applicable for brushless machines.

e. Additional performance checks, if specified in the procurement document.

**NOTE**: The Methods need not be performed in above order.

**NOTE**: No adjustments, other than those permitted in the maintenance and service schedule of the procurement document, shall be made after the above performance checks except as required in subsequent performance checks.

690.1.3.2.2 Endurance. Start and operate the power system at the specified voltage connection and frequency using the applicable fuel and lubricating oil(s) specified in the procurement document. Properly position doors, shrouds, access panels, etc., in accordance with the instructions on the power system or in the technical manual. Perform the first 50 hours of testing under this Method utilizing the power system fuel tank, if provided. If applicable, use the auxiliary fuel system per the procurement requirements. Load the power system in accordance with the cyclic load schedule of TABLE 690.1-I, unless otherwise specified in the procurement document. Repeat the one hundred hour cycle as required to complete the endurance time specified in the procurement document. For a power system with more than one power output system, load each output system in accordance with the cyclic load schedule of TABLE 690.1-I. Throughout the entire endurance test, continuously operate the power system without shutdown except for the required scheduled maintenance and servicing as permitted by the procurement document.

a. Read all power system panel instruments, including the engine gauges, at maximum time intervals of four hours and record these readings on the data sheet per METHOD 203.1 (see FIGURE 690.1-1). Record the ambient atmospheric pressure every four hours. When reading the power system panel instrumentation, visually inspect the power system for leaks, excessive vibration, loose bolts, etc., with findings recorded on the data sheet and repairs if applicable.

b. Continuously record the voltage, frequency, load, and thermal readings throughout the endurance test. Include the voltage and frequency, the time of day, elapsed hours of endurance, and corresponding data reading number in the test instrumentation data. Record any indications of abnormal or unusual power system performance with explanations on the data sheet.

c. Prior to every scheduled oil change, perform METHOD 608.1 Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) for rated load only. If no scheduled oil change is required on the power system, perform METHOD 608.1 for rated load every 300 hours. After any unscheduled maintenance is complete, perform METHOD 608.1 for rated load only.

d. In addition to the data recorded above, maintain a separate log identified by power system nomenclature and serial number throughout the endurance run. The log shall contain, as a minimum, the following information:

    1. Date, shift hours, elapsed endurance hours and a brief statement on the prevailing weather conditions.

    2. All adjustments, if made, as permitted by the procurement document.

    3. Information regarding scheduled maintenance performed. This shall include the time and number of personnel to perform each service or maintenance operation.

    4. Title, Method number and data sheet numbers for all performance checks.

    5. All shutdowns, with explanations.

    6. Results of periodic visual inspection of the power system.

    7. In a separate section of the log, tabulate all parts replacement, repairs, and oil consumption between oil changes. These entries shall also include elapsed endurance hours, total power system hours (power system hour meter reading) and date.

690.1.3.2.3 Post-Endurance.

a. Immediately after completing the endurance test and prior to any maintenance or servicing of the power system, repeat the performance tests listed in 690.1.3.2.1.

b. Perform the scheduled maintenance and servicing but do not overhaul the power system.

690.1.4 Results. Include all recorded data, data from all performance checks, the log, disassembly data and a summary in the results. Briefly analyze the results of this test in the summary in 100 hour maximum segments or as otherwise specified, including any abnormalities of the operation of the power system.

690.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Length of endurance run.

b. Cyclic load schedule, if different from TABLE 690.1-I.

c. Additional instrumentation requirements, if any.

d. Additional performance checks required, if any, and the elapsed hours during the endurance at which they are to be performed.

e. Scheduled service and maintenance required and the hours of operation at which they are to be performed.

f. Reassembly or reconditioning instructions, if applicable.

g. Fuel(s) and lubricant(s) to be used during the performance of this Method.

h. Performance requirements to satisfy the tests in 690.1.3.2.1.

TABLE 690.1-I. Cyclic load schedule.

| **Run Number** | **Percent of Rated Load** | **Number of hours at Each Condition** |
|---|---|---|
| 1 | 50 | 24 |
| 2 | 0 | 4 |
| 3 | 75 | 24 |
| 4 | 25 | 24 |
| 5 | 100 | 24 |

**DESCRIPTION:** 10KW, 60HZ
120 V SINGLE - PHASE
POWER SYSTEM

**MFGR:** ENGENSETS
**MODEL NO.** SF-10.0-MD
**SERIAL NO.** 12969
**REF.** MIL-STD-705/690.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

ENDURANCE TEST

**TEST NO.** 47

**SHEET:** 1 OF 2

**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 101 | 316 | | 418 | | | 613 | | | POWER SYSTEM INSTRUMENTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | END HRS | TESTER INITIALS | VOLTMETER | % CURRENT | FREQ | | | | |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | VOLTS | % | HZ | | | | |
| **SYM** | | | X25 | X1 | X25 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1530 | STARTED POWER SYSTEM APPLIED 75% LOAD PLACE POWER SYSTEM ON ENDURANCE RUNNING ON POWER SYSTEM TANK | | | | | | | | | | | | | | | |
| | 1630 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 1 | RGR | 120.5 | 76 | 59.8 | | | | |
| | 1730 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 2 | RGR | | | | | | | |
| | 1830 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.1 | 3 | RGR | | | | | | | |
| | 1930 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 4 | RGR | 120.5 | 76 | 59.8 | | | | |
| | 2030 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.1 | 5 | RGR | | | | | | | |
| | 2130 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.1 | 6 | RGR | | | | | | | |
| | 2230 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 7 | RGR | | | | | | | |
| | 2330 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 8 | RGR | 120.5 | 76 | 59.8 | | | | |
| | 2330 | SHUTDOWN POWER SYSTEM FOR OIL CHECK-NO OIL ADDED | | | | | | | | | | | | | | | |
| | 2340 | RESTARTED POWER SYSTEM APPLIED 75% LOAD | | | | | | | | | | | | | | | |
| 1/15/16 | 0040 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 9 | RGR | | | | | | | |
| | 0140 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 10 | RGR | | | | | | | |
| | 0240 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.1 | 11 | RGR | | | | | | | |
| | 0340 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.1 | 12 | RGR | 120.5 | 76 | 59.8 | | | | |
| | 0440 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 13 | RGR | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 0540 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 14 | RGR | | | | | | | |
| | 0640 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.1 | 15 | RGR | | | | | | | |
| | 0740 | 120.0 | 3.12 | 78.0 | .300 | 7.50 | .80 | 60.0 | 16 | RGR | 120.5 | 76 | 59.8 | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. NO 1313 | | | | | | | | | | | | | | | | |
| | DATA RECORDER NO. 1503 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 690.1-1 Portion of a typical test record for endurance test (Page 1 of 2).

**DESCRIPTION:** 10KW, 60HZ
120 V SINGLE - PHASE
POWER SYSTEM

**MFGR:** ENGENSETS
**MODEL NO.** SF-10.0-MD
**SERIAL NO.** 12969
**REF.** MIL-STD-705/690.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

ENDURANCE TEST

**TEST NO.** 47

**SHEET:** 2 OF 2

**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | 1073 | | | | | | | | | | | | 784 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | OIL SUMP | OIL GALLERY | ENGINE AIR | | EXH | GEN AIR | | GEN FRAME | | CONT. PANEL | AIR IN | AVG AMB | PRESSURES | | | | |
| | | | IN | OUT | | IN | OUT | TOP | BOTTOM | | | | EXH | AIR IN | BARS | | |
| **UNITS** | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | in HG | in HG | in HG | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** | **34** |
| | | | | | | | | | | | | | | | | | |
| | 155 | 180 | 11 | 25 | 896 | 12 | 16 | 20 | 18 | 13 | 13 | 13 | 72.0 | 27.76 | 27.76 | | |
| | 152 | 175 | 4 | 21 | 768 | 5 | 9 | 13 | 11 | 8 | 11 | 11 | 72.0 | 27.81 | 27.81 | | |
| | 151 | 175 | 4 | 21 | 768 | 5 | 9 | 13 | 11 | 8 | 6 | 4 | 72.0 | 27.81 | 27.81 | | |
| | 150 | 174 | 3 | 20 | 770 | 4 | 8 | 12 | 10 | 7 | 4 | 4 | 72.0 | 27.83 | 27.83 | | |
| | 149 | 173 | 1 | 18 | 767 | 2 | 6 | 10 | 8 | 5 | 3 | 3 | 72.0 | 27.83 | 27.83 | | |
| | 149 | 173 | -1 | 16 | 765 | 0 | 4 | 8 | 6 | 3 | 1 | 1 | 72.0 | 27.83 | 27.83 | | |
| | 148 | 171 | -2 | 15 | 766 | -1 | 3 | 7 | 5 | 2 | -1 | -1 | 72.0 | 27.84 | 27.84 | | |
| | 147 | 171 | -3 | 14 | 766 | -2 | 2 | 6 | 4 | 1 | -3 | -3 | 72.0 | 27.85 | 27.85 | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 146 | 170 | -4 | 13 | 764 | -3 | 1 | 5 | 3 | 2 | -4 | -4 | 72.0 | 27.86 | 27.86 | | |
| | 146 | 168 | -4 | 13 | 764 | -3 | 1 | 5 | 3 | 0 | -4 | -4 | 72.0 | 27.86 | 27.86 | | |
| | 143 | 166 | -6 | 11 | 765 | -5 | -1 | 3 | 1 | -2 | -6 | -6 | 72.0 | 27.86 | 27.86 | | |
| | 143 | 167 | -7 | 10 | 764 | -6 | -2 | 2 | 0 | -3 | -7 | -7 | 72.0 | 27.90 | 27.90 | | |
| | 142 | 166 | -7 | 10 | 765 | -6 | -2 | 2 | 0 | -3 | -7 | -7 | 72.0 | 27.90 | 27.90 | | |
| | 142 | 164 | -7 | 10 | 770 | -6 | -2 | 2 | 0 | -3 | -7 | -7 | 72.0 | 27.90 | 27.90 | | |
| | 140 | 162 | -9 | 8 | 767 | -8 | -4 | 0 | -2 | -5 | -9 | -9 | 72.0 | 27.90 | 27.90 | | |
| | 141 | 164 | -8 | 9 | 766 | -7 | -3 | 1 | -1 | -4 | -8 | -8 | 72.0 | 27.90 | 27.90 | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. NO 1313 | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

FIGURE 690.1-1 Portion of a typical test record for endurance test (Page 2 of 2).

# METHOD 695.1b

# RELIABILITY TEST

695.1.1 General. The reliability test is designed to measure the probability that a power system will perform as intended. While this Method is called "Reliability Test", the actual parameter developed will be the Mean-Time-Between-Failure (MTBF). Testers may use this Method for a time-terminated reliability test as required by the procurement document. Testers may also use this Method for a probability ratio sequential reliability test as required by the procurement document.

695.1.2 Apparatus. Use instrumentation for measuring temperature and pressure in accordance with METHOD 110.1 and METHOD 112.1, respectively. Use a stopwatch/timer. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

695.1.3 Procedure.

695.1.3.1 Preparation of test.

a. Unless otherwise specified in the procurement document, place the power system outdoors such that it is completely exposed to the weather on all sides, and directly on a level, solid reinforced concrete surface at least 3 inches thick. Do not restrain the power system in any manner. If the power system must be restrained to prevent "walking", indicate so in the test results.

b. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, for one voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document. For power systems having more than one power output system (e.g., high voltage AC and low voltage DC, power system battery charging system not included, or two AC systems of different frequencies), separate loads and instrumentation are required for each output system.

c. Record the following items on both data sheets and file(s):

1. The date.
2. The serial number(s) of the recording meter(s).
3. Power system identification.
4. The data reading number (indexing).

d. Install appropriate thermocouples to measure the following temperatures:

**NOTE**: Not all power systems will require instrumentation of all of the listed items. The list contains items normally instrumented; however, additional thermal instrumentation may be required for the specified performance checks.

1. Engine coolant (inlet and outlet).
2. Spark plug(s).
3. Exhaust gas (combined exhaust gases in exhaust manifold or turbine tailpipe).
4. Lubricating oil sump and gallery for first article power systems (and sump only for production power systems).
5. Engine combustion air in (located at the inlet of the intake manifold).
6. Control panel cubicle (ambient air, inside).
7. Ambient temperature (in accordance with 202.1.4).
8. Generator stator frame (top and bottom, outside).
9. Generator cooling air (inlet and outlet).

10. Air entering power system.

695.1.3.2 Failure classification definition. The contracting officer shall have final determination of all failure classifications. Use the failure classifications defined below unless otherwise specified in the procurement document:

a. A relevant failure is any failure of a component, part or assembly which prevents the power system from starting, stopping, or providing quality power; or any component, part or assembly failure, which causes a critical failure of the power system or a catastrophic safety hazard. Relevant failure(s) shall be used to calculate the MTBF requirement.

b. A critical failure is a relevant failure requiring removal of the engine, cylinder head, oil pan, gear cover, or AC generator to repair, if applicable.

c. A catastrophic safety hazard failure is an incident which 1) causes the total destruction of the power system, 2) causes an injury or illness resulting in a fatality or permanent total disability, or 3) causes severe environmental damage. An example of severe environmental damage would be total loss of fuel from a massive leak in the fuel tank.

695.1.3.3 Test.

695.1.3.3.1 Performance evaluation. Within the first 24 hours of the test, perform the following Methods without power system temperature or pressure instrumentation, unless expressly needed for maximum power correction or stabilization verification:

a. METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. METHOD 640.1, Maximum Power Test (for Gasoline and Diesel Power Systems).

c. METHOD 670.1, Fuel Consumption Test (Steady-State).

695.1.3.3.2 Reliability operation. Start and operate the power system at the specified voltage connection and frequency using the fuel, coolant and lubricating oil(s) specified in the procurement document. Properly position doors, shrouds, access panels, etc., in accordance with the instructions on the power system or in the technical manual. Perform the first 50 hours of testing under this Method utilizing the power system fuel tank, if provided. If applicable, use the auxiliary fuel system per the procurement document requirements. Operate the power system at the loads specified in TABLE 695.1-I unless otherwise specified in the procurement document. For power systems with more than one power output system, load each output system as specified in TABLE 695.1-I. Throughout the entire duration of this Method, continuously operate the power system without shutdown except for the required scheduled maintenance and servicing as permitted by the procurement document and as provided in 695.1.3.3.3.

a. Read all power system panel instruments, including the engine gauges, at maximum time intervals of four hours and record them on the data sheet per METHOD 203.1 (see FIGURE 695.1-1). The ambient atmospheric pressure shall be read every four hours. When reading the power system panel instrumentation, visually inspect the power system for leaks, excessive vibration, loose bolts, etc., with findings recorded on the data sheet and repairs made if applicable.

b. Record the voltage, frequency, load and thermal readings continuously throughout the reliability test. Test instrumentation data shall include the voltage and frequency, the time of day, elapsed hours of reliability testing, and corresponding data reading number. Mark any indications of abnormal or unusual power system performance with explanations on the data sheet.

c. Prior to every scheduled oil change, perform METHOD 608.1 Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) for rated load only. If no scheduled oil change is required on the power system, perform METHOD 608.1 for rated load every 300 hours. After any unscheduled maintenance is complete, perform METHOD 608.1 for rated load only.

d. In addition to the data recorded above, maintain a separate log identified by power system nomenclature and serial number throughout the reliability evaluation. The log shall contain, as a minimum, the following information:

    1. Date, shift hours, elapsed reliability hours and brief statement on the prevailing weather conditions.

    2. All adjustments, if made, as permitted by the procurement document and man-hours expended.

    3. Information regarding scheduled and unscheduled maintenance performed. This shall include clock hours, man-hours, and number of personnel to perform each service or maintenance operation.

    4. Title, Method number, and data sheet numbers for all performance checks.

5. All shutdowns, with explanation.

6. Results of periodic visual inspection of the power system.

7. In a separate section of the log, tabulate all replacement or repair of parts and oil consumption between oil changes. These entries shall also include elapsed reliability hours, total power system hours (power system hour meter reading) and date.

e. In addition to the data recorded above, prepare failure analysis sheets for each incident on forms similar to that in FIGURE 695.1-1.

TABLE 695.1-I. Cyclic load schedule.

| Run Number | Percent of Rated Load | Number of hours at Each Condition |
|---|---|---|
| 1 | 50 | 24 |
| 2 | 0 | 4 |
| 3 | 75 | 24 |
| 4 | 25 | 24 |
| 5 | 100 | 24 |

695.1.3.3.3 Reliability duration. The duration of this Method shall be in accordance with the procurement document. If a time-terminated test is specified, the duration of this Method shall be 500 hours unless otherwise specified in the procurement document. Repeat the cyclic load schedule in TABLE 695.1-I as required to fulfill these requirements. After 1200 hours of operation under this Method and every 1000 hours thereafter, shutdown the power system at other than scheduled maintenance shutdowns for at least 72 hours but not more than 120 hours. During this period of shutdown no servicing, maintenance or adjusting of the power system shall be permitted. This shutdown period is to determine the ability of the power system to start after prolonged shutdown.

695.1.3.4 Post reliability. Within the 24 hours after the completion of the Reliability Test and prior to any maintenance or servicing of the power system, repeat the performance checks listed in 695.1.3.3.1.

695.1.4 Results.

a. The results of this test shall include all recorded data, data from all performance checks, the log, failure reports, and a summary. The summary shall briefly analyze the results of this test including any abnormalities of the operation of the power system and shall include, but not be limited to, the following:

1. Stopwatch/timer reading when failure occurred.

2. Description of failed components.

3. Cause of each failure.

4. Man-hours to isolate and repair each failure.

5. Corrective action taken to correct each failure.

b. Use the results from step a above to determine the MTBF and the Maintenance Ratio (MR) with the following formulas used for these calculations:

$$MTBF\ (Observed) = \frac{Total\ Operational\ Hours}{Number\ of\ Failures}$$

$$MR = \frac{Total\ Man\text{-}hours\ for\ Preventative\ and\ Corrective\ Maintenance}{Total\ Operational\ Hours}$$

695.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Duration of test.

b. Number of power systems to be subjected to this Method.

c. Number of failures allowed per duration of test.

d. Load schedule if different from that in TABLE 695.1-I.

e. Additional performance checks required, if any, and the elapsed hours when they shall be performed.

f. Scheduled maintenance and service required and the hours of operation at which they shall be performed.

g. Fuels and lubricants to be used for the performance of this Method.

h. Voltage connections and frequency at which this Method shall be performed.

i. Minimum acceptable value of "specified" value for MTBF.

j. Maximum allowable Maintenance Ratio (MR), if specified.

k. Performance requirements to satisfy the tests in 695.1.3.3.1.

l. Failure classification definition if other than as specified herein.

RELIABILITY
FAILURE REPORT

TEST: Method 695.1 ETM HRS: ___________ END HRS: ________________
UNIT: ______ kW, ___________HZ DATE: ___________________
MFGR: ______________________ TIME: ____________________
POWER SYSTEM S/N: ____________ WEATHER: _______________
LOAD: ____________ FUEL: ___________ VOLTAGE: ________________
FAULT INDICATORS: _______________________________________________________
POWER SYSTEM PANEL INDICATORS: _____________________________________
FAILURE: __________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________
HOW FAILURE DETECTED: __________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________
FAILED ITEM: ______________________________________________________________
REPAIR ACTION: ____________________________________________________________
____________________________________________________________________________
____________________________________________________________________________
SPECIAL TOOLS: NO ________________ YES ________________
TYPE: ________________________________________________________________________

| Find Prob Area w/o Test Equip | Find Prob Item w/Test Equip | Disassemble | Replacement or Repair | Reassemble | Adjustment | Checkout |
|---|---|---|---|---|---|---|
| Hr Min | Hr Min | Hr Min | Hr Min | Hr Min | Hr Min | Hr Min |
| Men | Men | Men | Men | Men | Men | Men |

TOTAL HOURS FOR ALL PHASES OF REPAIR: ___________________________________
REMARKS: ____________________________________________________________________
_________________________________________________________________________________
_______________________________________________________________________________
RECORDER: __________________________________________________________________
CONTRACTING OFFICER FAILURE CLASSIFICATION: ___________________________

FIGURE 695.1-1 Example of reliability failure report

METHOD 695.2

WET STACKING TEST

695.2.1 General. Power systems shall inherently minimize the negative effects of continuous light load operation.

695.2.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring the ambient temperature as described in METHOD 110.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

695.2.3 Procedure.

a. Perform METHOD 695.1, Reliability Test using the fuel specified in the procurement document except for the following:

    1. Do not perform METHOD 670.1, Fuel Consumption Test, before and after the test.

    2. The duration of the test shall be 300 hours or as specified in the procurement document.

    3. The load for the 300 hours shall be 10% rated load.

695.2.4 Results. Compare the results of the before and post tests to the procurement requirements.

695.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The requirements necessary to evaluate METHOD 608.1.

b. Usually, no relevant failures are allowed during this test. If this is not true, number of relevant failures allowed.

c. Minimum value of maximum power required. (For turbocharged engine-driven power systems: The value of load and length of time the power system is to be operated at this load if other than as specified in METHOD 640.1.)

d. Voltage connection(s) and frequency(ies) at which this Method is to be performed.

e. Duration of the test if other than as specified herein.

f. Fuel to be used.

METHOD 701.1e

STARTING AND OPERATING TEST
(COLD AND SEVERE COLD BATTERY START)

701.1.1 General. The power system must satisfactorily start and operate in cold and severe cold temperature environments.

701.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. Also, use battery voltage and current recording type instrumentation. The voltage, frequency, and current recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the specified low temperature with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.2.

Use the apparatus needed to verify batteries have been cycled and are fully charged in accordance with METHOD 222.1, Battery Servicing and Condition Assurance Prior to “Cold Starting” Tests.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

701.1.3 Procedure.

701.1.3.1 Preparation for test.

a. Install appropriate thermocouples to measure all of the following temperatures.

**NOTE**: All below temperatures are required unless inapplicable or waived by the procurement document. For example, no spark plug temperature is to be monitored if there are no spark plugs.

**NOTE**: This list contains items normally instrumented; however, some power systems may require additional thermal instrumentation. Install thermal instrumentation in accordance with the instructions in METHOD 202.1.

1. Ambient air temperature.
2. Engine coolant (engine outlet and inlet).
3. Spark plug(s).
4. Lubricating oil (sump and gallery).
5. Engine combustion air in (located at the inlet of the intake manifold).
6. Battery electrolyte or battery surface.
7. Heater coolant (air or liquid-into and out of the heater).
8. Heater exhaust.
9. Battery box air (at each end of battery box).
10. Engine exhaust gas.
11. Generator stator frame (top and bottom, outside).
12. Generator cooling air (inlet and outlet).
13. Control panel cubicle (ambient air, inside).
14. Air entering power system.
15. Fuel in on-board fuel tank.

b. Start and operate the power system until the lubricating oil is warm enough to drain.

c. Drain the coolant from the engine block, the radiator, coolant pump, heater, and all coolant lines. Ensure the power system is completely drained. Fill the coolant system with the proper solution of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

d. Drain the fuel from all fuel tanks, lines, strainers, pumps and filters. Flush tanks with low temperature fuel using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets on strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuel of the proper grade (low temperature fuel as specified in the procurement document). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

e. Drain the lubricating oil from the engine, filters, strainers and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubrication oil. Fill and label a small container with a sample (approximately 8 ounces) of the oil used.

f. Operate the winterization system as applicable. Ensure that all controls work properly. If necessary, temporarily bypass some controls if the ambient temperature is too high.

**CAUTION: Do not operate the winterization system for longer than necessary to perform the checkout as the heater may damage the power system.**

g. Operate any fuel priming pumps on the power system with the discharge lines open to clear lines of normal ambient fuel.

h. Check technical manual or operating and servicing instructions to see that all necessary power system maintenance has been performed.

i. Start and operate the power system for approximately 15 minutes at no load to allow the arctic fuel and lubricant to thoroughly circulate. During this period open oil lines at gages and safety controls to drain normal temperature oil. Shutdown the power system and drain all fuel tanks as well as the oil from the air cleaners. Fill power system fuel tanks. Fill the air cleaner oil reservoirs with the proper grade of lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of fuel.

j. Ensure test batteries have been cycled and charged using a battery analyzer to verify state of charge in accordance with METHOD 222.1 before placing them in the cold room.

k. Place sample containers of fuel, lubricant, and coolant in the cold room.

l. Place the power system in the cold room. If the power system is equipped for an auxiliary fuel supply, connect the auxiliary fuel supply to the power system using the auxiliary fuel hoses supplied with the power system. Use an auxiliary fuel supply having sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. Place this auxiliary fuel supply in the cold room.

m. Connect the load and battery current and voltage instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document. Make the voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

n. Where temperature measurements are made by means of thermocouples, bring the thermocouple leads out of the cold room to permit the temperature to be read by instruments located in normal ambient temperatures. Locate all electrical instruments ouside the cold room, except those provided as part of the power system.

701.1.3.2 Test.

a. Expose the complete power system (including all fuels, lubricants, coolants and hydraulic oils to be used) to the specified low temperature until such time as all thermocouples are at the specified low temperature or until 24 hours have elapsed, whichever comes later. During all steps of this test, all ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the procurement document. Prepare the power system by following the operating instructions on the power system. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet per METHOD 203.1 (see FIGURE 701.1-1).

b. Follow the operating instructions on the power system and turn the winterization system on, if applicable. Record the time the winterization system turned on.

c. Record all temperature readings continuously during this test. (See FIGURE 701.1-1).

**CAUTION: Care must be taken in cranking the engine. Excessive cranking can damage the starter. See the instructions on the power system or the technical manual for the maximum cranking time.**

d. Operate the winterization system a minimum of 50 minutes and a maximum of 55 minutes, unless otherwise specified in the procurement document. Turn off the winterization system and record the time of operation. After the winterization system is turned off, perform the two required cranking cycles with the power system inactive, to preclude starting. Turn on recording instrumentation and leave on until this Method is completed. Start the power system. The power system must be operating at rated voltage and rated frequency without further use of any type of starting aids or winterization equipment within 1 hour from the time the winterization system was first turned on. If the power system does not start within the 1 hour, stop test and report failure on data sheet.

e. After the power system starts, operate it at no load, rated voltage and rated frequency for a period of 15 minutes.

f. If necessary, reset the frequency to the rated value and record the amount the frequency had drifted from the time of power system start.

g. Within 16 minutes after the power system starts, apply rated load in one step with the circuit interrupter. Leave rated load on the power system for 30 seconds, then drop the load to no load in one step using the circuit interrupter. Operate at no load for 30 seconds. Again, using the circuit interrupter, apply and drop rated load two more times with 30 seconds of operation at these load conditions.

h. Apply rated load and operate power system for 5 minutes. After 5 minutes of rated load operation, drop the load to no load and allow the power system to stabilize at no load. Stabilization shall be in accordance with METHOD 608.1 with all instrumentation required by METHOD 701.1 recorded during stabilization.

i. Apply rated load in one step and allow the power system to stabilize at rated load, rated voltage, and rated frequency. Stabilization shall be in accordance with METHOD 608.1 with all instrumentation required by METHOD 701.1 recorded during stabilization.

j. After stabilization has occurred, unless otherwise specified in the procurement document, operate the power system in accordance with the instructions on the power system or in the technical manual and perform the following Methods in the order shown at the specified low temperature, voltage connection and frequency:

   1. METHOD 608.1, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term). In addition to the required data, all instrumentation as specified in METHOD 701.1 shall be recorded at the same time for the stabilization portion of this test.

   2. METHOD 511.1, Regulator Range Test. In addition to the required data, all instrumentation as specified in METHOD 701.1 shall be recorded at the same time for the stabilization portion of this test.

3. METHOD 513.2, Indicating Instrument Test (Electrical).

4. METHOD 510.1, Rheostat Range Test.

| |
|---|
| **NOTE**: METHOD 510.1 shall only be performed on power systems so equipped. |

k. If the total operating time between the start of the no load stabilization run (step h) and the completion of the tests listed in step j above is less than 8 hours, then continue to run the power system at no load, rated voltage and rated frequency until the accumulated operating time is at least 8 hours.

701.1.4 Results. Results shall be as specified in the Methods listed in 701.1.3.2j. Compare the manner in which the power system functioned, as denoted by the instrument and temperature readings, with the procurement document requirements.

701.1.5 Procurement document requirements. The following details must be specified in the individual procurement document:

a. Temperature at which Method is to be performed.

b. Type of fuel, lubricating oil, and coolant to be used.

c. Additional tests to be performed not listed in 701.1.3.2j.

d. Voltage connection and frequency at which this Method is to be performed.

e. Allowable starting time if different than specified in 701.1.3.2d.

f. Requirements for auxiliary fuel supply system.

g. Requirements necessary to evaluate METHOD 608.1.

h. Requirements necessary to evaluate METHOD 511.1.

i. Requirements necessary to evaluate METHOD 513.2.

j. Requirements necessary to evaluate METHOD 510.1, if applicable.

k. Engine temperature requirements.

l. Requirements for checking devices in 701.1.3.2a.

m. Definition of full fuel tank, if applicable.

n. Temperature of cold room when arctic fuel is to be added, if applicable.

o. Whether or not the power system needs to be run to circulate the arctic fuel after being added, if applicable.

**DESCRIPTION:** 15 KW, 60 HZ
120 V SINGLE PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-15.0-MD
**SERIAL NO.** 10629
**REF.** MIL-STD-705/701.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

STARTING AND OPERATING TEST
(COLD AND SEVERE COLD BATTERY START)

**TEST NO.** 27

**SHEET:** 1 OF 2

**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 489 | 51172 | | 476 | | 211 | 2062 | | | 1167 | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | POWER OUTPUT | | POWER FACTOR | FREQ | | | HEATER COOLANT | | LUBE OIL | | ENG AIR IN | CONT COMP. | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | IN | OUT | SUMP | GALLERY | °F | °F | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | °F | °F | °F | °F | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0750 | 24 HOUR SOAK AT -65°F COMPLETE | | | | | | | | | | | | | | | |
| | 0755 | CHECKED ALL DOORS, HOSES, AND SWITCHES FOR FREEDOM OF MOVEMENT -- ALL OK | | | | | | | | | | | | | | | |
| | 0800 | -- | -- | -- | -- | -- | -- | -- | | | -65 | -65 | -66 | -65 | -65 | -65 | -66 |
| | 0810 | WINTERIZATION SYSTEM ON | | | | | | | | | | | | | | | -65 |
| | 0812 | WINTERIZATION SYSTEM OPERATING | | | | | | | | | | | | | | | |
| | 0820 | -- | -- | -- | -- | -- | -- | -- | | | -25 | +40 | -55 | -60 | -50 | -65 | -65 |
| | 0830 | -- | -- | -- | -- | -- | -- | -- | | | 0 | +70 | -40 | -54 | -40 | -48 | -66 |
| | 0840 | -- | -- | -- | -- | -- | -- | -- | | | +50 | 100 | -30 | -48 | -30 | -40 | -65 |
| | 0850 | -- | -- | -- | -- | -- | -- | -- | | | 70 | 150 | -5 | -42 | -2 | -35 | -65 |
| | 0900 | -- | -- | -- | -- | -- | -- | -- | | | 100 | 175 | +15 | -34 | +25 | -30 | -65 |
| | 0901 | FIRST CRANKING CYCLE IGNITION OFF 30 SEC. | | | | | | | | | | | | | | | |
| | | SECOND CRANKING CYCLE IGNITION OFF 30 SEC. | | | | | | | | | | | | | | | |
| | 0905 | THIRD CRANKING CYCLE IGNITION ON 10 SEC ENGINE STARTED | | | | | | | | | | | | | | | -65 |
| | 0905 | WINTERIZATION SYSTEM TURNED OFF | | | | | | | | | | | | | | | |
| | 0906 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | -- | -- | 98 | +19 | 65 | -50 | -66 |
| | 0916 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | -- | -- | 106 | 108 | 72 | -53 | -65 |
| | 0922 | APPLIED RATED LOAD FOR 30 SEC. | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | 0923 | APPLIED RATED LOAD FOR 30 SEC. | | | | | | | | | | | | | | | |
| | 0924 | APPLIED RATED LOAD FOR 30 SEC. | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURE USING C.T. #1306 | | | | | | | | | | | | | | | | |

FIGURE 701.1-1 Portion of a typical test record for starting and operating test (cold and severe cold battery start).

# METHOD 701.2e

## STARTING AND OPERATING TEST (BASIC COLD BATTERY START, -25ºF)

701.2.1 General. The power system must satisfactorily start and operate in basic cold environments without the use of any winterization equipment.

701.2.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring temperature shall be as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. Also, use battery voltage and current recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the specified low temperature with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.2.

Use the apparatus needed to verify batteries have been cycled and are fully charged in accordance with METHOD 222.1, Battery serving and Condition Assurance Prior to "Cold Starting" Tests.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

701.2.3 Procedure. If this Method is performed immediately following METHOD 701.1 or METHOD 702.1, omit 701.2.3.1 except that the tester may change the batteries.

701.2.3.1 Preparation for test.

a. Install appropriate thermocouples to measure all of the following temperatures.

| |
|---|
| **NOTE**: All below temperatures are required unless inapplicable or waived by the procurement document. For example, no spark plug temperature is to be monitored if there are no spark plugs. |

| |
|---|
| **NOTE**: This list contains items normally instrumented; however, some power systems may require additional thermal instrumentation. Install the thermal instrumentation in accordance with the instructions in METHOD 202.1. |

1. Ambient air temperature.
2. Engine coolant (engine outlet and inlet).
3. Spark plug(s).
4. Lubricating oil (sump and gallery).
5. Engine combustion air in (located at the inlet of the intake manifold).
6. Battery electrolyte or battery surface.
7. Engine exhaust gas.
8. Generator stator frame (top and bottom, outside).
9. Generator cooling air (inlet and outlet).
10. Control panel cubicle (ambient air, inside).
11. Air entering power system.
12. Battery box air (at each end of battery box).
13. Fuel in on-board fuel tank.

b. Start and operate the power system until the lubricating oil is warm enough to drain.

c. Drain the coolant from the engine block, the radiator, coolant pump, heater, and all coolant lines. Ensure the power system is completely drained. Fill the coolant system with the proper solution of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

d. Drain the fuel from all fuel tanks, lines, strainers, pumps and filters. Flush tanks with low temperature fuel using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets on strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuel of the proper grade (low temperature fuel specified in the procurement document). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

e. Drain the lubrication oil from the engine, filters, strainers and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of the oil used.

f. Operate any fuel priming pumps on the set with the distance lines open to clear lines of normal ambient fuel.

g. Check technical manual or operating and servicing instructions to see that all necessary power system maintenance has been performed.

h. Start and operate the power system for approximately 15 minutes at no load to allow the fuel and lubricants to thoroughly circulate. During this period open oil lines at gages and safety controls to drain normal temperature oil. Shutdown the power system and drain all power system fuel tanks as well as the oil from the air cleaners. Fill power system fuel tanks. Fill the air cleaner oil reservoirs with the proper grade of lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of fuel used.

i. Ensure test batteries have been cycled and charged using a battery analyzer to verify state of charge in accordance with METHOD 222.1 before placing them in the cold room.

j. Place sample containers of fuel, lubricant, and coolant in the cold room.

k. Place the power system in the cold room. If the power system is equipped for an auxiliary fuel supply, connect the auxiliary fuel supply to the power system using the auxiliary fuel hoses supplied with the power system. Use an auxiliary fuel supply having sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. Place the auxiliary fuel supply in the cold room.

l. Connect the load and battery current and voltage instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

m. Where temperature measurements are made by means of thermocouples, bring the thermocouple leads out of the cold room to permit the temperature to be read by instruments located in normal ambient temperatures. Locate all electrical instruments ouside the cold room, except those provided as part of the power system.

701.2.3.2 Test.

a. Expose the complete power system (including all fuels, lubricants, coolants and hydraulic oils to be used) to -25ºF (-32ºC) until such time as all thermocouples are at the specified low temperature or until 24 hours have elapsed, whichever comes later. During all steps of this test, all ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the procurement document. Prepare the power system by following the operating instructions on the power system or technical manual. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet per METHOD 203.1 (see FIGURE 701.2-1).

b. Turn on recording instrumentation and leave on until this Method is completed.

c. Prior to the first attempt to start, but within the allotted 5 minutes, complete two required cranking cycles with the power system inactive (to preclude starting). By following the instructions on the power system or in the technical manual, start the power system. Record the time when cranking is started. Record the time when the power system starts. See FIGURE 701.2-1.

**CAUTION: Care must be taken in cranking the engine. Excessive cranking may damage the starter. See the instructions on the power system or the technical manual for the maximum cranking time.**

d. Allow the power system to warm up at no load, rated voltage and rated frequency for a period of 15 minutes.

e. If necessary, reset the frequency to the rated value and record the amount the frequency had drifted from the time of power system start.

f. Within 16 minutes after the power system starts, apply rated load in one step with the power system circuit interrupter. Leave rated load on the power system for 30 seconds, then drop the load to no load in one step using the circuit interrupter. Operate at no load for 30 seconds. Again, using the circuit interrupter, apply and drop rated load two more times with 30 seconds of operation at these load conditions.

g. Apply rated load and operate power system for 5 minutes. After 5 minutes of rated load operation, drop the load to no load and allow the power system to stabilize at no load. Stabilization shall be in accordance with METHOD 608.1 with all instrumentation required by METHOD 701.2 recorded during stabilization.

h. Apply rated load in one step and allow the power system to stabilize at rated load, rated voltage, and rated frequency. Stabilization shall be in accordance with METHOD 608.1 with all instrumentation required by METHOD 701.2 recorded during stabilization.

i. After stabilization has occurred, unless otherwise specified in the procurement document, operate the power system in accordance with the instructions on the power system or in the technical manual and perform the following Methods in the order shown at -25ºF (-32ºC) and at the specified voltage connection and frequency:

1. METHOD 608.1, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term). In addition to the required data, record all thermal instrumentation as specified in 701.2.3.1 at the same time for the stabilization portion of this test.

2. METHOD 511.1, Regulator Range Test. In addition to the required data, record all instrumentation as specified in METHOD 701.2 at the same time for the stabilization portion of this test.

3. METHOD 513.2, Indicating Instrument Test (Electrical).

4. METHOD 510.1, Rheostat Range Test.

**NOTE**: METHOD 510.1 shall only be performed on power systems so equipped.

j. If the total operating time between the start of the no load stabilization run (step g) and the completion of the tests listed in step i above does not equal 8 hours, then continue to run the power system at no load, rated voltage and rated frequency until the accumulated operating time is equal to 8 hours.

701.2.4 Results. Results shall be as specified in the Methods listed in 701.2.3.2i. Compare the manner in which the power system functioned, as denoted by the instrument and temperature readings, with the procurement document requirements.

701.2.5 Procurement document requirements. The following details must be specified in the individual procurement document:

a. Temperature at which Method is to be performed, if other than as specified herein.

b. Type of fuel, lubricating oil, and coolant to be used.

c. Additional tests to be performed not listed in 701.2.3.2i.

d. Voltage connection and frequency at which this Method is to be performed.

e. Allowable starting time if different than specified in 701.2.3.2d.

f. Duration of cranking cycle (see 701.2.3.2c).

g. Requirements of auxiliary fuel supply system.

h. Requirements necessary to evaluate METHOD 608.1.

i. Requirements necessary to evaluate METHOD 511.1.

j. Requirements necessary to evaluate METHOD 513.2.

k. Requirements necessary to evaluate METHOD 510.1, if applicable.

l. Minimum allowable engine temperatures after 1 hour of operation at rated load.

m. Requirements for checking devices in 701.2.3.2a.

| | | |
|---|---|---|
| **DESCRIPTION:** 15 KW, 60HZ<br>120V, SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SF-15.0-MD<br>**SERIAL NO.** 10629<br>**REF.** MIL-STD-705/701.2 | **PHILADELPHIA REGION<br>DEFENSE CONTRACT ADMINISTRATION<br>SERVICE**<br><br>STARTING AND OPERATING TEST<br>(BASIC COLD BATTERY START, -25°F) | **TEST NO.** 71<br><br>**SHEET:** 1 OF 2<br><br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |

| **INST.→** | | 489 | 51172 | | 476 | | 211 | 2062 | | | 1167 | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | | | ENGINE COOLANT | | LUBE OIL | | GENERATOR AIR | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | IN | OUT | SUMP | GALLERY | IN | OUT | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | °F | °F | °F | °F | °F | °F | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0750 | -- | -- | -- | -- | -- | -- | -- | | | -26 | -25 | -27 | -28 | -26 | -26 | -25 |
| | 0755 | FIRST CRANKING CYCLE – IGNITION OFF – 30 SEC | | | | | | | | | | | | | | | |
| | | SECOND CRANKING CYCLE – IGNITION OFF – 30 SEC | | | | | | | | | | | | | | | |
| | 0758 | THIRD CRANKING CYCLE – IGNITION OFF – 10 SEC ENGINE STARTED | | | | | | | | | | | | | | | -25 |
| | 0800 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | -24 | -10 | -20 | -5 | -26 | -20 | -26 |
| | 0810 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.2 | | | -5 | +20 | +2 | +30 | -25 | -18 | -25 |
| | 0813 | APPLIED RATED LOAD FOR 30 SECONDS | | | | | | | | | | | | | | | |
| | 0814 | APPLIED RATED LOAD FOR 30 SECONDS | | | | | | | | | | | | | | | |
| | 0815 | APPLIED RATED LOAD FOR 30 SECONDS | | | | | | | | | | | | | | | |
| | 0816 | APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0820 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | | | +50 | +90 | +40 | 115 | -26 | -5 | -27 |
| | 0821 | DROPPED LOAD – BEGIN NO LOAD STABILIZATION | | | | | | | | | | | | | | | |
| | 0830 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | +80 | 130 | 70 | 160 | -25 | -8 | -27 |
| | 0835 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | +90 | 140 | 90 | 140 | -26 | -8 | -25 |
| | 0840 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | 93 | 145 | 95 | 142 | -25 | -9 | -26 |
| | 0845 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | 94 | 146 | 96 | 142 | -25 | -10 | -26 |
| | 0850 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | 94 | 146 | 96 | 142 | -26 | -10 | -26 |
| | 0855 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.0 | | | 96 | 148 | 97 | 143 | -26 | -7 | -26 |
| | 0900 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | | | 98 | 150 | 99 | 148 | -26 | -2 | -27 |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING A C.T. NO 1378 | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | RECORDING VOLTAGE & FREQUENCY METER NO 1707 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 701.2-1 Portion of a typical test record for starting and operating (basic cold battery start, -25°F) test.

METHOD 701.3d

STARTING AND OPERATING TEST
(COLD AND SEVERE COLD, MANUAL CRANK)

701.3.1 General. The power system must satisfactorily start and operate under cold and severe cold environments.

701.3.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

– Rise time for the frequency shall be 250 ms.

– Rise time for the voltage shall be 60 ms.

– Input shall be up to 500 volts RMS.

– Output shall be ±5 volts DC maximum.

– The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the specified low temperature with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.2.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

701.3.3 Procedure.

701.3.3.1 Preparation for test.

a. Install appropriate thermocouples to measure all of the following temperatures.

> **NOTE**: All below temperatures are required unless inapplicable or waived by the procurement document. For example, no spark plug temperature is to be monitored if there are no spark plugs.

**NOTE**: This list contains items normally instrumented; however, some power systems may require additional thermal instrumentation. The thermal instrumentation shall be installed in accordance with the instructions in METHOD 202.1.

1. Ambient air temperature.
2. Engine coolant (engine outlet and inlet).
3. Spark plug(s).
4. Lubricating oil (sump and gallery).
5. Engine combustion air in (located at the inlet of the intake manifold).
6. Heater coolant (air or liquid-into and out of the heater).
7. Heater exhaust gas.
8. Engine exhaust gas.
9. Generator stator frame (top and bottom, outside).
10. Generator cooling air (inlet and outlet).
11. Control panel cubicle (ambient air, inside).
12. Air entering power system.
13. Fuel in on-board fuel tank.

b. Start and operate the power system until the lubricating oil is warm enough to drain.

c. Drain the coolant from the engine block, the radiator, coolant pump, heater, and all coolant lines. Ensure the power system is completely drained. Fill the coolant system with the proper solution of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

d. Drain the fuel from all fuel tanks, lines, strainers, pumps and filters. Flush tanks with low temperature fuel using 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets on strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuel of the proper grade (low temperature fuel specified in the procurement document).

Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

e. Drain the lubricating oil from the engine, filters, strainers and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of the oil used.

f. Operate the winterization system as applicable. Ensure all controls work properly. If necessary, disconnect some controls if ambient temperature is too high.

**CAUTION: Do not operate the winterization system for longer than necessary to perform the checkout as the heater may damage the power system.**

g. Operate any fuel priming pumps on the power system with the discharge lines open to clear lines of normal ambient fuel.

h. Check technical manual or operating and servicing instructions to see that all necessary power system maintenance has been performed.

i. Start and operate the power system for approximately 15 minutes at no load to allow the arctic fuel and lubricants to thoroughly circulate. During this period open oil lines at gages and safety controls to drain normal temperature oil. Shutdown the power system and drain all power system fuel tanks as well as the oil from the air cleaners. Fill power system fuel tanks. Fill and label a small container with sample (approximately 8 ounces) of fuel used.

j. Place sample containers of fuel, lubricant, and coolant in the cold room.

k. Place the power system in the cold room. If the power system is equipped for an auxiliary fuel supply, connect the fuel supply to the power system using the auxiliary fuel hoses supplied with the power system. Use an auxiliary fuel supply having sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. Place the auxiliary fuel supply in the cold room.

l. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

m. Where temperature measurements are made by means of thermocouples, bring the thermocouple leads out of the cold room to permit the temperature to be read by instruments located in normal ambient temperatures. Locate all electrical instruments outside the cold room, except those provided as part of the power system.

701.3.3.2 Test.

a. Expose the complete power system (including all fuels, lubricants, coolants and hydraulic oils to be used during this Method) to the specified low temperature until such time as all thermocouples are at the specified low temperature or until 24 hours have elapsed whichever comes later. During all steps of this test, all ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the procurement documents. Prepare the power system by following the operating instructions on the power system. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet per METHOD 203.1 (see FIGURE 701.3-1).

b. Follow the operating instructions on the power system and turn the winterization system on, if applicable. Record the time the winterization system turned on.

c. Record the readings of temperature devices continuously during this test. See FIGURE 701.3-1. Operate the winterization system until the power system is sufficiently warm to start but no longer than the time allowed in the procurement document. Then turn the power system off and record the time.

**CAUTION: Care must be taken in cranking the engine. Excessive cranking can damage the starter. See the instructions on the power system or the technical manual for the maximum cranking time.**

d. Start the power system in accordance with the operating instructions on the power system or the technical manual. Record the number of cranks required. The power system must be operating at rated voltage and rated frequency without further use of any type of starting aids or winterization system within the specified period from the time the winterization system was first applied to the power system. If the power system does not start within the time allowed in the procurement document, stop test and report failure on data sheet.

e. After the power system starts, allow it to warm up at no load, rated voltage and rated frequency for a period of 15 minutes.

f. If necessary, reset the frequency to the rated value and record the amount the frequency had drifted from the time of power system start.

g. Within 16 minutes after the power system starts, apply rated load in one step with the circuit interrupter, starting with the interrupter in the off position. Leave rated load on the power system for 30 seconds, then drop the load to no load in one step using the circuit interrupter. Operate at no load for 30 seconds. Again, using the circuit interrupter, apply and drop rated load two more times with 30 seconds of operation at these load conditions.

h. Apply rated load and operate power system for 5 minutes. After 5 minutes of rated load operation, drop the load to no load in one step and allow the power system to stabilize at no load. Stabilization shall be in accordance with METHOD 608.1 with all instrumentation required by METHOD 701.3 recorded during stabilization.

i. Apply rated load in one step and allow the power system to stabilize at rated load, rated voltage, and rated frequency. Stabilization shall be in accordance with METHOD 608.1 with all instrumentation required by METHOD 701.3 recorded during stabilization.

j. After stabilization has occurred, unless otherwise specified in the procurement document, operate the power system in accordance with the instructions on the power system or in the technical manual and perform the following Methods in the order shown at the specified low temperature, voltage connection and frequency:

   1. METHOD 608.1, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term). In addition to the required data, record all thermal instrumentation as specified in 701.3.3.1 at the same time for the stabilization portion of this test.

   2. METHOD 511.1, Regulator Range Test. In addition to the required data, record all thermal instrumentation as specified in 701.3.3.1 at the same time for the stabilization portion of this test.

   3. METHOD 513.2, Indicating Instrument Test (Electrical).

   4. METHOD 510.1, Rheostat Range Test.

**NOTE**: METHOD 510.1 shall only be performed on power systems so equipped.

k. If the total operating time between the start of the no load stabilization run and the completion of the tests listed in j above is less than 8 hours, then continue to run the power system at no load, rated voltage and rated frequency until the accumulated operating time is at least 8 hours.

701.3.4 Results. Results shall be as specified in the Methods listed in 701.3.3.2j. Compare the manner in which the power system functioned, as denoted by the instrument and temperature readings, with the procurement document requirements.

701.3.5 Procurement document requirements. The following details must be specified in the individual procurement document:

a. Temperature at which Method is to be performed.

b. Type of fuel, lubricating oil, and coolant to be used.

c. Additional tests to be performed not listed in 701.3.3.2j.

d. Voltage connection and frequency at which this Method is to be performed.

e. Allowable heating and starting time.

f. Requirements for auxiliary fuel supply system.

g. Requirements necessary to evaluate METHOD 608.1.

h. Requirements necessary to evaluate METHOD 511.1.

i. Requirements necessary to evaluate METHOD 513.2.

j. Requirements necessary to evaluate METHOD 510.1, if applicable.

k. Engine temperature requirements.

l. Requirements for checking devices in 701.3.3.2a.

**DESCRIPTION:** 3 KW, 60HZ
120 V, SINGLE PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-3.0-MD
**SERIAL NO.** 01364
**REF.** MIL-STD-705/701.3

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

STARTING AND OPERATING TEST
(COLD AND SEVERE COLD, MANUAL CRANK)

**TEST NO.** 37

**SHEET:** 1 OF 2

**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 489 | 51172 | | 476 | | 211 | 2062 | | | 1167 | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | | | LUBE OIL | | SPARK PLUGS | | | | AVG AMB TEMP |
| | | | | | | | | | | | SUMP | GALLERY | CYC 1 | CYC 2 | CYC 3 | CYC 4 | |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | °F | °F | °F | °F | °F | °F | °F |
| **SYM** | | | X10 | X1 | X10 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0750 | 24 HOUR SOAK AT -65°F COMPLETE | | | | | | | | | | | | | | | |
| | 0755 | CHECKED ALL SWITCHES FOR FREEDOM OF MOVEMENT – ALL OK | | | | | | | | | | | | | | | |
| | 0800 | -- | -- | -- | -- | -- | -- | -- | | | -65 | -65 | -65 | -65 | -65 | -65 | -65 |
| | 0800 | FIRST APPLIED HEAT TO POWER SYSTEM | | | | | | | | | | | | | | | |
| | 0810 | -- | -- | -- | -- | -- | -- | -- | | | +10 | +15 | -30 | -12 | -32 | -8 | -65 |
| | 0812 | STARTED MANUAL CRANKS | | | | | | | | | | | | | | | |
| | 0814 | ENGINE STARTED AFTER 13 CRANKS WITH STARTER ROPE | | | | | | | | | | | | | | | |
| | 0824 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.8 | | | 30 | 50 | +255 | 271 | 260 | 266 | -65 |
| | 0830 | APPLIED RATED LOAD FOR 30 SEC | | | | | | | | | | | | | | | |
| | 0831 | APPLIED RATED LOAD FOR 30 SEC | | | | | | | | | | | | | | | |
| | 0832 | APPLIED RATED LOAD FOR 30 SEC | | | | | | | | | | | | | | | |
| | 0833 | APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0835 | 120.0 | 3.1 | 31.0 | 0.30 | 3.0 | .80 | 60.0 | | | 50 | 73 | 310 | 306 | 322 | 318 | -65 |
| | 0838 | DROPPED LOAD – BEGIN NO LOAD STABILIZATION | | | | | | | | | | | | | | | |
| | 0840 | 121.3 | 0 | 0 | 0 | 0 | -- | 61.6 | | | 55 | 76 | 272 | 271 | 283 | 279 | -65 |
| | 0845 | 121.3 | 0 | 0 | 0 | 0 | -- | 61.6 | | | 58 | 78 | 275 | 270 | 281 | 277 | -65 |
| | 0850 | 121.3 | 0 | 0 | 0 | 0 | -- | 61.6 | | | 59 | 79 | 272 | 270 | 282 | 278 | -65 |
| | 0855 | 121.3 | 0 | 0 | 0 | 0 | -- | 61.6 | | | 59 | 79 | 270 | 271 | 281 | 281 | -66 |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. NO 1308 | | | | | | | | | | | | | | | | |
| | RECORDING VOLTAGE & FREQUENCY METER NO 1877 | | | | | | | | | | | | | | | | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

FIGURE 701.3-1 Portion of a typical test record for starting and operating test (cold and severe cold, manual crank).

METHOD 701.4d

STARTING AND OPERATING TEST
(BASIC COLD MANUAL CRANK, -25ºF)

701.4.1 General. The power system must satisfactorily start and operate in basic cold environments without the use of any winterization equipment.

701.4.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

– Rise time for the frequency shall be 250 ms.

– Rise time for the voltage shall be 60 ms.

– Input shall be up to 500 volts RMS.

– Output shall be ±5 volts DC maximum.

– The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the specified low temperature with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.2.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

701.4.3 Procedure. If this test is performed immediately following METHOD 701.3, omit steps in 701.4.3.1 and steps a and b of 701.4.3.2.

701.4.3.1 Preparation for test.

a. Install appropriate thermocouples to measure all of the following temperatures.

| |
|---|
| **NOTE**: All below temperatures are required unless inapplicable or waived by the procurement document. For example, no spark plug temperature is to be monitored if there are no spark plugs. |

**NOTE**: This list contains items normally instrumented; however, some power systems may require additional thermal instrumentation. The thermal instrumentation shall be installed in accordance with the instructions in METHOD 202.1.

1. Ambient air temperature.
2. Engine coolant (engine outlet and inlet).
3. Spark plug(s).
4. Lubricating oil (sump and gallery).
5. Engine combustion air in (located at the inlet of the intake manifold).
6. Engine exhaust gas.
7. Generator stator frame (top and bottom, outside).
8. Generator cooling air (inlet and outlet).
9. Control panel cubicle (ambient air, inside).
10. Air entering power system.
11. Fuel in on-board fuel tank.

b. Start and operate the power system until the lubricating oil is warm enough to drain.

c. Drain the coolant from the engine block, the radiator, coolant pump, heater, and all coolant lines. Ensure the power system is completely drained. Fill the coolant system with the proper solution of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

d. Drain the fuel from all fuel tanks, lines, strainers, pumps and filters. Flush tanks with approximately 10 percent of rated tank capacity low temperature fuel. Clean all fuel strainers and replace filter elements. Install new gaskets on strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuel of the proper grade (low temperature fuel specified in the procurement document). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

e. Drain the lubricating oil from the engine, filters, strainers and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubricating oil. Fill a small container with a sample (approximately 8 ounces) of the oil used.

f. Operate any fuel priming pumps on the power system with the discharge lines open to clear lines of normal ambient fuel.

g. Check technical manual or operating and servicing instructions to see that all power system maintenance has been performed.

h. Start and operate the power system for approximately 15 minutes at no load to allow the fuel and lubricants to thoroughly circulate. During this period open oil lines at gages and safety controls to drain normal temperature oil. Shutdown the power system and drain all power system fuel tanks as well as the oil from the air cleaners. Fill power system fuel tanks, except for power systems with gasoline engines. Fill and label a small container with a sample (approximately 8 ounces) of fuel used.

i. Place sample containers of fuel, lubricant, and coolant in the cold room.

j. Place the power system in the cold room. If the power system is equipped for an auxiliary fuel supply, connect the fuel supply to the power system using the auxiliary fuel hoses supplied with the power system. Use an auxiliary fuel supply having sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. Place this auxiliary fuel supply in the cold room. Set the fuel supply valve in the auxiliary fuel position.

k. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

l. Where temperature measurements are made by means of thermocouples, bring the thermocouple leads out of the cold room to permit the temperature to be read by instruments located in normal ambient temperatures. Locate all electrical instruments outside the cold room, except those provided as part of the power system.

701.4.3.2 Test.

a. Expose the complete power system (including all fuels, lubricants, coolants and hydraulic oils to be used during this Method) to the specified low temperature until such time as all components are at the specified low temperature. During all steps of this test, all ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature or until 24 hours have elapsed, whichever comes later. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the procurement documents. Prepare the power system by following the operating instructions on the power system. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet per METHOD 203.1 (see FIGURE 701.4-1).

b. Record all temperature readings continuously during this test. See FIGURE 701.4-1.

**CAUTION: Care must be taken in cranking the engine. Excessive cranking can damage the starter. See the instructions on the power system or the technical manual for the maximum cranking time.**

c. Follow the operating instructions on the power system or in the technical manual, start the power system within 5 minutes. Record the time when cranking is started. Record the number of cranks. Record the time when the power system starts. See FIGURE 701.4-1.

d. Allow the engine to warm up at no load, rated voltage and rated frequency for a period of 15 minutes.

e. If necessary, reset the frequency to the rated value and record the amount the frequency had drifted from the time of power system start.

f. Within 16 minutes after the power system starts, apply rated load in one step with the circuit interrupter. Leave rated load on the power system for 30 seconds, then drop the load to no load in one step using the circuit interrupter. Operate at no load for 30 seconds. Again, using the circuit interrupter, apply and drop rated load two more times with 30 seconds of operation at these load conditions.

g. Apply rated load and operate power system for 5 minutes. After 5 minutes of rated load operation, drop the load to no load in one step and allow the power system to stabilize at no load. Stabilization shall be in accordance with METHOD 608.1 with all instrumentation required by METHOD 701.4 recorded during stabilization.

h. Apply rated load in one step and allow the power system to stabilize at rated load, rated voltage, and rated frequency. Stabilization shall be in accordance with METHOD 608.1 with all instrumentation required by METHOD 701.4 recorded during stabilization.

i. After stabilization has occurred, unless otherwise specified in the procurement document, operate the power system in accordance with the instructions on the power system or in the technical manual and perform the following Methods in the order shown at the specified low temperature, voltage connection and frequency:

1. METHOD 608.1, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term). In addition to the required data, record all thermal instrumentation as specified in 701.4.3.1 at the same time for the stabilization portion of this test.

2. METHOD 511.1, Regulator Range Test.

3. METHOD 513.2, Indicating Instrument Test (Electrical).

4. METHOD 510.1, Rheostat Range Test.

**NOTE**: METHOD 510.1 shall only be performed on power systems so equipped.

j. If the total operating time between the start of the no load stabilization run and the completion of the tests listed in step i above is less than 8 hours, then continue to run the power system at no load, rated voltage and rated frequency until the accumulated operating time is at least 8 hours.

701.4.4 Results. Results shall be as specified in the methods listed in 701.4.3.2i. Compare the manner in which the power system functioned, as denoted by the instrument and temperature readings, with the procurement document requirements.

701.4.5 Procurement document requirements. The following details must be specified in the individual procurement document:

a. Temperature at which Method is to be performed.

b. Type of fuel, lubricating oil, and coolant to be used.

c. Additional tests to be performed not listed in 701.4.3.2i.

d. Voltage connection and frequency at which this Method is to be performed.

e. Allowable starting time if different than specified in 701.4.3.2c.

f. Requirements for auxiliary fuel supply systems.

g. Requirements necessary to evaluate METHOD 608.1.

h. Requirements necessary to evaluate METHOD 511.1.

i. Requirements necessary to evaluate METHOD 513.2.

j. Requirements necessary to evaluate METHOD 510.1, if applicable.

k. Engine temperature requirements.

l. Requirements for checking devices in 701.4.3.2a.

**DESCRIPTION:** 3 KW, 60 HZ
120 V, SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-3.0-MD
**SERIAL NO.** 07130
**REF.** MIL-STD-705/701.4

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

STARTING AND OPERATING TEST
(BASIC COLD MANUAL CRANK, -25°F)

**TEST NO.** 78

**SHEET:** 1 OF 2

**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 489 | 51172 | | 476 | | 211 | 2063 | | | 1167 | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ. | | | LUBE OIL | | SPARK PLUGS | | | | AVG AMB TEMP |
| | | | | | | | | | | | SUMP | GALLERY | CYL 1 | CYL 2 | CYL 3 | CYL 4 | |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | °F | °F | °F | °F | °F | °F | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | -- | -- | -- | -- | -- | -- | -- | | | -25 | -26 | -25 | -25 | -25 | -25 | -26 |
| | 0803 | STARTED CRANKING | | | | | | | | | | | | | | | -26 |
| | 0807 | ENGINE STARTED | | | | | | | | | | | | | | | -26 |
| | 0817 | 120.0 | 0 | 0 | 0 | 0 | -- | 60.9 | | | +15 | +40 | +255 | +246 | +248 | +244 | -25 |
| | 0823 | APPLIED RATED LOAD FOR 30 SEC | | | | | | FREQUENCY DRIFT WAS 0.4 HZ | | | | | | | | | |
| | 0824 | APPLIED RATED LOAD FOR 30 SEC | | | | | | | | | | | | | | | |
| | 0825 | APPLIED RATED LOAD FOR 30 SEC | | | | | | | | | | | | | | | |
| | 0826 | APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0830 | 120.0 | 3.1 | .31 | .30 | 3.0 | .80 | 60.1 | | | 75 | 115 | 325 | 317 | 322 | 314 | -26 |
| | 0831 | DROPPED LOAD – BEGIN NO LOAD STABILIZATION | | | | | | | | | | | | | | | |
| | 0840 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 80 | 117 | 260 | 256 | 259 | 252 | -27 |
| | 0845 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 81 | 118 | 258 | 256 | 257 | 250 | -26 |
| | 0850 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 82 | 119 | 258 | 254 | 257 | 250 | -26 |
| | 0855 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 82 | 119 | 258 | 254 | 257 | 250 | -26 |
| | 0900 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 82 | 119 | 258 | 254 | 257 | 250 | -26 |
| | 0905 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 82 | 119 | 258 | 254 | 257 | 250 | -26 |
| | 0910 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 82 | 119 | 258 | 254 | 257 | 250 | -26 |
| | 0915 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 82 | 119 | 258 | 254 | 257 | 250 | -26 |
| | 0920 | 121.2 | 0 | 0 | 0 | 0 | -- | 61.0 | | | 82 | 119 | 258 | 254 | 257 | 250 | -26 |
| | | | | | | | | | | | | | | | | | |

| | | |
|---|---|---|
| **NOTES** | LINE CURRENT MEASURED USING C.T. NO 1308 | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY |
| | RECORDING VOLTAGE & FREQUENCY METER NO 1877 | |
| | | |

FIGURE 701.4-1 Portion of a typical test record for starting and operating test (basic cold manual crank, -25°F).

# METHOD 702.1c

## STANDBY OPERATION TEST
## (EXTREME COLD)

**NOTE**: Method 702.1c was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

702.1.1 General. The ability of the winterization equipment to maintain engine temperatures at such values as to permit rapid starting of the generator set in arctic conditions is necessary.

702.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient and set temperatures shall be as described and illustrated in MIL-HDBK-705. In addition, a controlled temperature room as described and illustrated in MIL-HDBK-705, method 114.2 having sufficient capacity to maintain the specified low temperature throughout this method shall be required.

702.1.3 Procedure. This method is normally performed in conjunction with method 701.1. If this is so, omit 701.1.3.1 entirely, and steps a and b of 702.1.3.2 except the tester is allowed to change batteries.

702.1.3.1 Preparation for test.

a. Install appropriate thermocouples to measure the following temperatures. (Note: Not all sets will require instrumentation of all of the listed items. This list contains items normally instrumented; however, some sets may require additional thermal instrumentation.) The thermal instrumentation shall be installed in accordance with the instructions in MIL-HDBK-705, method 202.1.

   1. Ambient air temperature.

   2. Engine coolant (engine outlet and inlet).

   3. Spark plug(s).

   4. Lubricating oil (sump and gallery).

   5. Engine combustion air in (located at the inlet of the intake manifold).

   6. Storage battery electrolyte (thermocouple(s) shall be so located that the electrolyte temperature at the center of the electrolyte is measured).

   7. Heater transfer medium (air or liquid - into and out of the heater).

8. Heater exhaust.

9. Battery box air (at each end of battery box).

10. Engine exhaust.

11. Generator stator frame (top and bottom, outside).

12. Generator cooling air (inlet and outlet).

13. Control panel cubicle (ambient air, inside).

14. Air entering generator set.

b. Start and operate the generator set until the lubricating oil is warm enough to drain. Drain the coolant from the engine block, radiator, coolant pump, heater, and all coolant lines. Be sure that the set is completely drained. Fill and label the coolant system with the proper solution of antifreeze. Fill a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

c. Drain the fuel from all fuel tanks, lines, strainers, pumps and filters. Flush tanks low-temperature fuel with using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets on strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuels of the proper grade (low temperature fuel specified in the procurement document). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

d. Drain the lubricating oil from the engine, filters, strainers and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of the oil used.

e. Start and operate the winterization system. See that all controls work properly. It may be necessary to temporarily bypass controls if the ambient temperature is too high. Do not operate the heater for longer than necessary to perform the check-out.

f. Operate any fuel priming pumps on the set with the discharge lines open to clear lines of normal ambient fuel.

g. On all units, as applicable, check the spark plugs, magneto, distributor, valve clearances, injector timing, etc. Check instruction manual or operating and servicing instructions to see that all set requirements or recommendations have been performed.

h. Start and operate the generator set for approximately 15 minutes at no load to allow the arctic fuels and lubricants to thoroughly circulate. During this period open oil lines at gages and safety controls to drain normal temperature oil. Shutdown the set and drain all set fuel tanks as well as the oil from the air cleaners. Fill set fuel tanks, except for sets with gasoline engines. Fill and label a small container with a sample (approximately 8 ounces) of fuel used.

i. If a storage battery is part of the set, fill it with electrolyte having the specified gravity recommended for arctic operation. The batteries shall by cycled and completely charged (see MIL-HDBK-705, method 222.1) before placing them in the cold room.

j. Place containers of fuel, lubricant(s), and coolant in the cold room.

k. Place the generator set in the cold room. If the set is equipped with a three-way valve for an auxiliary fuel supply, connect the fuel supply to the engine through the three-way valve using the auxiliary fuel hoses (length and size of hoses are specified in the procurement document)supplied with the generator set. The auxiliary fuel supply must have sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. This auxiliary fuel supply shall be in the cold room. Set the fuel supply valve in the auxiliary fuel position.

l. Connect the load and field instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for the voltage connection and frequency specified in the procurement document. Unless otherwise specified, connect the signal input of the recording meter(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage sensing input to the voltage regulator. (Power the recording meter(s) from the commercial utility.)

m. Where temperature measurements are made by means of thermocouples, the thermocouple leads shall be brought out of the cold room to permit the temperature to be read by instruments located in normal ambient temperatures. All electrical instruments, except those provided as part of the generator set, shall be located outside the cold room with the exception of shunts used in determining field currents. In addition to the circuitry shown in the applicable figure of MIL-HDBK-705 (see step l above), provisions shall be made for measuring the voltage on the generator side of the circuit breaker with instruments located outside the cold room.

702.1.3.2 Test.

a. For sets with gasoline engines, decrease the temperature in the cold room and when the ambient temperature has reached approximately 0 °F (-17.7 °C) open the auxiliary fuel container and fill the set tank. (Note: The volatility of arctic fuel at temperatures above 0 °F (-17.7 °C) necessitates storing the fuel in sealed containers.) Fill and label a small container with a sample of the fuel used. Place this sample alongside samples of fuel, lubricating oil, and coolant taken previously in preparation for test, in a location in the cold chamber where they may be observed.

b. Start and operate the set for approximately 15 minutes at no load to allow the arctic fuel to thoroughly circulate. Then shut down the set.

c. As soon as the low temperature chamber reaches the specified low temperature or immediately following the shutdown of the generator set concluding method 701.1, place the winterization equipment into standby operation in accordance with the instructions on the set or in the technical manual. If the winterization heater has separate fuel tank, fill the tank before starting the heater. During all steps of this Method all of the eight ambient thermocouples shall indicate temperatures equal to or colder than the specified cold temperature. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet.

d. Maintain the winterization equipment in standby operation for 24 hours unless otherwise specified in the procurement document.

e. Read and record all thermal instrumentation in maximum intervals of one hour.

f. During the specified operation period, keep a record of the amount of fuel added to the fuel tank if the winterization heater uses a separate fuel tank.

g. At each hourly reading inspect the battery temperature readings to determine if the batteries are overheating.

h. One hour before the end of the specified period, open the generator set at the side panels to determine if there are any fuel or coolant leads. In addition, determine if there is any frost build-up inside the housing. Record findings on the data sheet.

i. At the end of the specified period, shut down the winterization equipment and start the generator set, following instructions on the set or in the technical manual. Unless otherwise specified in the procurement document, use the set batteries to start the set; but it will not be necessary to make trial cranking with ignition or fuel shut off before attempting to start the engine. Record the elapsed time from initial cranking until the generator set starts.

j. After the engine starts, operate the set at rated voltage and rated frequency (speed) at no load. Open the side panel and inspect the set for fuel, oil, and coolant leaks. Record findings on the data sheet.

k. Using the set circuit interrupter, apply and drop half rated load in one step several times (three should be sufficient). Record electrical instrumentation readings on the data sheet.

l. Perform additional tests or inspections are required by the procurement document.

702.1.4 Results. Compare the winterization equipment and generator set performance with the requirements of the procurement document.

702.1.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. Length of time this Method is to be performed if other than 24 hours.

b. Ambient temperature at which this Method is to be performed.

c. Number of hours that the winterization equipment must operate before refilling the fuel tank, if the winterization equipment has a separate fuel tank.

d. Maximum allowable temperature of battery electrolyte.

e. Cranking instructions for starting engine after standby operation tests.

f. Time limit in which the set must start after initial cranking attempt.

g. Voltage connection and frequency at which this Method is to be performed.

h. Type of fuel, lubricating oil, and coolant to be used.

**DESCRIPTION:** 15 KW, 60 HZ
120 V SINGLE-PHASE
GENERATOR SET

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-15.0-MD
**SERIAL NO.** 10638
**REF.** MIL-STD-705/702.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

STANDBY OPERATION TEST

**TEST NO.** 19

**SHEET:** 1 OF 2

**DATE:** 14 SEPT, 1971
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | 1075 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | ENG COOLANT | | LUBE OIL | | ENG AIR IN | BATTERY ELECTROLYTE | | | | HEATER COOLANT | | HEATER EXHAUST | BATT BOX AIR | | ENG EXHAUST | AVG AMB TEMP |
| | | IN | OUT | SUMP | GALLERY | | CELL 2 | CELL 5 | CELL 8 | CELL 11 | IN | OUT | | RIGHT | LEFT | | |
| **UNITS** | HRS | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1915 | SET SHUT DOWN – PLACED SET IN STANDBY OPERATION | | | | | | | | | | | | | | | -65 |
| | 1925 | 111 | 175 | 155 | 150 | 75 | 26 | 15 | 17 | 28 | 90 | 149 | 1390 | 110 | 100 | -- | -67 |
| | 2025 | 108 | 169 | 123 | 121 | 70 | 55 | 59 | 60 | 57 | 66 | 139 | 960 | 125 | 115 | -- | -66 |
| | 2125 | 88 | 167 | 103 | 101 | 62 | 66 | 66 | 67 | 64 | 47 | 142 | 940 | 127 | 118 | -- | -65 |
| | 2225 | 73 | 167 | 88 | 86 | 50 | 71 | 69 | 69 | 67 | 39 | 143 | 917 | 128 | 119 | -- | -66 |
| | 2325 | 62 | 164 | 75 | 74 | 40 | 76 | 72 | 73 | 70 | 31 | 143 | 880 | 123 | 113 | -- | -66 |
| 9/15/25 | 0025 | 52 | 159 | 64 | 63 | 30 | 79 | 73 | 74 | 71 | 25 | 140 | 860 | 120 | 109 | -- | -66 |
| | 0125 | 44 | 154 | 57 | 55 | 21 | 82 | 74 | 75 | 74 | 21 | 135 | 870 | 122 | 110 | -- | -65 |
| | 0225 | 39 | 148 | 51 | 49 | 12 | 83 | 75 | 76 | 75 | 18 | 130 | 840 | 124 | 112 | -- | -65 |
| | 0325 | 36 | 146 | 47 | 46 | 5 | 87 | 77 | 77 | 77 | 16 | 125 | 850 | 121 | 108 | -- | -66 |
| | 0425 | 32 | 142 | 44 | 42 | 3 | 88 | 78 | 78 | 78 | 14 | 122 | 840 | 120 | 106 | -- | -67 |
| | 0525 | 30 | 140 | 42 | 40 | -3 | 90 | 78 | 79 | 80 | 13 | 118 | 845 | 115 | 99 | -- | -66 |
| | 0625 | 27 | 138 | 40 | 39 | -7 | 92 | 80 | 80 | 83 | 12 | 115 | 845 | 120 | 104 | -- | -66 |
| | 0725 | 26 | 138 | 39 | 37 | -10 | 94 | 80 | 81 | 84 | 12 | 114 | 860 | 123 | 109 | -- | -66 |
| | 0825 | 25 | 137 | 38 | 36 | -15 | 95 | 81 | 81 | 85 | 12 | 113 | 860 | 126 | 111 | -- | -65 |
| | 0925 | 23 | 135 | 36 | 34 | -16 | 96 | 82 | 81 | 85 | 11 | 112 | 830 | 129 | 117 | -- | -66 |
| | 1025 | 22 | 134 | 35 | 33 | -19 | 97 | 81 | 81 | 87 | 11 | 112 | 862 | 127 | 113 | -- | -66 |
| | 1125 | 22 | 135 | 35 | 33 | -19 | 96 | 82 | 83 | 87 | 11 | 111 | 875 | 118 | 96 | -- | -66 |
| | 1225 | 21 | 134 | 39 | 31 | -18 | 96 | 81 | 82 | 87 | 10 | 110 | 830 | 112 | 94 | -- | -66 |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |

FIGURE 702.1-I Portion of a typical test record for standby operation test.

**DESCRIPTION:** 15 KW, 60 HZ
120 V, SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-15.0-MD

**SERIAL NO.** 10638

**REF.** MIL-STD-705/702.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

STANDBY OPERATION TEST

**TEST NO.** 19

**SHEET:** 1 OF 1

**DATE:** 15 SEP 1970

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST.→** | | 136 | | 287 | | 324 | | 516 | | 778 | | 143 | 222 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | EXCITER FIELD | | | | | |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | VOLTS | AMPS | | | | |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1925 | ENGINE STARTED IN 20 SEC | | | | | | | | | | | | | | | |
| | 1940 | OPERATED CIRCUIT INTERRUPTED 3 TIMES | | | | | | | | | | | | | | | |
| | 1940 | | 120.0 | 0 | 0 | 0 | 0 | | -- | | 60.0 | 18.4 | 1.32 | | | | |
| | 1942 | | 120.0 | 1.95 | 78.0 | .188 | 7.5 | | .80 | | 60.0 | 31.6 | 2.73 | | | | |
| | 1944 | | 120.0 | 0 | 0 | 0 | 0 | | -- | | 60.0 | 18.7 | 1.32 | | | | |
| | 1946 | | 120.0 | 1.95 | 78.0 | .188 | 7.5 | | .80 | | 60.0 | 32.1 | 2.73 | | | | |
| | 1948 | | 120.0 | 0 | 0 | 0 | 0 | | -- | | 60.0 | 19.1 | 1.32 | | | | |
| | 1950 | | 120.0 | 1.95 | 78.0 | .188 | 7.5 | | .80 | | 60.0 | 32.7 | 2.73 | | | | |
| | 1953 | SHUT SET DOWN – END OF TEST | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. NO 307 | | | | | | | | | | | | | | | | |
| | EXCITER FIELD CURRENT MEASURED USING 1 A, 50 mV SHUNT NO 188 | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

FIGURE 702.1-II Portion of a typical test record for standby operation test.

# METHOD 710.1e

# HIGH TEMPERATURE TEST

710.1.1 General. To ensure reliable electrical power generation a power system must be capable of operating over a wide range of environmental conditions including hot.

710.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the specified high temperature with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.1.

Use pressure instrumentation as described and illustrated in METHOD 112.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

710.1.3 Procedure.

710.1.3.1 Preparation for test.

a. Install appropriate thermocouples to measure all of the following temperatures:

> **NOTE**: All below temperatures are required unless inapplicable or waived by the procurement document. For example, no spark plug temperature is to be monitored if there are no spark plugs.

**NOTE**: This list contains items normally instrumented; however, some power systems may require additional thermal instrumentation. Install the thermal instrumentation in accordance with the instructions in METHOD 202.1.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s).
4. Exhaust gases (the exhaust manifold(s) of reciprocating engines shall be drilled and tapped as close as possible to the combustion chamber(s). For gas turbine engines, locate thermocouples in the tailpipe approximately one turbine wheel diameter downstream from the last turbine stage).
5. Lubricating oil sump and gallery for preproduction power systems and power systems and sump only for production power systems.
6. Oil cooler (inlet and outlet).
7. Hydraulic oil sump.
8. Engine combustion air in (located at the inlet of the intake manifold).
9. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
10. Generator cooling air (inlet and outlet).
11. Generator stator frame (top and bottom, outside).
12. Generator exciter (stator housing for rotation exciters, transformers for static exciters).
13. Generator voltage regulator (ambient air, inside).
14. Control panel cubicle (ambient air, inside).
15. Relay and control boxes (ambient air, inside).
16. Battery electrolyte or battery surface.

17. Average ambient air temperature (METHOD 202.1).

18. Air entering power system for housed power systems.

b. Install appropriate pressure instrumentation to measure barometric pressure and if applicable the following:

   1. Pressure in the vicinity of the combustion air intake (inside enclosed power systems).

   2. Exhaust gas pressure (combined exhaust gases in exhaust manifold or tailpipe).

   3. Intake air manifold pressure (between air filters and manifold).

c. Place the instrumented power system in the temperature chamber and obtain and maintain the ambient temperature within the chamber at the value specified in the procurement document. During all parts of this Method, the average of the ambient thermocouples (see METHOD 202.1) shall not be less than the specified temperature and of these thermocouples, none shall indicate more than 5°F (2.78°C) above or below the specified ambient.

d. Connect the load instrumentation in accordance with the applicable figure of 205.1.10, and as required for the Methods listed in 710.1.3.2f below for a voltage connection and frequency specified in the procurement document.

e. Connect switch(es) to the generator armature coil(s), for which the temperature rise is to be determined, such that the coil(s) may be isolated for resistance measurements (if rapid access is available to isolate the individual windings this step may be omitted).

710.1.3.2 Test.

a. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 710.1-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 710.1.5) after the last adjustment to load, voltage, and frequency has been made.

1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 710.1.3.2a. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

b. After stabilization has occurred, stop the power system so that temperatures of rotating components and windings may be taken. For application of the contact method to rotating parts, or the resistance method to the armature coils

(see METHOD 110.1 and METHOD 202.1); quickly shutdown the power system
.

**WARNING:**

**Do not connect bridges, meters, or temperature measuring equipment for measuring resistance or temperature to circuits which may still be energized, e.g., during the time that the power system is coming to a stop. Failure to do so may cause physical injury or death.**

c. Immediately after the shutdown, start to record the resistance bridge readings of the coils and the temperatures of the components where the contact method of measuring temperature rise is used.

Record the resistance measurements in accordance with instructions given in METHOD 110.1.

Record the first thermocouple reading within 30 seconds after shutdown and take additional readings at approximately 30 second intervals until one reading has been recorded after the temperature has begun to decrease, or three minutes has elapsed since power system shutdown, whichever is longer, being certain that the maximum temperature reached by each component has been recorded. Continuous or multipoint temperature recorder(s) may be used to record component temperatures as long as the above time requirements are met.

d. Repeat steps a through c above for each of the coils specified in the procurement document.

e. Repeat steps a through d above at each additional specified voltage connection and frequency and stabilization voltage.

f. Unless otherwise specified, operate the power system in accordance with the instructions on the power system or in the technical manual and perform the following Methods at the specified ambient temperature, voltage connection and frequency:

1. METHOD 512.1, Circuit Interrupter Test (Short Circuit).

2. METHOD 512.3, Circuit Interrupter Test (Overvoltage and Undervoltage).

3. METHOD 513.2, Indicating Instrument Test (Electrical).

4. METHOD 655.1, DC Control Test.

| |
|---|
| **NOTE**: The above methods are listed in numerical order; however, they need not be performed in this order. |

g. Repeat step a to re-establish stabilization values. Stabilization for the tests below will be considered valid once the power system has been operated a sufficient period of time to achieve the previously established voltage and current. Run the tests below sequentially with no shutdown between tests (if a shutdown occurs, for any reason, stabilization will have to be re-established):

1. METHOD 511.1, Regulator Range Test.

2. METHOD 511.2, Frequency Adjustment Range Test.

3. METHOD 512.2, Circuit Interrupter Test (Overload Current).

4. METHOD 608.1 Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term). (In addition to the required data, record all thermal and pressure instrumentation as specified in 710.1.3.1 at the same time for the stabilization portion of this test).

5. METHOD 608.2, Long Term Frequency and Voltage Stability Test. (In addition to the required data, record all thermal and pressure instrumentation as specified in 710.1.3.1 at the same time for all portions of this test).

6. METHOD 619.2, Voltage Dip and Rise for Rated Load Test.

| |
|---|
| **NOTE**: The above Methods are listed in numerical order; however, they need not be performed in this order. |

h. Repeat steps f and g above for each additional specified voltage connection and frequency.

i. Perform the following test for gasoline, diesel and gas turbine engine-driven power systems:

| |
|---|
| **NOTE:** For this test, the temperature of the fuel at the fuel source shall be stabilized at or above the temperature of the temperature chamber. |

1. Operate the power system at rated load until the fuel and lubricating oil temperatures are stabilized. Stabilization will be considered to have occurred when three consecutive fuel and lubrication oil temperature readings, taken at minimum intervals of 10 minutes, remain unchanged.

2. Immediately after the third stable temperature reading, shutdown the power system for five minutes.

3. Restart the engine and operate the power system at no load. During the restart, check for evidence of excessive heat transfer to the fuel system as evidenced by vapor lock, difficult starting, or uneven running. Operate the power system at no load for sufficient time to obtain steady operation. Record on the data sheet any difficulty in starting or uneven running.

710.1.4 Results. Results shall be as specified in Methods listed in 710.1.3.2f and 710.1.3.2g and in the individual methods specified in 710.1.3.2b. For the test performed in 710.1.3.2i, the data sheet shall show as a minimum, whether or not the power system started and operated normally and reasons for any difficult starting or uneven running. For the test performed in 710.1.3.2c the data sheet shall show the temperature rise of each winding as specified in METHOD 110.1. Compare these results with the procurement document requirements.

710.1.5 Procurement document requirements. The following details must be specified in the procurement document:

a. Ambient temperature at which this Method is to be performed.

b. Temperature rise allowed for each class of insulation, giving the Method of measurement.

c. Coils, components or assemblies for which the temperatures rise is to be determined.

d. Voltage connection(s) and frequency(ies) at which temperature rise is to be determined.

e. Methods to be performed in addition to or other than those listed in 710.1.3.2f and 710.1.3.2g.

f. Requirements necessary to evaluate the Methods listed in 710.1.3.2f and 710.1.3.2g.

g. Starting and operating requirements for the test performed in 710.1.3.2i.

**DESCRIPTION:** 10 KW, 60 HZ
120 V SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-10.0-MD
**SERIAL NO.** 27018
**REF.** MIL-STD-705/710.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

HIGH TEMPERATURE TEST

**TEST NO.** 39

**SHEET:** 1 OF 2

**DATE:** 15 JANUARY 2016
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 106 | 207 | | 308 | | 409 | 510 | | | 613 | | | | | | 614 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLT. | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | | | ENG AIR IN | ENG AIR OUT | | | | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | °F | °F | | | | | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0900 | STARTED POWER SYSTEM APPLIED RATED LOAD. | | | | | | | | | | | | | | | 125 |
| 1 | 0910 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 147 | | | | | 125 |
| 2 | 0920 | 120.2 | 2.61 | 104 | .254 | 10.2 | .81 | 60.3 | | | 126 | 146 | | | | | 125 |
| | 0930 | ADJUSTED LOAD, VOLTAGE, AND FREQUENCY TO RATED | | | | | | | | | | | | | | | |
| 3 | 0940 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 147 | | | | | 125 |
| 4 | 0950 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 148 | | | | | 125 |
| 5 | 1000 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 127 | 149 | | | | | 125 |
| 6 | 1010 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 127 | 149 | | | | | 125 |
| | 1012 | SHUTDOWN FOR RESISTANCE READING $T_1$-$T_4$ | | | | | | | | | | | | | | | |
| | 1017 | RESTARTED POWER SYSTEM APPLIED RATED LOAD-NO SIGNS OF ROUGH RUNNING NO DIFFICULTY IN | | | | | | | | | | | | | | | |
| | | RESTARTING POWER SYSTEM. | | | | | | | | | | | | | | | |
| 7 | 1030 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 148 | | | | | 125 |
| 8 | 1040 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 148 | | | | | 125 |
| 9 | 1050 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 148 | | | | | 125 |
| 10 | 1100 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 148 | | | | | 125 |
| | 1103 | SHUTDOWN FOR RESISTANCE READING $T_2$-$T_5$ | | | | | | | | | | | | | | | |
| | 1110 | RESTARTED POWER SYSTEM, APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| 11 | 1130 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 148 | | | | | 125 |
| 12 | 1140 | 120.0 | 2.60 | 104 | .250 | 10.0 | .80 | 60.0 | | | 126 | 148 | | | | | 125 |
| | | | | | | | | | | | | | | | | | |

| **NOTES** | |
|---|---|
| | C.T. # 1311 |
| | T.I. # 717 |
| | |

SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY

FIGURE 710.1-1 Portion of a typical test record for high temperature test.

# METHOD 711.1e

# HUMIDITY TEST

711.1.1 General. The power system must be capable of being exposed to the humid atmosphere of tropic or swamp areas with no damage or deterioration in performance.

711.1.2 Apparatus. Use the apparatus required by METHOD 608.1 and METHOD 301.1. In addition, use a test chamber capable of maintaining the required humidity and temperature per METHOD 114.1. Arrange the source(s) of heat and cooling for the chamber so radiant heat (or cooling) shall not fall upon the power system being tested. Direct injection of $CO_2$ (carbon dioxide) shall not be permitted due to the acid formed by contact of $CO_2$ with water. Do not allow the velocity of the air in the test area to exceed 150 feet per minute. The total external volume of the power system to be tested shall be not more than 50 percent of the total volume of the test chamber.

Use distilled or demineralized water having a pH value of between 6.5 and 7.5 at 25°C (77°F) to obtain the desired humidity.

Use instruments for measuring temperature and humidity.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

711.1.3 Procedure.

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term), within 4 hours before the start of the test.

b. After performing METHOD 608.1, but prior to the start of the humidity cycling, isolate the armature and field (exciter field only for brushless generators) and measure their insulation resistances in accordance with METHOD 301.1, except that the values need not be corrected for temperature. Record the resistance values and ambient temperature at which they were measured. For power systems other than rotating electrical machines, isolate and measure the insulation resistance of control and power circuits as appropriate.

c. Subject the power system to continuous cycling for a total of five of the 48-hour cycles described in FIGURE 711.1-1.

d. Remove the power system from the test chamber immediately upon completion of step c above. Within 1 hour after removal from the test chamber and without removal of moisture, measure the insulation resistance of all circuits initially measured under step b in accordance with METHOD 301.1, except that the power system shall not be operated prior to this test and measured values shall not be corrected for temperature.

e. Reconnect all circuits and perform METHOD 608.1 within 4 hours after removal from the test chamber.

f. Examine the power system for corrosion or other physical damage resulting from the test.

g. Record all actual test conditions and results.

711.1.4 Results. Compare the results with the requirements of the procurement document.

711.1.5 Procurement document requirements. The following items will be specified in the individual procurement document:

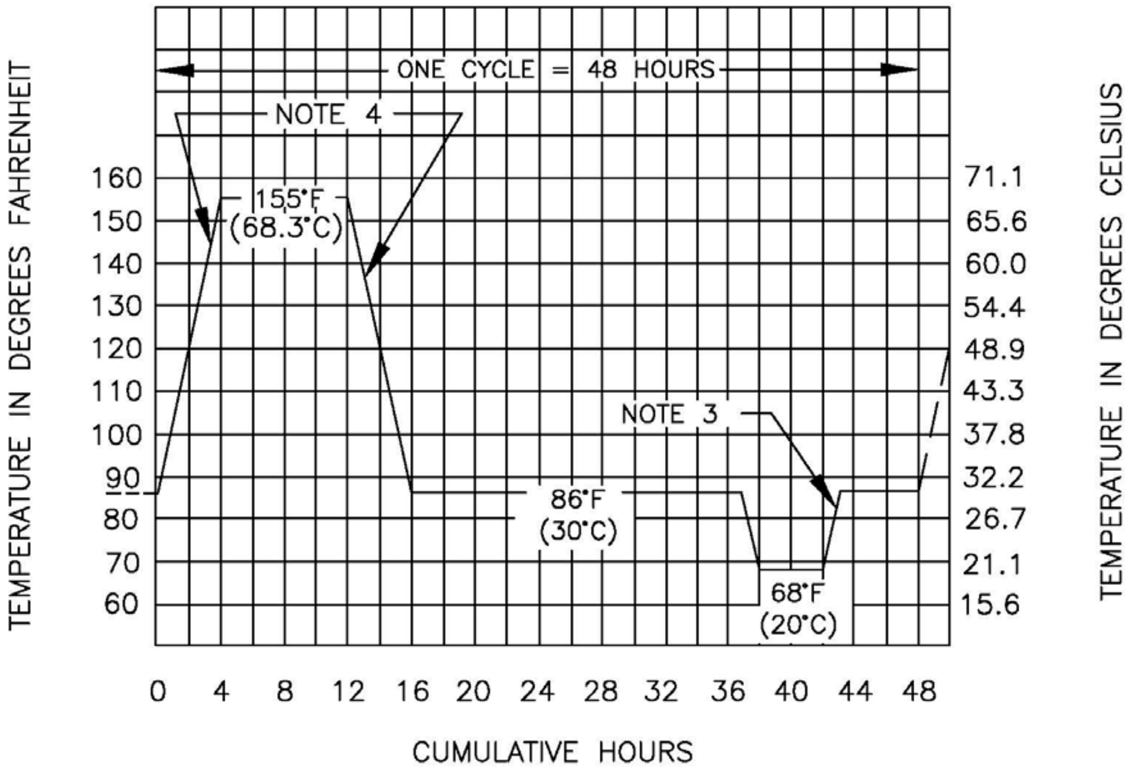
a. Minimum acceptable insulation resistance value.

b. Temperature, humidity, cycling and duration, if different than specified herein.

c. Definition of temperature and humidity damage.

d. Requirements necessary to evaluate METHOD 608.1.

e. Requirements necessary to evaluate METHOD 301.1.




NOTES:

1. THE ACTUAL TEMPERATURE DURING THE CYCLE SHALL BE WITHIN 5°F(2.7°C) OF THE TEMPERATURE SHOWN ON THE CHART.

2. RELATIVE HUMIDITY SHALL BE MAINTAINED BETWEEN 90 AND 98% AT ALL TIMES DURING THE CYCLE.

3. THE MEASURED INCREASE IN TEMPERATURE FROM 68 ± 5°F (20 ± 2.7°C) TO 86 ± 5°F (30 ± 2.7°C) SHALL NOT BE LESS THAN 18°F(10°C).

4. THE RATE OF TEMPERATURE CHANGE BETWEEN 86°F (30°C) AND 155°F (68.3°C) SHALL BE NOT LESS THAN 15°F(8.3°C) PER HOUR.

FIGURE 711.1-1 Humidity test cycle.

# METHOD 711.2c

## FUNGUS RESISTANCE TEST

711.2.1 General. The power system must not permit the growth of fungi.

711.2.2 Apparatus. Use apparatus in accordance with Method 508 of MIL-STD-810. Use apparatus required by METHOD 608.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

711.2.3 Procedure.

711.2.3.1 Preparation for test.

a. Connect instrumentation needed to perform METHOD 608.1, Frequency and Voltage Regulation Stability and Transient Response Test (Short Term), to the power system for the pre- and post- tests.

711.2.3.2 Test.

| |
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| **NOTE**: As stated in 2.1.2b of Method 508 of MIL-STD-810, "Because of the potentially unrepresentative combination of environmental effects, it is generally inappropriate to conduct this test on the same test sample previously subjected to salt fog, sand and dust, or humidity tests. However, if it is necessary, perform the fungus test before salt fog, or sand and dust tests. A heavy concentration of salt may affect the germinating fungus growth, and sand and dust can provide nutrients, thus leading to a false indication of the biosusceptibility of the test item. Be sure to decontaminate the test item prior to other testing (see Annex A)." |

a. Perform METHOD 608.1 on the power system within four hours before the start of test.

b. Visually inspect the power system. Take photographs where normal air flow does not exist and where fungal growth is expected.

c. Perform Method 508 of MIL-STD-810 on the power system under the following conditions:

    1. The test fungus used shall be aspergillus flavus (QM 380).

    2. Inoculate the power system in places where photographs were taken.

3. Incubate the power system at a constant temperature and humidity conditions of 30 ± 2ºC (86 ± 3.6ºF) at a relative humidity of at least 90 percent but less than 100 percent or as otherwise specified in the procurement document.

4. The duration of the test shall be 28 days unless otherwise specified in the procurement document.

d. Visually inspect the power system. Take photographs showing where fungal growth has appeared and at all locations where the photographs were originally taken.

e. Perform METHOD 608.1 on the power system within four hours after completion of the test.

711.2.4 Results. Compare any fungal growth with that allowed by the procurement document.

711.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The mold chamber cycle, if other than as specified herein.

b. The duration of this Method, if other than as specified herein.

c. Allowable fungal growth on the power system, if any.

d. Definition of power system damage, if applicable.

e. Number and type of components to be tested, if the complete power system is not tested.

f. The requirements necessary to evaluate METHOD 608.1.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V, SINGLE-PHASE<br>POWER SYSTEM | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE** | **TEST NO.** 79 |
| **MFGR:** ENGENSETS, INC | FUNGUS RESISTANCE TEST | **SHEET:** 1 OF 1 |
| **MODEL NO.** SF-10.0-MD | | **DATE:** SEE BELOW |
| **SERIAL NO.** 12711 | | **RECORDER:** L. WRIGHT |
| **REF.** MIL-STD-705/711.2 | | **PROJ. ENGR** J.J. JONES |
| | | **SHIFT LEADER:** H. SMITH |
| | | **OBSERVER:** L. SEE |

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| **INST.→** | | | | | | | | | | | | | | | | | |
| **READ NO↓** | DATE | | TIME | | | | | | | | | | | | | | |
| **UNITS** | | | HRS | | | | | | | | | | | | | | |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | | | | | | | | | | | | | | | | | |
| | JAN 15, 2016 | | 1100 | INTRODUCED FUNGI INTO MOLD CHAMBER | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | JAN 30, 2016 | | 1100 | PLACED POWER SYSTEM IN MOLD CHAMBER – SPRAYED POWER SYSTEM WITH SUSPENSIONS OF | | | | | | | | | | | | | |
| | | | | TEST ORGANISMS – PLACED CONTROL STRIPS NEXT TO POWER SYSTEM. | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | MAR 1, 2016 | | 1100 | REMOVED POWER SYSTEM FROM CHAMBER – EXAMINED FOR FUNGI GROWTH – NONE FOUND | | | | | | | | | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |
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FIGURE 711.2-1 Typical test record for fungus resistance test.

METHOD 711.3d

RAIN TEST

711.3.1 General. Since most power systems are expected to be operated outdoors, without shelter of any kind, this test is performed to assure proper operation during a heavy rain storm.

711.3.2 Apparatus. Use instrumentation for measuring load conditions shall be as described and illustrated in METHOD 205.1. Use instrumentation for measuring ambient temperature as described in METHOD 110.1. Use apparatus needed to perform Procedure I of Method 506 of MIL-STD-810. Use apparatus needed to perform METHOD 608.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

711.3.3 Procedure.

711.3.3.1 Preparation for test.

a. Place the power system in the rain environment location.

b. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

c. Turn on instrumentation used to perform METHOD 608.1.

d. Ensure the test area is at normal ambient temperature (68°F to 86°F or 20°C to 30°C) at the beginning of the test. No further regulation of temperature is required.

711.3.3.2 Test. Conduct the test in accordance with Method 506, Procedure I, of MIL-STD-810 with the following conditions:

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours before the start of the test. Record all data per METHOD 203.1 (see FIGURE 711.3-1).

b. Ensure all doors are in operating position and the control panel door(s) is in the open position.

c. A simulated rainfall of 5 inches of rain per hour shall impinge on the power system at angles from the vertical up to 45°, at a wind velocity of 40 mph (18 m/s). Subject the power system to the water spray for 3 consecutive hours. Expose each side of the power system to simulated blowing rain for 30 minutes, beginning with the control panel end of the power system. At the beginning of last hour of the test, and with the simulated blowing rain on the control panel end of the power system, turn on the power system and perform METHOD 608.1. Continue operating the power system during the simulated blowing rain until completion of METHOD 608.1 or completion of the third hour, whichever is longer.

d. Immediately after exposure to the rain, examine the power system for evidence of water penetration or damage. Record findings.

e. Without moving the power system, perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours after completion of the test.

711.3.4 Results. The data sheet shall indicate the length of test, quantity and incident angle of the water, any malfunction, water penetration that may cause component malfunction, and water damage. Determine the results of the METHOD 608.1 tests and compare them to procurement document requirements.

711.3.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The voltage connection and frequency at which this Method is to be performed.

b. Any operational checks to be performed at the beginning and conclusion of this test if other than as specified herein.

c. Rainfall in inches per hour, if other than as specified herein.

d. Angle of rain impingement, if other than as specified herein.

e. The requirements necessary to evaluate METHOD 608.1.

| DESCRIPTION / EQUIPMENT | | TEST DATA |
|---|---|---|
| **DESCRIPTION:** 15 KW, 60 HZ<br>120V, SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SF-15.0-MD<br>**SERIAL NO.** 16039<br>**REF.** MIL-STD-705/711.3 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>RAIN TEST | **TEST NO.** 16<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |

| **INST.→** | | 116 | 218 | | 301 | | 516 | 711 | 5077 | | | | | | | 037 | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | RAIN DEPTH | | | | | | | WATER TEMP | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | IN | | | | | | | °F | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | -- | -- | -- | -- | -- | -- | -- | 0 | START RAIN | | | | | | 64 | 67 |
| | 0900 | -- | -- | -- | -- | -- | -- | -- | 4.1 | PLACED POWER SYSTEM IN CHAMBER | | | | | | 64 | 71 |
| | 0930 | -- | -- | -- | -- | -- | -- | -- | 6.3 | | | | | | | 64 | 70 |
| | 1000 | -- | -- | -- | -- | -- | -- | -- | 8.2 | | | | | | | 65 | 70 |
| | 1030 | -- | -- | -- | -- | -- | -- | -- | 10.1 | | | | | | | 65 | 70 |
| | 1045 | STARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1100 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 12.2 | | | | | | | 65 | 72 |
| | 1130 | 120.0 | 3.90 | 156 | .375 | 15.0 | .80 | 60.0 | 14.3 | | | | | | | 65 | 74 |
| | 1145 | SHUTDOWN POWER SYSTEM | | | | | | | | | | | | | | | |
| | 1200 | -- | -- | -- | -- | -- | -- | -- | 16.2 | STOPPED RAIN – INSPECTED POWER SYSTEM | | | | | | 65 | 74 |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | VISUAL INSPECTION REVEALED MINOR | | | | | | | |
| | | | | | | | | | | WATER PENATRATION IN | | | | | | | |
| | | | | | | | | | | GENERATOR AREA OF POWER SYSTEM , NO OTHER | | | | | | | |
| | | | | | | | | | | WATER WAS OBSERVED INSIDE POWER SYSTEM | | | | | | | |
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| **NOTES** | LINE CURRENT MEASURED USING C.T. NO 1299 | | | | | | | | | | | | | | | | |

FIGURE 711.3-1 Typical test record for rain test.

# METHOD 711.4c

## SAND AND DUST TEST

711.4.1 General. The power system must be capable of being exposed to severe wind driven sand and dust without deterioration in performance.

711.4.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in METHOD 205.1. Use instrumentation for measuring ambient temperature as described in METHOD 110.1. Use apparatus required to perform the test in accordance with Procedure II of Method 510 of MIL-STD-810. Use apparatus needed to perform METHOD 608.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

711.4.3 Procedure.

711.4.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

711.4.3.2 Test Procedure.

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within 4 hours before the start of the test.

b. Perform the test in accordance with Procedure II of Method 510 of MIL-STD-810 under the following conditions:

    1. Place the power system on a bed of sand and dust of the same composition specified in Procedure II of Method 510 of MIL-STD-810.

    2. Maintain air velocity at a minimum of 32.2 km/h (20 mph).

    3. Sand concentration shall be 1.4 g/m$^3$.

    4. Perform the test at prevailing ambient temperature and relative humidity.

    5. The test shall consist of four 90-minute intervals. Orient the power system with each side exposed to the blowing sand for one 90-minute interval. Operate the power system at no load for a minimum of 10 minutes during the last half of each 90-minute interval.

c. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours after completion of the test.

711.4.4 Results. Compare the results with the procurement document requirements.

711.4.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The requirements necessary to evaluate METHOD 608.1.

b. The voltage connection and frequency at which this Method is to be performed.

# METHOD 711.5c

# SALT FOG TEST

711.5.1 General. The power system must be capable of being exposed to severe salt fog and sea spray without deterioration in performance.

711.5.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in METHOD 205.1. Use instrumentation for measuring ambient temperature as described in METHOD 110.1. Use apparatus required to perform the test in accordance with Method 509 of MIL-STD-810. Use apparatus needed to perform METHOD 608.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

711.5.3 Procedure.

a. Inspect and record any evidence of corrosion on the power system on data sheet per METHOD 203.1.

b. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours before the start of test.

c. Perform Method 509 of MIL-STD-810 under the following conditions:

   1. Use a salt concentration of 5 ± 1 percent solution.

   2. Test the power system in normal operating condition with all doors and louvers in their operating positions.

   3. Subject the power system to two 48-hour cycles as follows:

      a. 24 hours – salt fog exposure.

      b. 24 hours – standard ambient (drying).

d. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours after completion of the test.

e. Examine power system for corrosion or other physical damage and record results on data sheet.

711.5.4 Results. Compare the results obtained with the procurement document requirements.

711.5.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Salt concentration.

b. Number of hours of exposure to salt fog if other than as specified herein.

c. Degree or amount of permissible corrosive action.

d. The requirements necessary to evaluate METHOD 608.1.

e. Voltage connection and frequency at which this Method is to be performed.

# METHOD 711.6b

# IMMERSION TEST

**NOTE**: Method 711.6b was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

711.6.1 General. The generator set must be capable of proper operation after total immersion.

711.6.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, ambient and liquid temperatures shall be as described and illustrated in MIL-HDBK-705. In addition a container of sufficient size and depth for total immersion of the generator set, and if procedure No. 2 is specified, an altitude chamber in which the container may be placed shall be required.

711.6.3 Procedures.

711.6.3.1 Procedure No. 1.

a. Perform method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. Protect the generator set for immersion only as specified in the procurement document or technical manual.

c. Completely immerse (to the depth specified in the procurement document) the generator set in a bath of tap water (or other liquid if so specified) for a period of 72 hours. During this period maintain the temperature of the water between 50 °F (10 °C) and 77 °F (25 °C) unless otherwise specified in the procurement document.

d. At the end of the 72 hour period remove the generator set from the bath and inspect for leaks and any damage caused by immersion. Estimate and record amount of liquid penetration.

e. Perform method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

711.6.3.2 Procedure No. 2.

a. Perform method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. Protect the generator set for immersion only as specified in the procurement document or technical manual.

c. Completely immerse (to the depth specified in the procurement document) the generator set in a bath of tap water.

d. Place the container in an altitude chamber containing a view plate and reduce the pressure within the chamber to the value specified in the procurement document.

e. Maintain this reduced pressure for the specified period of time.

f. At the end of the specified time period return the pressure within the chamber to atmospheric and remove the generator set from the bath. Inspect the set for leaks and any damage caused by immersion. Estimate and record amount of liquid penetration.

g. Perform method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

711.6.4 Results. Compare the results obtained with the procurement document requirements.

711.6.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Amount of protection to be given the set for immersion.

b. Whether procedure 1 or 2, or both, are to be performed.

c. Amount of liquid penetration allowable.

d. The voltage requirements specified in paragraph 608.1.5a of method 608.1.

e. The frequency requirements specified in paragraph 608.1.5b of method 608.1.

f. Voltage connection and frequency at which this method is to be performed.

g. Conditions of immersion:

    1. Procedure 1:

        a. Immersion liquid to be used, if other than as specified herein.

        b. Temperature of immersion liquid, if other than as specified herein.

        c. Duration of immersion, if other than as specified herein.

d. Depth of immersion.

2. Procedure 2:

   a. Pressure at which this Method is to be performed.

   b. Duration of this Method.

   c. Depth of immersion.

METHOD 720.1e

ALTITUDE OPERATION TEST

720.1.1 General. Atmospheric pressure decreases as altitude increases. Operation of a power system is affected by a decrease in atmospheric pressure. It is imperative that the power system function properly at altitudes above sea level.

720.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. The voltage and frequency recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the specified high temperature with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.3.

Use pressure instrumentation as described and illustrated in METHOD 112.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

720.1.3 Procedure.

720.1.3.1 Preparation for test.

a. Install appropriate thermocouples to measure all of the following temperatures:

**NOTE**: All below temperatures are required unless inapplicable or waived by the procurement document. For example, no spark plug temperature is to be monitored if there are no spark plugs.

**NOTE**: This list contains items normally instrumented; however, some power systems may require additional thermal instrumentation. The thermal instrumentation shall be installed in accordance with METHOD 202.1.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s).
4. Exhaust gases (drill and tap the exhaust manifold(s) of reciprocating engines as close as possible to the combustion chamber(s)). For gas turbine engines, locate thermocouples in the tail pipe approximately one turbine wheel diameter from the last turbine stage).
5. Lubricating oil sump and gallery.
6. Oil cooler (inlet and outlet).
7. Hydraulic oil slump.
8. Engine combustion air in (located at the inlet of the intake manifold).
9. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
10. Generator cooling air (inlet and outlet).
11. Generator stator frame (top and bottom, outside).
12. Generator exciter (stator housing for rotating exciters, transformers for the static exciters).
13. Generator voltage regulator (ambient air inside).
14. Control panel cubicle (ambient air inside).
15. Relay and control boxes (ambient air inside).
16. Battery electrolyte or battery surface.

17. Average ambient air temperature (METHOD 202.1).

18. Air entering power system.

b. Install appropriate pressure instrumentation to measure the following items if applicable:

   1. Pressure in the vicinity of the combustion air intake (inside enclosed power systems).

   2. Exhaust gas pressure (located at the point where the engine exhaust gases discharge into the pressure chamber exhaust system).

   3. Intake manifold pressure.

c. Place the instrumented power system in the pressure chamber and obtain and maintain the ambient temperature within the chamber at the value specified in the procurement document. During all parts of this Method, the average of the ambient thermocouples (see METHOD 202.1) shall be not less than the specified temperature and of these thermocouples, none indicating more than 5°F (2.78°C) above or below the specified ambient.

d. Connect the load and field instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

e. Connect switch(es) to the generator armature coil(s), for which the temperature rise is to be determined (the armature winding that gave the highest temperature rise during the high temperature test, METHOD 710.1), such that the coil(s) may be isolated for resistance measurements. Unless otherwise specified, connect the signal input of the recording meter(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage sensing input to the voltage regulator.

720.1.3.2 Test.

**WARNING**:

**If the test chamber is not equipped so that a tester can safely enter the altitude chamber, means shall be made to operate the power system and perform all necessary tests from outside the chamber. Failure to do so may cause personal injury or death.**

a. Operate the chamber at the altitude and ambient temperature specified in the procurement document until the temperature readings of all thermal instrumentation have stabilized at or above the specified ambient temperature.

b. With the power system stabilized at the required altitude and temperature, turn on the recording on the recording instrumentation. The altitude during all parts of this test shall be not less than that specified. Maintain the air pressure in the test chamber to that corresponding to the specified altitude, as given in Table IV of the US Standard Atmosphere, see TABLE 720.1-I.

c. Start and operate the power system and allow it to stabilize at rated load, rated voltage, and rated frequency. During this period, record all instrument readings per METHOD 203.1 (see FIGURE 720.1-1) at minimum intervals of 5 minutes. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when either of the following two conditions have been met: four consecutive 5 minute interval readings of the oil temperature remain constant and are all within +/- two percent of each other after the last adjustment to load, voltage, and frequency has been made; or when nine consecutive 5 minute interval readings of the voltage and frequency output remain constant within the bandwidth requirement (see 720.1.5) after the last adjustment to load, voltage, and frequency has been made.

    1. If necessary, make adjustments to the load to ensure required load is applied to the power system.

    2. If necessary, make adjustments to the voltage and frequency using the adjustments on the control panel to maintain rated voltage and frequency.

**WARNING:**

**If it is necessary to adjust voltage and frequency by any means other than using the devices on the control panel of the power system, shutdown the power system. Failure to do so may cause personal injury or death.**

a. If the adjustments to the voltage and frequency on the control panel are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system.

b. For power systems utilizing a droop-type speed control system as the prime speed control, if the adjustments to the voltage and frequency are not adequate to bring the readings to the required levels, drop load and turn the power system off. Make any adjustments available on the power system including the speed and droop portions of the control.

3. Stabilize per 720.1.3.2c. If the power system cannot be stabilized after all possible adjustments are made to the load, voltage, and frequency, stop test and record failure.

**NOTE:** The stabilization period starts over after any adjustment to the voltage or frequency.

**NOTE**: If this test is performed immediately following another test which has established stabilization values, stabilization will be considered valid once all the previously established values and operating parameters are obtained (initial stabilization readings therefore must include all values needed for subsequent testing). Operation of the power system must not be interrupted between this test and the test that established stabilization values.

d. After stabilization has occurred shutdown the power system so that the temperature of the coil of the armature that gave the highest temperature rise during the high temperature test may be taken. For application of the resistance method to the armature coil (see METHOD 110.1 and METHOD 202.1) shutdown the power system quickly.

**WARNING:**

**Do not connect bridges or other equipment for measuring resistance or temperature to circuits which may still be energized, e.g., during the time that the power system is coming to a stop. Failure to do so may cause personal injury or death.**

e. Immediately after the shutdown, start to record the resistance bridge readings of the coil. Record resistance measurements in accordance with instructions given in METHOD 110.1.

f. Repeat steps c, d, and e above but use the load condition that gave the maximum field temperature rise during the high temperature test.

g. Unless otherwise specified, operate the power system in accordance with the instructions on the power system or in the technical manual and perform the following Methods at the specified ambient temperature, ambient air pressure, voltage connection and frequency:

1. METHOD 511.1, Regulator Range Test.

2. METHOD 513.2, Indicating Instrument Test (Electrical).

3. METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term). (In addition to the required data, record all thermal and pressure instrumentation as specified in 720.1.3.1 at the same time for the stabilization portion of this test.)

4. METHOD 640.1, Maximum Power Test.

**NOTE**: The above methods are listed in numerical order; however, they need not be performed in this order.

720.1.4 Results. Results shall be as specified in methods listed in 720.1.3.2g and in the individual methods specified in 720.1.2.3d. For the test performed in 720.1.3.2b, show the length of time required to start the power system, whether or not the power system operated normally and reasons for any difficult starting or uneven running on the data sheet. For the test performed in 720.1.3.2e show the temperature rise of each winding as specified in METHOD 110.1 on the data sheet. Compare these results with the procurement document requirements.

720.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Altitude and temperature at which this Method is to be performed.

b. Voltage connection and frequency at which this Method is to be performed.

c. Temperature rise allowed for the windings or other component to be tested.

d. The requirements necessary to evaluate METHOD 608.1.

e. The accuracy of each panel instrument.

f. Methods to be performed in addition to or other than those listed in 720.1.3.2g.

TABLE 720.1-I. Atmospheric table.

| **Altitude (feet)** | **Atmospheric Pressure (mm Hg)** | **Atmospheric Pressure (in. Hg)** |
|---|---|---|
| 0 | 760.0 | 29.92 |
| 1,500 | 719.7 | 28.33 |
| 2,000 | 706.6 | 27.82 |
| 3,000 | 681.2 | 26.82 |
| 4,000 | 656.3 | 25.84 |
| 5,000 | 623.4 | 24.90 |
| 6,000 | 609.0 | 23.98 |
| 8,000 | 564.9 | 22.24 |
| 10,000 | 522.6 | 20.58 |

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V, SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SF-10.0-MD<br>**SERIAL NO.** 11077<br>**REF.** MIL-STD-705/720.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>ALTITUDE OPERATION TEST<br>8000 FT | **TEST NO.** 43<br><br>**SHEET:** 1 OF 2<br><br>**DATE:** 15 JANUARY 2016<br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |

| **INST.→** | | 101 | 202 | | 303 | | 405 | 505 | | | | | 1001 | | | 1076 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERM VOLTAGE | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | FREQ | | | BARO PRESS | EXH. CHAMBER PRESS | ENGINE AIR IN | ENGINE AIR OUT | | | AVG AMB TEMP |
| **UNITS** | HRS | VOLTS | AMPS | AMPS | KW | KW | -- | HZ | | | in Hg | in $H_20$ | °F | °F | | | °F |
| **SYM** | | | X40 | X1 | X40 | X1 | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | STARTED CHAMBER | | | | | | | | | 22.24 | 0 | 87 | 88 | | | 90 |
| | 0900 | | | | | | | | | | 22.24 | 0 | 90 | 90 | | | 90 |
| | 0900 | STARTED POWER SYSTEM IN 15 SEC. APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0910 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 92 | 98 | | | 90 |
| | 0920 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 94 | 100 | | | 90 |
| | 0930 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 95 | 103 | | | 90 |
| | 0940 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.1 | | | 22.24 | -3.2 | 96 | 104 | | | 90 |
| | 0950 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 96 | 104 | | | 90 |
| | 1000 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 96 | 105 | | | 90 |
| | 1010 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 97 | 105 | | | 90 |
| | 1020 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 97 | 106 | | | 90 |
| | 1030 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 97 | 107 | | | 90 |
| | 1040 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 97 | 107 | | | 90 |
| | 1050 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 97 | 107 | | | 90 |
| | 1100 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.2 | 97 | 107 | | | 90 |
| | 1105 | SHUTDOWN FOR RESISTANCE READING $T_8$-$T_{11}$ | | | | | | | | | | | | | | | |
| | 1110 | RESTARTED POWER SYSTEM – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 1120 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.1 | 97 | 107 | | | 90 |
| | 1130 | 120.0 | 2.60 | 104 | .25 | 10.0 | .80 | 60.0 | | | 22.24 | -3.1 | 97 | 107 | | | 90 |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENT MEASURED USING C.T. NO 1305 | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | RECORDING VOLTAGE AND FREQ METER NO. 1701 | | | | | | | | | | | | | | | | |

FIGURE 720.1-1 Portion of a typical test record for altitude operation test.

METHOD 731.1d

STORAGE TEST
(SEVERE COLD, -60°F)

731.1.1 General. The power system must be capable of storage without damage in extreme low temperature environments.

731.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. Also, use battery voltage and current recording type instrumentation. The voltage, frequency, and current recording type instrumentation, other than oscilloscopes, shall have the following specifications:

– Rise time for the frequency shall be 250 ms.

– Rise time for the voltage shall be 60 ms.

– Input shall be up to 500 volts RMS.

– Output shall be ±5 volts DC maximum.

– The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the specified low temperature with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.2.

The apparatus needed to verify batteries have been cycled and are fully charged in accordance with METHOD 222.1, Battery Servicing and Condition Assurance Prior to “Cold Starting” Tests, shall be required.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

731.1.3 Procedure.

731.1.3.1 Preparation for test.

a. Install appropriate thermocouples to measure all of the following temperatures.

**NOTE**: All below temperatures are required unless inapplicable or waived by the procurement document. For example, no spark plug temperature is to be monitored if there are no spark plugs.

**NOTE**: This list contains items normally instrumented; however, some power systems may require additional thermal instrumentation. The thermal instrumentation shall be installed in accordance with the instructions in METHOD 202.1.

1. Ambient air temperature.
2. Engine coolant (engine outlet and inlet).
3. Spark plug(s).
4. Lubricating oil (sump and gallery).
5. Engine combustion air in (located at the inlet of the intake manifold).
6. Battery electrolyte or battery surface.
7. Heater coolant (air or liquid-into and out of the heater).
8. Heater exhaust.
9. Battery box air (at each end of battery box).
10. Engine exhaust gas.
11. Generator stator frame (top and bottom, outside).
12. Generator cooling air (inlet and outlet).
13. Control panel cubicle (ambient air, inside).
14. Air entering power system.
15. Fuel in on-board fuel tank.

b. Start and operate the power system until the lubricating oil is warm enough to drain.

c. Drain the coolant from the engine block, the radiator, coolant pump, heater, and all coolant lines. Ensure the power system is completely drained. Fill the coolant system with the proper grade of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

d. Drain the fuel from all fuel tanks, lines, strainers, pumps and filters. Flush tanks with low temperature fuel using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets on strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuel of the proper grade (low temperature fuel as specified in the procurement document). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

e. Drain the lubricating oil from the engine, filters strainers and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubricating oil. Fill a small container with a sample (approximately 8 ounces) of the oil used.

f. Operate the winterization system, as applicable. Ensure all controls work properly. Temporarily bypass some controls if the ambient temperature is too high.

| **NOTE**: Do not operate the heater for longer than necessary to perform the checkout. |
|---|

g. Operate any fuel priming pumps on the power system with the discharge lines open to clear lines of normal ambient fuel.

h. On all power systems, check the ignition system, fuel injector timing, valve clearance and other sub-systems as applicable. Check operating manual and maintenance instructions to ensure all power system checks were performed properly.

i. Start and operate the power system for approximately 15 minutes at no load to allow the arctic fuel and lubricants to thoroughly circulate. During this period open oil lines at gages and safety controls to drain normal temperature oil. Shutdown the power system and drain all power system fuel tanks as well as the oil from the air cleaners. Fill power system fuel tanks. Fill and label a small container with a sample (approximately 8 ounces) of fuel used.

j. Ensure test batteries have been cycled and charged using a battery analyzer to verify state of charge in accordance with METHOD 222.1 before placing them in the cold room.

k. Place sample containers of fuel, lubricant(s), and coolant in the cold room.

l. Place the power system in the cold room. If the power system is equipped for an auxiliary fuel supply, connect the auxiliary fuel supply to the power system using the auxiliary fuel hoses supplied with the power system. The auxiliary fuel supply must have sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. Place the auxiliary fuel supply in the cold room.

m. Connect the load and battery current and voltage instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document. Make voltage and frequency readings at a line-to-neutral point on the power source side of the power system circuit interrupter for each voltage connection specified in the procurement document.

n. Where temperature measurements are made by means of thermocouples, bring the thermocouple leads out of the cold room to permit the temperature to be read by instruments located in normal ambient temperatures. Locate all electrical instruments, except those provided as part of the power system, outside the cold room.

731.1.3.2 Test.

a. Expose the complete power system (including all fuels, lubricants, coolants and hydraulic oils to be used during this Method) to ambient temperature of -40°F (-40°C) until such time as all thermocouples are at the specified low temperature or until 24 hours have elapsed, whichever comes later. During all steps of this test, all ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the procurement document. Prepare the power system by following the operating instructions on the power system. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet per METHOD 203.1 (see FIGURE 731.1-1).

b. Expose the power system to an ambient temperature of -60°F (-51°C) until all thermocouples are at the specified low temperature or until 24 hours have elapsed, whichever comes later. Maintain the ambient temperature at -60°F (-51°C) for 24 hours after the stabilization is attained. During this period, inspect the power system for evidence of distortion or cracking of the components, and leaks in fuel, lubrication, and cooling systems.

c. Raise the ambient temperature to -40°F (-40°C) and maintain this temperature until the temperature of all components of the power system stabilize at this value.

d. Raise the ambient temperature to normal ambient temperature and maintain this temperature until the temperature of all components of the power system stabilize at this value.

e. Drain the arctic fuel, lubricating oil, and coolant from the power system. Do not remove fuel strainers, filters, gaskets, etc. Refill the power system with normal ambient fuel, lubricating oil, and coolant.

f. Start and operate the power system at idle speed (reduced speed if no idle speed is attainable), inspect the set for leaks, faulty operation, etc. After the unit has been warmed up, increase speed to rated. Inspect the power system again and then apply rated load and perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

**NOTE**: This Method may be combined with METHOD 701.1, Starting and Operating Test (Cold and Severe Cold Battery Start) in which case, steps c, d, e, and f of this Method should be deleted and after stabilization at -60°F (-51°C) the ambient temperature should be raised to -40°F (-40°C) and the power system stabilized at this value before proceeding with METHOD 701.1.

731.1.4 Results. Compare the results with the procurement document requirements.

731.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Requirements necessary to evaluate METHOD 608.1.

b. The voltage connection and frequency at which this Method is to be performed.

c. Extreme cold temperature, if other than as specified herein.

d. Types of fuel, lubricant, and coolant to be used.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V, SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br>**MODEL NO.** SF-10.0-MD<br>**SERIAL NO.** 14761<br>**REF.** MIL-STD-705/731.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>STORAGE TEST (SEVERE COLD, -60°F) | **TEST NO.** 76<br><br>**SHEET:** 1 OF 2<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br>**PROJ. ENGR** J.J. JONES<br>**SHIFT LEADER:** H. SMITH<br>**OBSERVER:** L. SEE |

| **INST.→** | 1076 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | ENGINE AIR | | | | | | ENGINE EXHAUST | LUBE OIL | | | GEN AIR | | GEN FRAME | | EXCITER FRAME | AVG AMB TEMP |
| | | IN | OUT | | | | | | SUMP | GALLERY | | IN | OUT | TOP | BOTTOM | | |
| **UNITS** | HRS | °F | °F | | | | | °F | °F | °F | | °F | °F | °F | °F | °F | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0910 | CHAMBER REACHED 0°F | | | | | | | | | | | | | | | 0 |
| | 0915 | STARTED POWER SYSTEM | | | | | | | | | | | | | | | -2 |
| | 0930 | SHUTDOWN POWER SYSTEM | | | | | | | | | | | | | | | -3 |
| | 1115 | | | | | | | | | | | | | | | | -40 |
| | 1930 | -40 | -40 | | | | | -40 | -42 | -42 | | -40 | -40 | -41 | -41 | -42 | -40 |
| 3/2 | 0015 | | | | | | | | | | | | | | | | -60 |
| | 1610 | -61 | -61 | | | | | -61 | -60 | -60 | | -61 | -60 | -60 | -60 | -60 | -62 |
| 3/3 | 1500 | INSPECTED POWER SYSTEM NO VISIBLE DAMAGE | | | | | | | | | | | | | | | -60 |
| | 1610 | -61 | -60 | | | | | -60 | -61 | -61 | | -61 | -60 | -61 | -61 | -61 | -60 |
| | 1800 | | | | | | | | | | | | | | | | -40 |
| 3/4 | 0600 | -42 | -41 | | | | | -41 | -42 | -41 | | -40 | -40 | -42 | -42 | -41 | -40 |
| | | | | | | | | | | | | | | | | | |
| | 1100 | CHANGED FUEL + OIL TO NORMAL AMBIENT | | | | | | | | | | | | | | | +75 |
| | | | | | | | | | | | | | | | | | |
| | 1130 | STARTED POWER SYSTEM – NO LEAKS OR DIFFICULT RUNNING NOTED | | | | | | | | | | | | | | | 76 |
| | 1140 | STARTED METHOD 301.1 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 731.1-1 Portion of a typical test record for storage test (severe cold, -60°F).

# METHOD 732.1d

## STORAGE TEST
## (HOT, +160°F)

732.1.1 General. The power system must be capable of storage without damage in hot temperature environments.

732.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in accordance with the applicable figure of METHOD 205.1. Use instrumentation for measuring temperature as described in METHOD 110.1. In addition, use voltage and frequency recording type instrumentation. Also, use battery voltage and current recording type instrumentation. The voltage, frequency, and current recording type instrumentation, other than oscilloscopes, shall have the following specifications:

- Rise time for the frequency shall be 250 ms.
- Rise time for the voltage shall be 60 ms.
- Input shall be up to 500 volts RMS.
- Output shall be ±5 volts DC maximum.
- The signal input(s) and output(s) shall be ungrounded.

If an analog signal is digitized, the sampling frequency shall be at least 25 percent higher than twice the highest frequency component of the analog signal. The sampling frequency for any waveforms acquired using voltage and frequency recording type meter shall be at least 100 Hz. Save the data in an ASCII text file in a common delimited form.

Use a controlled temperature room having sufficient capacity to maintain the specified temperature with the power system operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in METHOD 114.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

732.1.3 Procedure.

732.1.3.1 Preparation for test.

a. Install appropriate thermocouples to measure all of the following temperatures.

| |
|---|
| **NOTE**: All below temperatures are required unless inapplicable or waived by the procurement document. For example, no spark plug temperature is to be monitored if there are no spark plugs. |

**NOTE**: This list contains items normally instrumented; however, some power systems may require additional thermal instrumentation. The thermal instrumentation shall be installed in accordance with the instructions in METHOD 202.1.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s).
4. Exhaust gases (drill and tap the exhaust manifold(s) of reciprocating engines as close as possible to the combustion chamber(s)). For gas turbine engines, locate the thermocouples in the tailpipe approximately one turbine wheel diameter downstream from the last turbine stage).
5. Lubricating oil (sump and gallery).
6. Oil cooler (inlet and outlet).
7. Hydraulic oil sump.
8. Engine combustion air in (located at the inlet of the intake manifold).
9. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
10. Generator cooling air (inlet and outlet).
11. Generator stator frame (top and bottom, outside).
12. Generator exciter (stator housing for rotating exciters, transformers for static exciters).
13. Generator voltage regulator (ambient air inside).
14. Control panel cubicle (ambient air inside).
15. Relay and control boxes (ambient air inside).
16. Battery electrolyte or battery surface.
17. Average ambient air temperature (METHOD 202.1).

18. Air entering power system for housed power systems.

b. Connect the load and field instrumentation in accordance with the applicable figure of 205.1.10.

732.1.3.2 Test.

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. Place the instrumented power system in a test chamber and expose the power system to an ambient temperature of 90°F (32.2°C) until the thermocouples stabilize at this value. During all parts of this Methods, none of the ambient thermocouples shall read less than the specified temperature.

c. During a five hour interval, gradually raise the ambient temperature to 160°F (71.1°C) or as specified in the procurement document. Maintain this ambient temperature until the temperature of all components of the power system stabilize at this value or for one hour whichever is shorter.

d. During a five hour interval, gradually reduce the ambient temperature to 90°F (32.2°C). Maintain this temperature until the temperature of all thermocouples of the power system stabilize at this value.

e. Lower the ambient temperature to normal ambient temperature and maintain this temperature until the temperature of all components of the power system stabilizes at this value. Inspect the power system for any evidence of deterioration due to high temperature.

f. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term), at normal ambient temperature.

**NOTE**: This test may be combined with METHOD 710.1, High Temperature Test, in which case step d above should be deleted and the temperature gradually reduced to 125°F (51.5°C) in a 2-1/2 hour interval and maintained until stabilization of the temperature of all thermocouples of the power system occurs. Perform steps e and f above before proceeding with METHOD 710.1.

732.1.4 Results. Compare the results with the procurement document requirements.

732.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Requirements necessary to evaluate METHOD 608.1.

b. The voltage connection and frequency at which this Method is to be performed.

c. The high temperature, if other than as specified herein.

| | | |
|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 13711<br><br>**REF.** MIL-STD-705/732.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>STORAGE TEST<br>(HOT, +160°F) | **TEST NO.** 89<br><br>**SHEET:** 1 OF 2<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST.→** | 1076 | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | ENGINE AIR | | | | | | ENGINE EXHAUST | LUBE OIL | | | GEN AIR | | GEN FRAME | | EXCITER FRAME | AVG AMB TEMP |
| | | IN | OUT | | | | | | SUMP | GALLERY | | IN | OUT | IN | OUT | | |
| **UNITS** | HRS | °F | °F | | | | | °F | °F | °F | | °F | °F | °F | °F | °F | °F |
| **SYM** | | | | | | | | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 1530 | PERFORMED METHOD 608.1 | | | | | | | | | | | | | | | |
| | 1600 | PLACED POWER SYSTEM IN CHAMBER | | | | | | | | | | | | | | | 90 |
| 3/2 | 0800 | 90 | 90 | | | | | 90 | 91 | 91 | | 90 | 90 | 91 | 91 | 91 | 90 |
| | 0800 | BEGIN INCREASING AMBIENT TEMPERATURE | | | | | | | | | | | | | | | |
| | 1300 | | | | | | | | | | | | | | | | 160 |
| 3/3 | 0800 | 161 | 161 | | | | | 161 | 161 | 161 | | 160 | 160 | 160 | 160 | 160 | 161 |
| | 0800 | BEGIN DECREASING AMBIENT TEMPERATURE | | | | | | | | | | | | | | | |
| | 1300 | | | | | | | | | | | | | | | | 90 |
| 3/4 | 0800 | 91 | 90 | | | | | 91 | 90 | 91 | | 90 | 91 | 90 | 90 | 90 | 90 |
| | 0815 | VISUAL INSPECTION REVEALED NO DAMAGE DUE TO HIGH TEMPERATURE STORAGE | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1000 | STARTED METHOD 710.1 | | | | | | | | | | | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 732.1-1 Portion of a typical test record for storage test (hot, 160°F).

# METHOD 740.1c

# VIBRATION TEST

**NOTE**: Method 740.1c was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

740.1.1 General. The generator set must be capable of withstanding externally imparted vibrations.

740.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705. In addition, a synchronous drive package testing machine having a total excursion of 1 inch, a capacity of 1,000 pounds, and table measuring 5 feet by 5 feet, L.A.B. Corporation or Gaynes Engineering Co., or equal shall be required.

740.1.3 Procedure.

a. Perform Method 614.1, Voltage and Frequency Regulation Test.

b. Place the generator set on the vibration table with the set resting on its base. The set shall be unrestricted in movement on the table (fences or barriers shall be the only means used to prevent lateral movement of the set off the table). Initially, there shall be at least 1 inch clearance between the set and the fence or barrier.

c. Vibrate the generator set for the time specified in the procurement document at such a frequency that the set leaves the table momentarily at some interval during each vibration cycle of the test table. Test for proper vibration frequency by inserting a piece of cardboard, approximately 1/16 inch thick, between edge of the set and the platform of the machine.

d. After vibration, inspect the generator set for visual damage and record any damage on the data sheet.

e. Perform Method 614.1, Voltage and Frequency Regulation Test.

740.1.4 Results. Compare the condition of the generator set after vibration with the procurement document requirements.

740.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Duration of the vibration portion of this Method.

b. Voltage connection and frequency at which the pre- and post-vibration operation methods are to be performed.

c. Allowable voltage regulation.

d. Allowable frequency regulation.

e. Definition of vibration damage.

| | | |
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| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V SINGLE-PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC.<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/740.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>VIBRATION TEST | **TEST NO.** 18<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** FEBRUARY 12, 1971<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

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| | 09:15 | STARTED VIBRATION – 1/16" THICK CARDBOARD JUST SLIPS UNDER SET | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 09:45 | STOPPED VIBRATION | | | | | | | | | | | | | | | |
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| | | | VISUAL INSPECTION REVEALED THE FOLLOWING: | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | VOLTAGE REGULATOR MOUNTING HARDWARE LOOSE | | | | | | | | | | | | | |
| | | | | FUEL FILTER BOWL BROKEN | | | | | | | | | | | | | |
| | | | | FUEL LINE LOOSE AT THREE CONNECTIONS (CARB, BOTH SIDE OF BOWL) | | | | | | | | | | | | | |
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| **NOTES** | ALL ITEMS TIGHTENED OR REPLACED PRIOR TO PERFORMING METHOD 614.1 | | | | | | | | | | | | | | | | |
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FIGURE 740.1-I Portion of a typical test record for vibration test.

# METHOD 740.2d

## DROP TEST (FREE FALL)

740.2.1 General. The power system must be capable of withstanding drops from reasonable heights to assure damage free transportability.

740.2.2 Apparatus. Use apparatus in accordance with Procedure IV of Method 516 of MIL-STD-810. Use apparatus required by METHOD 608.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

740.2.3 Procedure.

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours before the start of test.

b. Ensure the on-board power system fuel tank is approximately half full of fuel. All liquids (except fuel) shall be at normal operating levels.

c. Drop the power system 9 inches on its base in accordance with Procedure IV of Method 516 of MIL-STD-810.

d. Visually inspect the power system for damage and record results on data sheet per METHOD 203.1 (see FIGURE 740.2-1).

e. Drop the power system on each corner of its base at a height of 9 inches and at an angle of 30 degrees. Visually inspect the power system for damage after each drop.

f. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours after completion of the test.

740.2.4 Results. Compare the results with the procurement document requirements.

740.2.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The height of the drops the power system must undergo if other than as stated herein.

b. The number of drops if other than as specified herein.

c. Whether the drops are to be flat, corner or both if other than as specified herein.

d. Angle of corner drop, if other than as specified herein.

e. The requirements necessary to evaluate METHOD 608.1.

f. The voltage connection and frequency at which this Method shall be performed.

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| **DESCRIPTION:** 10 KW, 60 HZ<br>120 V, SINGLE-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/740.2 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>DROP TEST (FREE FALL) | **TEST NO.** 19<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

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| | 0900 | PERFORMED METHOD 608.1 | | | | | | | | | | | | | | | |
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| | 0920 | DROPPED POWER SYSTEM FROM 9” HEIGHT | | | | | | | | | | | | | | | |
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| | 0930 | DROPPED POWER SYSTEM ON EACH OF FOUR CORNERS FROM 9” | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 0935 | VISUAL INSPECTION AFTER EACH DROP REVEALED NO DAMAGE TO POWER SYSTEM | | | | | | | | | | | | | | | |
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| | 1100 | PERFORMED METHOD 608.1 | | | | | | | | | | | | | | | |
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| **NOTES** | | | | | | | | | | | | | | | | | |

FIGURE 740.2-1 Portion of a typical test record for drop test (free fall).

METHOD 740.3d

DROP TEST (ENDS)

740.3.1 General. The power system must be capable of withstanding end drops which may be encountered in normal transportation.

740.3.2 Apparatus. Use apparatus in accordance with Procedure IV of Method 516 of MIL-STD-810 shall be required. Use apparatus required by METHOD 608.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

740.3.3 Procedure.

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours before the start of test.

b. Ensure on-board power system fuel tank is approximately half full of fuel. Ensure all liquids (except fuel) are at normal operating level.

c. Drop the power system in accordance with Procedure IV of Method 516 of MIL-STD-810 at a height of 9 inches on one edge of its base.

d. Visually inspect the power system for damage and record results on data sheet per METHOD 203.1.

e. Repeat steps c and d on all other edges of its base.

f. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours after completion of the test.

740.3.4 Results. Compare the results with the procurement document requirements.

740.3.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The height of the drops if other than as specified herein.

b. The requirements necessary to evaluate METHOD 608.1.

c. The voltage connection and frequency at which this Method is to be performed.

METHOD 740.4d

LIFTING AND TIEDOWN TEST

740.4.1 General. The power system must be capable of withstanding normal stresses of lifting and tiedown during transportation. Some power systems may be required to be towed for short distances.

740.4.2 Apparatus. Use apparatus needed to perform the applicable testing of MIL-STD-209, Interface Standard for Lifting and Tiedown Provisions.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

740.4.3 Procedure.

740.4.3.1 Pre-test examination.

a. Examine the power system to prove it meets the following lifting and tiedown provision requirements of MIL-STD-209:

   1. The surface of the provisions shall be rounded (minimum of 1/8 inch radius to round cross-section) or chamfered (minimum of 1/16 by 1/16 inch), and smoothed.

   2. Determine whether the provisions are removable or not. If they are removable, the provisions are unacceptable.

   3. If stowable "hideaway" lifting provisions are used, they shall meet the following requirements:

      i. If stowed provisions are covered, the cover shall be removed and provision unstowed without tools.

      ii. Allowances must be made to stow the cover when the provisions are in use.

      iii. If a provision loses some of its strength capacity in its stowed position, it shall be made inaccessible so that it cannot be misused.

      iv. If tools or locking pins are used to employ the stowed provisions, a suitable means must be provided to prevent the loss of these tools or pins.

b. Perform a baseline Non-Destructive Test (NDT) of the welds on the provisions and the connecting structure around the provisions in accordance with 4.13 of MIL-STD-209.

c. Examine the power system to determine if it meets the marking requirements of 5.7 of MIL-STD-209.

740.4.3.2 Lifting provisions test.

a. Test the power system in accordance with 5.1.5 of MIL-STD-209.

740.4.3.3 Tiedown provisions test.

a. Test the power system in accordance with 5.2.5 of MIL-STD-209.

740.4.3.4 Cargo tiedown provisions.

a. If applicable, test the power system in accordance with 5.4.5 of MIL-STD-209.

740.4.3.5 Large cargo tiedown provisions.

a. If applicable, test the power system in accordance with 5.5.5 of MIL-STD-209.

740.4.3.6 Supplemental air transport tiedown provisions.

a. If the power system weighs 10,000 pounds or more and has an internal air transport requirement, test the power system in accordance with 5.6.5 of MIL-STD-209.

740.4.3.7 Towing test.

a. If applicable, use the towing eye or towing point on one end of the power system, secure the power system to an object that will not move under a force of 5 times the power system weight. Attach the winch and scale to the towing eye at the other end of the power system and apply a horizontal force equal to 5 times the power system weight.

740.4.3.8 Post-test examination.

a. Repeat the baseline Non-Destructive Test (NDT) of the welds on the lifting and tiedown and towing provisions and the connecting structure around the provisions from 740.4.3.1.

740.4.4 Results. Examine the power system and record any deformation or damage.

740.4.5 <u>Procurement document requirements</u>. The following items must be specified in the individual procurement document.

a. Any deviation from the testing requirements of MIL-STD-209.

b. Whether towing test is required.

c. If applicable, marking requirements in addition to those required in 5.7 of MIL-STD-209.

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|---|---|---|
| **DESCRIPTION:** 10 KW, 60 HZ<br>120/208 V 3-PHASE<br>POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-10.0-MD<br><br>**SERIAL NO.** 26017<br><br>**REF.** MIL-STD-705/740.4 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>LIFTING AND TIEDOWN TEST | **TEST NO.** 43<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

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| | 1412 | LIFTED POWER SYSTEM BY LIFTING EYE CLEAR OF GROUND – WEIGHT = 814 LBS 13" FROM LEVEL | | | | | | | | | | | | | | | |
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| | 1500 | BOLTED POWER SYSTEM DOWN USING HOLES IN BASE – APPLIED A LIFTING FORCE OF 6,512 LBS | | | | | | | | | | | | | | | |
| | | TO LIFTING EYE – NO VISIBLE DAMAGE OR DEFORMATION. | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1545 | WITH THE TOWING EYE ON THE POWER SYSTEM FIXED TO THE TEST RIG A | | | | | | | | | | | | | | | |
| | | TOWING (HORIZONAL) FORCE OF 4,070 LBS WAS APPLIED TO THE OTHER TOWING | | | | | | | | | | | | | | | |
| | | EYE –NO VISABLE DAMAGE OR DEFORMATION. | | | | | | | | | | | | | | | |
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FIGURE 740.4-1 Typical test record for lifting and tiedown test.

# METHOD 740.5d

## RAILROAD IMPACT TEST

740.5.1 General. The power system must be capable of withstanding the vibration and shock encountered in all forms of railroad transportation and movement. The mechanical integrity of the power system is tested by means of the shock loading encountered during the railroad impact test. The test also evaluates the method of tie-down on the rail car.

740.5.2 Apparatus. Use two railroad cars with a total standing weight of not less than 250,000 pounds, divided approximately equally between the two cars, and one standard flat railroad car (test car) all with standard draft gear couplings and conventional underframes, a means of moving the test car, an electrical or electronic device to determine the test car speed at impact, and shock measuring equipment as applicable. Use apparatus required by Method 526 of MIL-STD-810. Use apparatus required by METHOD 608.1.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

740.5.3 Procedure.

740.5.3.1 Pre-test. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term), on the power system within eight hours before the start of the test and before mounting the power system on the railroad test car.

740.5.3.2 Preparation for test.

a. Mount the power system on the impact end of the railroad test car in accordance with the standard loading and bracing method as approved by the Military Surface Deployment and Distribution Command Transportation Engineering Agency in accordance with section 6 of the Association of American Railroads (AAR) "Rules Governing the Loading of Department of Defense Material on Open Top Cars" unless otherwise specified. Do not use exotic or unusual tiedown methods. Mount the longitudinal axis of the power system parallel to the length of the test car.

> **NOTE**: If two power systems are tested at the same time, mount them with the control panel in opposite directions, if applicable.

b. Unless otherwise specified, fill the on-board power system fuel tank to 50 to 75 percent full of fuel. Ensure all liquids (except fuel) are at normal operating level.

c. The power system shall not require any type of packaging for the test.

d. If the power system is installed on a trailer and attached to a prime mover, do not set the trailer brakes. If the power system is installed on a trailer and not attached to a prime mover, set the trailer brakes.

740.5.3.3 Test.

a. Perform the test in accordance with Method 526 of MIL-STD-810 except for the following:

    1. Start and operate the power system at no load and rated voltage and frequency for one minute after completion of all forward impacts.

    2. Start and operate the power system at no load and rated voltage and frequency for one minute after completion of all reverse impacts.

b. Remove power system from railroad test car and perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within eight hours after completion of the test.

740.5.4 Results.

a. Compare the results of the test with the requirements of the procurement document for any damage to the power system.

b. Compare the results of the two METHOD 608.1 tests with the requirements of the procurement document.

740.5.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The quantity of power systems to be tested.

b. The power system orientation and method of tiedown if other than that specified by the Military Surface Deployment and Distribution Command Transportation Engineering Agency.

c. Speeds other than as specified in Method 526 of MIL-STD-810.

d. The failure definition for damage.

e. The requirements necessary to evaluate METHOD 608.1.

f. Percentage of fuel in power system on-board fuel tank if other than as specified herein.

| | | |
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| **DESCRIPTION:** 30 KW, 60 HZ<br>120/208 V OR 120 V<br>3-PHASE, POWER SYSTEM<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-30.0-MD<br><br>**SERIAL NO.** 21067<br><br>**REF.** MIL-STD-705/740.5 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>RAILROAD IMPACT TEST | **TEST NO.** 62<br><br>**SHEET:** 1 OF 4<br><br>**DATE:** 15 JANUARY 2016<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

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| | 0930 | COMPLETED PRE – 608.1 TEST. SEE SHEET 2-4 FOR DATA. | | | | | | | | | | | | | | | |
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| | 1000 | INSPECTION AFTER FIRST IMPACT | | | | = | (1) RIGHT REAR SHOCK MOUNT BROKE. | | | | | | | | | | |
| | | | | | | | (2) LEFT FRONT DOOR WOULD NOT OPEN. | | | | | | | | | | |
| | | | | | | | (3) DISTORTED SHEET METAL ON CONTROL PANEL. | | | | | | | | | | |
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| **NOTES** | Fuel Tank Half Full | | | | | | | | | | | | | | | | |

FIGURE 740.5-1 Typical test record for railroad impact test.

# METHOD 740.7a

## FORKLIFT HANDLING TEST

**NOTE**: Method 740.7a was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

740.7.1 General. Generator sets must have the ability to withstand handling by mechanical equipment such as forklifts.

740.7.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705. In addition, a hard rubber tired forklift truck of sufficient capacity for the weight of the set and six nominal 1 by 4-inch boards longer than the width of the forklift truck shall be required.

740.7.3 Procedure.

a. Perform method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. Adjust the forks to the spacing appropriate for the generator set under test.

c. The generator set shall be lifted clear of the ground by the forklift truck at one side of the set and transported on the forks in the level or backtilt position across a hard pavement for a distance not less than 100 feet. Parallel pairs of 1-inch boards spaced 54 inches apart shall be laid flatwise on the pavement across the path of the forklift truck. The first pair shall be placed squarely across the truck's path and centered 30 feet from the starting point; the second pair shall be laid 60 feet from the starting point at an angle of 60 ° to the truck's path so the left wheel strikes first; and the third pair shall be laid 90 feet from the starting point at about 75 ° to the truck's path so the right wheel strikes first. If the generator set is more than 36 inches wide and is stable on 36-inch long forks, the forks shall extend only 36 inches under the set. The forklift truck carrying the set shall travel the 100 feet in about 23 seconds at a uniform speed (normal walking speed, approximately 3 mph), and then shall be brought to a stop.

d. The generator set shall be observed during the traverse and while the forklift truck is at a stop for any damage, evidence of inadequacy, or deflection of the set that might cause damage. Record results of observations on the data sheet.

e. The forklift truck shall be moved from the side to the end of the generator set. The forks shall be run under the set as far as possible and then operated to lift the end 6 inches. Observe the set, particularly in the vicinity of the end of the forks, and record observations. If the set can thus be lifted clear of the floor, transport it on the forks over the same 100 foot course, and record observations. If it cannot be thus lifted, report the length of the forks used.

f. Repeat step e above from the opposite end of the set.

g. Perform method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

740.7.4 Results. Compare the results with the procurement document requirements.

740.7.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The direction(s) from which a forklift shall be capable of being used to transport the set.

b. The voltage requirements specified in paragraph 608.1.5b of method 608.1.

c. The frequency requirements specified in paragraph 608.1.5a of method 608.1.

d. The voltage connection and frequency at which this method is to be performed.

METHOD 750.1d

FUEL LIFT TEST

750.1.1 General. A fuel transfer pump must be capable of lifting and lowering fuel to the power system from an external fuel supply.

750.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in METHOD 205.1. Use instrumentation for measuring ambient temperature as described in METHOD 110.1. In addition, use an external fuel supply and a fuel line as specified in the procurement document.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

750.1.3 Procedure.

750.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

b. Drain the fuel from the power system fuel tank if applicable.

c. Connect the fuel line between the power system and an external fuel supply.

750.1.3.2 Test.

a. Locate the bottom of the external fuel supply 6 feet below the fuel transfer pump.

b. Operate the power system's auxiliary fuel system in accordance with the operating instructions or technical manual.

**CAUTION: Continuing to prime the power system longer than the time allowed in the operating instructions or technical manual may cause failure of the transfer pump.**

c. Start the power system in accordance with the operating instructions on the power system or in the technical manual. If the power system does not start, stop test and record failure.

d. If the power system started, apply rated load. During all portions of this Method, record all instrumentation at maximum intervals of 15 minutes per METHOD 203.1 (see FIGURE 750.1-1).

e. Continue to operate the power system at rated voltage, rated frequency and rated load for one hour from the external fuel supply.

f. Turn off the power system.

g. Drain the fuel from the power system fuel tank.

h. Locate the bottom of the external fuel supply 6 feet above the fuel transfer pump.

i. Repeat steps b through f.

j. After 5 minutes, check to see if fuel is entering the power system fuel tank. Record results on data sheet.

750.1.4 Results. Compare the operation of the power system with the procurement document requirements.

750.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Height of the external fuel supply in relation to the power system fuel transfer pump if other than as specified herein.

b. The voltage connection(s) and frequency(ies) at which this Method is to be performed.

c. Type of fuel to be used.

d. Length and size of fuel line.

**DESCRIPTION:** 10 KW 60 HZ
120 VOLT SINGLE-PHASE
POWER SYSTEM

**MFGR:** ENGENSETS, INC

**MODEL NO.** SF-10.0-MD

**SERIAL NO.** 10777

**REF.** MIL-STD-705/750.1b

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

FUEL LIFT TEST

**TEST NO.** 19

**SHEET:** 1 OF 1

**DATE:** 15 JANUARY 2016

**RECORDER:** L. WRIGHT

**PROJ. ENGR** J.J. JONES

**SHIFT LEADER:** H. SMITH

**OBSERVER:** L. SEE

| **INST.→** | | 107 | | 212 | | 318 | | 287 | | 017 | | | | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | | | | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | | | | | | |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0800 | STARTED POWER SYSTEM WITH FUEL SUPPLY 6 FEET BELOW | | | | | | | | | | | | | | | |
| | 0800 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0815 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0830 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0845 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0900 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 0905 | TURNED OFF POWER SYSTEM | | | | | | | | | | | | | | | |
| | 0915 | DRAINED POWER SYSTEM FUEL TANK | | | | | | | | | | | | | | | |
| | 1000 | STARTED POWER SYSTEM WITH FUEL SUPPLY 6 FEET ABOVE | | | | | | | | | | | | | | | |
| | 1000 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 1015 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 1030 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 1045 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 1100 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | | | | | | 73 |
| | 1105 | TURNED OFF POWER SYSTEM | | | | | | | | | | | | | | | |
| | 1110 | EXAMINED POWER SYSTEM, FUEL IS ENTERING POWER SYSTEM | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | THE POWER SYSTEM OPERATED WITHIN SPECIFICATION LIMITS DURING ALL PARTS OF THIS TEST | | | | | | | | | | | | | | | | |

SIMULATED DATA
FOR ILLUSTRATIVE
PURPOSE ONLY

FIGURE 750.1-1 Typical test record for fuel lift test.

# METHOD 760.2c

## WINTERIZATION TEST

**NOTE**: Method 760.2c was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

760.2.1 General. The heater and its controls must function properly.

760.2.2 Apparatus. None other than the normal heater controls unless the overheat devices have to be bypassed.

760.2.3 Procedure.

a. Place the heater in operation by following the instructions on the set or in the technical manual. If the ambient temperature is such that the heater will not start, bypass the thermostats. Operate the heater for one cycle of operation.

b. If any of the thermostats were bypassed, they shall be returned to the control circuit.

c. Record whether the heater operated properly.

760.2.4 Results. Compare the results obtained with the procurement document requirements.

760.2.5 Procurement document requirements. The following item must be specified in the individual procurement document:

a. Proper operation criteria for the heater and its controls during the performance of this method.

METHOD 770.1c

RECTIFIER TEST

**NOTE**: Method 770.1c was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

770.1.1 General. The rectifiers must be capable of withstanding the peak voltage and currents encountered during any operating condition.

770.1.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient temperature shall be as described and illustrated in MIL-HDBK-705. In addition, a shorting switch and a memory type oscilloscope shall be required.

770.1.3 Procedure.

770.1.3.1 Preparation for test.

a. Connect the load and field instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 for one voltage connection and frequency specified in the procurement document.

b. Connect the shorting switch directly to the set output terminals.

c. Connect the memory oscilloscope to measure the voltage across one of the rectifiers specified in the procurement document (if necessary, slip rings shall be provided to evaluate rotating rectifiers).

770.1.3.2 Test.

a. Start and operate the generator set and allow the set to stabilize at rated load, rated voltage and rated frequency. During this period record all instrument readings including ambient temperature at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and frequency. Adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or frequency adjust devices. On sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the procurement document. Adjustments to the load, voltage or frequency controls shall be recorded on the data sheet at the time of adjustments. Unless otherwise specified in the procurement document, stabilization shall be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variation about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made (see FIGURE 770.1-1).

b. After stabilization has occurred turn on the memory oscilloscope and record the peak voltage across the rectifier as the load is reduced to zero in one step (see FIGURE 770.1-1).

c. Again use the memory oscilloscope and record the peak voltage across the rectifier as rated load is applied in one step.

d. While at rated load use the memory oscilloscope and record the peak voltage across the rectifier as the shorting switch is closed momentarily.

**NOTE**: In the case of 3-phase generator sets, a symmetrical 3-phase line-to-line short circuit shall be applied.

e. Repeat steps a through d above two additional times.

f. Connect the memory oscilloscope and shunt to indicate the current through the rectifier.

g. Repeat steps a through d above three additional times recording the peak current through the rectifier in each test.

h. Repeat steps a through g above for each rectifier specified in the procurement document.

i. Repeat steps a through h above for each voltage connection and frequency specified in the procurement document requirements.

j. Perform any additional procedures necessary for comparison of the rectifier ratings with the procurement document requirements.

770.1.4 Results. Compare the results with the rectifier ratings and compare both the results and the rectifier ratings with the procurement document requirements.

770.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Voltage connection(s) and frequency(ies) at which this method is to be performed.

b. Peak inverse voltage rating of each rectifier to be tested.

c. Peak current rating of each rectifier to be tested.

d. Each rectifier on which this method is to be performed.

**DESCRIPTION:** 10 KW, 60 HZ
120 V, SINGLE PHASE
GENERATOR SET

**MFGR:** ENGENSETS, INC
**MODEL NO.** SF-10.0-MD
**SERIAL NO.** 10742
**REF.** MIL-STD-705/770.1

**PHILADELPHIA REGION**
**DEFENSE CONTRACT ADMINISTRATION SERVICE**

RECTIFIER TEST

**TEST NO.** 27

**SHEET:** 1 OF 1

**DATE:** APRIL 25, 1971
**RECORDER:** L. WRIGHT
**PROJ. ENGR** J.J. JONES
**SHIFT LEADER:** H. SMITH
**OBSERVER:** L. SEE

| **INST.→** | | 104 | | 312 | | 218 | | 716 | | 412 | | 148 | 367 | | | | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | LINE CURRENT | | OUTPUT POWER | | POWER FACTOR | | FREQUENCY | | EXCITER FIELD | | PEAK INVERSE VOLT. | | | AVG AMB TEMP |
| **UNITS** | HRS | | VOLTS | AMPS | AMPS | KW | KW | | -- | | HZ | VOLTS | AMPS | DIODE | VOLTS | | °F |
| **SYM** | | | | X40 | X1 | X40 | X1 | | | | | | | No | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 08:15 | STARTED SET – APPLIED RATED LOAD | | | | | | | | | | | | | | | |
| | 0830 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.1 | 1.32 | | | | 74 |
| | 0840 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.3 | 1.32 | | | | 75 |
| | 0850 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| | 0900 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| | 0910 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| | 0920 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| | 0922 | DROPPED RATED LOAD IN ONE STEP | | | | | | | | | | | | CR1 | 27 | | |
| | 0924 | APPLIED RATED LOAD IN ONE STEP | | | | | | | | | | | | CR1 | 40 | | |
| | 0928 | APPLIED MOMENTARY SHORT CIRCUIT | | | | | | | | | | | | CR1 | 55 | | |
| | 0940 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.3 | 1.32 | | | | 75 |
| | 0950 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| | 1000 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| | 1010 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| | 1020 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| | 1022 | DROPPED RATED LOAD IN ONE STEP | | | | | | | | | | | | CR1 | 26 | | |
| | 1024 | APPLIED RATED LOAD IN ONE STEP | | | | | | | | | | | | CR1 | 41 | | |
| | 1028 | APPLIED MOMENTARY SHORT CIRCUIT | | | | | | | | | | | | CR1 | 55 | | |
| | 1040 | | 120.0 | 2.60 | 104 | .250 | 10.0 | | .80 | | 60.0 | 14.4 | 1.32 | | | | 75 |
| **NOTES** | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |

FIGURE 770.1-1 Portion of a typical test record for rectifier test.

# METHOD 771.1a

# LOAD BANK TEST

**NOTE**: Method 771.1a was not revised for MIL-STD-705D. See 6.3. Testers using this Method are advised to use the applicable information from MIL-HDBK-705C.

771.1.1 General. Load banks are added to some diesel generator sets to increase the time between major maintenance due to light load conditions. This is done by keeping the engine loaded to more than 50 percent of its horsepower rating. The proper function of the load bank is of importance in keeping maintenance costs to a minimum.

771.1.2 Apparatus. Instrumentation for measuring load conditions and ambient temperature shall be as described and illustrated in MIL-HDBK-705.

771.1.3 Procedure.

771.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, method 205.1, paragraph 205.1.10 to measure the load applied by the set load bank with the voltage sensing lines connected to the generator set output terminals for a voltage connection and frequency specified in the procurement document.

b. Connect the generator set integral load bank for the voltage connection used in step a above, and connect the load bank to the set electrically, if necessary.

771.1.3.2 Test.

a. Start and operate the generator set at rated voltage, rated frequency and no load. Record all instrument readings.

b. Using the load bank switch, energize the load bank at its minimum percent step. Record all instrument readings and note operation of load bank indicator light.

c. Repeat step b above for all other steps of the load bank switch.

d. Repeat step b above for any other load steps available.

e. Repeat 770.1.3 for any other voltage connection specified in the procurement document.

771.1.4 Results. Compare the power absorbed by the generator set integral load bank with the requirements specified in the requirements specified in the requirements specified in the procurement document.

771.1.5 Procurement document requirements. The following items must be specified in the individual procurement document.

a. The tolerance band in percent of rated load within which the load bank must operate at each step, if applicable.

b. The voltage connections at which this test shall be performed.

| | | |
|---|---|---|
| **DESCRIPTION:** 30 KW 60 HZ<br>120/208 V, 3-PHASE<br>GENERATOR SET<br><br>**MFGR:** ENGENSETS, INC<br><br>**MODEL NO.** SF-30.0-MD<br><br>**SERIAL NO.** 13057<br><br>**REF.** MIL-STD-705/771.1 | **PHILADELPHIA REGION**<br>**DEFENSE CONTRACT ADMINISTRATION SERVICE**<br><br>LOAD BANK TEST | **TEST NO.** 76<br><br>**SHEET:** 1 OF 1<br><br>**DATE:** SEPT 23, 1970<br><br>**RECORDER:** L. WRIGHT<br><br>**PROJ. ENGR** J.J. JONES<br><br>**SHIFT LEADER:** H. SMITH<br><br>**OBSERVER:** L. SEE |

| **INST.→** | | 107 | | | | | | 213 | | | 306 | | | | 518 | 506 | 1076 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **READ NO ↓** | TIME | TERMINAL VOLTAGE | | | | | | LINE CURRENT | | | OUTPUT POWER | | | | POWER FACTOR | FREQ | AVG AMB TEMP |
| | | $L_1$-N | $L_2$-N | $L_3$-N | $L_1$-$L_2$ | $L_2$-$L_3$ | $L_3$-$L_1$ | $L_1$ | $L_2$ | $L_3$ | $L_1$ | $L_2$ | $L_3$ | TOTAL | | | |
| **UNITS** | HRS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | VOLTS | AMPS | AMPS | AMPS | KW | KW | KW | KW | -- | HZ | °F |
| **SYM** | | | | | | | | X20 | X20 | X20 | X20 | X20 | X20 | X1 | | | |
| **COL** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
| | 0817 | STARTED SET | | | | | | | | | | | | | | | |
| | 0820 | 120.0 | 119.8 | 120.2 | 208 | 208 | 208 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | 60.0 | 73 |
| | 0822 | SWITCH IN 25% LOAD POSITION – LIGHT "ON" | | | | | | | | | | | | | | | |
| | 0824 | 120.0 | 119.8 | 120.2 | 208 | 208 | 208 | 0.65 | 0.67 | 0.66 | .078 | .078 | .079 | 4.70 | 1.0 | 60.0 | 73 |
| | 0826 | SWITCH IN 50% LOAD POSITION – LIGHT "ON" | | | | | | | | | | | | | | | |
| | 0828 | 120.0 | 119.8 | 120.2 | 208 | 208 | 208 | 1.30 | 1.32 | 1.32 | .156 | .156 | .158 | 9.40 | 1.0 | 60.0 | 74 |
| | 0830 | SWITCH IN 75% LOAD POSITION – LIGHT "ON" | | | | | | | | | | | | | | | |
| | 0832 | 120.0 | 119.8 | 120.1 | 208 | 208 | 208 | 1.95 | 1.99 | 1.98 | .234 | .234 | .237 | 14.10 | 1.0 | 60.0 | 74 |
| | 0835 | SWITCH IN 100% LOAD POSITION – LIGHT "ON" | | | | | | | | | | | | | | | |
| | 0837 | 120.0 | 119.7 | 120.1 | 208 | 208 | 208 | 2.60 | 2.60 | 2.60 | .312 | .312 | .312 | 18.80 | 1.0 | 60.0 | 74 |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | SIMULATED DATA FOR ILLUSTRATIVE PURPOSE ONLY | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| **NOTES** | LINE CURRENTS MEASURED USING C.T. $L_1$ - 3075 | | | | | | | | | | | | | | | | |
| | $L_2$ - 3036 | | | | | | | | | | | | | | | | |
| | $L_3$ - 3073 | | | | | | | | | | | | | | | | |

FIGURE 771.1-I Typical test record for load bank test.

METHOD 772.1

ICE GLAZE AND WIND TEST

772.1.1 General. The power system must be capable of operating with accumulations of ice glaze, freezing rain and hoarfrost.

772.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in METHOD 205.1. Use instrumentation for measuring ambient temperature as described in METHOD 110.1. Use apparatus required to perform the test in accordance with Method 521 of MIL-STD-810.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

772.1.3 Procedure.

772.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

772.1.3.2 Test Procedure.

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours from start of the test.

b. Perform the test in accordance with Method 521 of MIL-STD-810 under the following conditions:

    1. With the ambient temperature between -23ºC (-10ºF) and 0ºC (32ºF), and with a steady wind speed of at least 22.25 m/s (73 ft/s), deliver a uniform rain spray on the non-operating power system until 12.7 mm (0.5 inch) of ice glaze has accumulated on the top of the power system.

    2. After accumulation of 12.7 mm (0.5 inch) on the top of the power system, start and operate the power system at no load for a minimum of 1 hour.

**CAUTION: If necessary, de-icing is allowed only in order to operate the power system, e.g. open control panel door(s) and move louvers to operating position. No other de-icing is allowed. De-icing shall not damage the power system.**

c. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours after completion of the test.

772.1.4 Results. Compare the results with the procurement document requirements.

772.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The requirements necessary to evaluate METHOD 608.1.

b. The voltage connection and frequency at which this Method is to be performed.

c. Specific de-icing methods if applicable.

# METHOD 773.1

# SOLAR RADIATION TEST

773.1.1 General. The power system must have the ability to operate under ambient solar radiation without degrading its performance via induced heating or photo-degradation effects.

773.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in METHOD 205.1. Use instrumentation for measuring ambient temperature as described in METHOD 110.1. Use apparatus required to perform the test in accordance with Procedure I of Method 505 of MIL-STD-810.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

773.1.3 Procedure.

773.1.3.1 Preparation for test.

a. Connect the load instrumentation in accordance with the applicable figure of 205.1.10 for the voltage connection and frequency specified in the procurement document.

b. Install thermocouples at the following locations:

   1. Engine compartment.

   2. If the power system control cubicle or control panel has a cover, place the thermocouple on control cubicle or control panel behind the cover.

   3. If the power system control cubicle or control panel does not have a cover, place the thermocouple on the control cubicle or control panel.

   4. Fuel tank.

   5. Top, front, rear, and side surfaces of the housing.

   6. Ambient temperature in accordance with 202.1.4.

773.1.3.2 Test Procedure.

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours before the start of test.

b. Fill the power system onboard fuel tank and all other liquids to rated capacity.

c. Perform the test in accordance with Procedure I of Method 505 of MIL-STD-810 under the following conditions:

1. Cycling shall be in accordance with A1, worldwide deployment, as defined in 2.3.1 of Method 505 of MIL-STD-810.

2. Maintain the chamber air and test temperatures within +2ºC (+3.6ºF). The temperature difference shall not exceed 1ºC (1.8ºF) per meter horizontally or a maximum of 2.2ºC (4ºF). With the power system turned-off and the power system shielded from radiated heat, measure its temperature at a point(s) on a horizontal plane 0 to 50mm (2 inches) below the prescribed irradiation plane. Place the temperature sensor at half the distance between the test unit and the chamber wall or 1m (3.28 feet) from the test unit, whichever is smaller.

3. Position the power system in the chamber. Ensure one vertical side and its top receives the greatest amount of radiation during the first 24-hour cycle. Ensure the power system's other sides are exposed to solar radiation equally by the end of the test.

4. Singularly expose each side of the power system to four 24-hour, hot-dry test cycles.

5. Thoroughly examine the power system for physical damage.

c. Remove the power system from the chamber.

d. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term) within four hours after completion of the test.

773.1.4 Results. Compare the results with the procurement document requirements.

773.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The requirements necessary to evaluate METHOD 608.1.

b. The voltage connection and frequency at which this Method is to be performed.

c. Definition of damage.

d. Additional locations of thermocouples other than as specified herein.

METHOD 774.1

ROAD TRANSPORTABILITY TEST

774.1.1 General. The power system must be capable of withstanding the shock and vibration and endurance of off-road, cross-country transport without structural or functional damage. Skid-mounted power systems are transported within tactical wheeled vehicles as loose cargo or mounted on a trailer chassis. Trailer-mounted power systems are configured two ways: a single system on one trailer (Power Unit-PU); and two power systems with switch box and cables on one or two trailers (Power Plant-PP).

774.1.2 Apparatus. Use instrumentation for measuring load conditions as described and illustrated in METHOD 205.1. Use instrumentation for measuring ambient temperature as described in METHOD 110.1. Use a military truck of size applicable to the power system under test for skid power system testing. Use a military trailer and compatible military truck for PU and PP testing. Use instrumentation for measuring and recording the truck speed and road mileage.

Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4.

774.1.3 Procedure.

774.1.3.1 Power Unit and Power Plant (PU/PP).

774.1.3.1.1 Preparation for test.

a. Service the power system(s) to verify that all fluids are at normal operating levels with the exception of the fuel. Unless otherwise stated, fill the fuel tank halfway.

b. Verify the power system(s) and associated equipment is securely mounted to the trailer.

c. Inspect and service the trailer in accordance with its technical manual including the brake system, suspension, lighting, tire pressure and lubrication.

**CAUTION: Ancillary equipment is defined to be equipment placed on the trailer that is NOT part of the Power Unit/Power Plant. Place ancillary equipment so that the trailer's pintle weight limit is not exceeded. Failure to comply may cause damage to the trailer or prime mover.**

d. Positively secure ancillary equipment weight to the trailer. Take care in the placement of the weight so that access to the power system(s) is not restricted for inspections and operational tests.

774.1.3.1.2 Slope operation.

a. Calculate the theoretical tipping angles (critical angles) for both ends and sides of the PU/PP before traversing the slopes to establish a rough approximation of the maximum slopes on which the trailer can safely negotiate. In theory, the critical angle is when the center of gravity (CG) of the item is located vertically above its center of rotation (the mid-point of the tire in a single-axle trailer).

b. Side slope. Tow the PU/PP in a sine wave pattern along the horizontal length of the required side slope(s). Tow the trailer in both directions on the slope. During the traversal of a slope, stop the trailer for inspection purposes. Inspect the power unit or plant for any shifting of on-board equipment, and the overflow of any fluid reservoirs. Record the results of the inspection. Test the maximum side-slope ability of power units or plants having a high vertical CG with the aid of special safety precautions (i.e. a safety cable attached to the item to prevent accidental tip-over).

c. Longitudinal slope. Tow the PU/PP up and down the required longitudinal slope(s). Pay particular attention to the approach and departure of the trailer onto/from the slope. During traversal of the slope, stop the trailer for inspection purposes. Inspect the power unit or plant for any shifting of on-board equipment, and the overflow of any fluid reservoirs. Record the results of the inspection.

774.1.3.1.3 Road, shock and vibration test (Munson Test Area (MTA).

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. Expose the PU/PP to five cycles of the road, shock and vibration courses presented in TABLE 774.1-I.

   1. Visually inspect the PU/PP including the power system(s), equipment and trailer before, during, and after each driving period for any evidence of structural damage, deformation or degradation that may occur during travel. Record results of the inspections.

   2. At the end of each cycle of TABLE 774.1-I, perform METHOD 608.1 at rated load only to verify operability of the test units.

c. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

774.1.3.1.4 Road, endurance test (off road, cross country).

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. Expose the PU/PP to four cycles of the road schedule presented in TABLE 774.1-II.

1. At the beginning and end of each driving period (shift or day), start the PU/PP and run at no-load until stabilized to verify operability including rated voltage, frequency, and adequate oil pressure.

2. Visually inspect the PU/PP including the power system(s), equipment and trailer before, during, and after each driving period for any evidence of structural damage, deformation or degradation that may occur during travel. Record results of the inspections.

3. At the end of each roadability cycle of TABLE 774.1-II, perform METHOD 608.1 at rated load only to verify operability of the test units.

c. During traversal of the road courses, observe the trailer for evidence of weaving, inability to successfully track behind the towing vehicle, interference with the towing vehicle, fluid reservoir overflow, or any other hazardous characteristic. Record findings.

d. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

774.1.3.2 Skid-mounted power systems as loose cargo.

774.1.3.2.1 Preparation for test.

a. Service the power system to verify that all fluids are at normal operating levels with the exception of the fuel. Unless otherwise stated, fill the fuel tank halfway.

b. Tiedown the power system on a military vehicle using the lifting and tiedown eyes, if applicable, and cargo straps. The tiedown shall be in accordance with the requirements of the vehicle and SDDCTEA Pamphlet 55-20.

**WARNING:**

**Ensure power system is properly grounded if the METHOD 608.1 testing is performed on the vehicle. Failure to do so may cause personal injury or death.**

774.1.3.2.2 Road, endurance test.

a. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. Expose the power system to four cycles of the road schedule presented in TABLE 774.1-II.

1. At the beginning and end of each driving period (shift or day), start the power system and run at no-load until stabilized to verify operability including rated voltage, frequency, and adequate oil pressure.

2. At the beginning and end of each driving period (shift or day), start the power system and run at no-load until stabilized to verify operability including rated voltage, frequency, and adequate oil pressure.

3. At the end of each roadability cycle of TABLE 774.1-II, perform METHOD 608.1 at rated load only to verify operability of the test units.

c. Perform METHOD 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

774.1.4 Results. Compare the results with the procurement document requirements.

774.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Requirements necessary to evaluate METHOD 608.1.

b. The voltage connection and frequency at which this Method is to be performed.

c. Definition of damage.

d. Number of cycles if other than as specified herein.

e. Speeds if other than as specified herein.

f. Courses if other than as specified herein.

TABLE 774.1-I. Road, shock and vibration test courses and speeds.

| Test Course | Speed | |
|---|---|---|
| | mph | km/hr |
| Belgian Block | 20 | 32 |
| 2-Inch Washboard | 10 | 16 |
| 3-Inch Spaced Bump | 20 | 32 |
| Radial Washboard | 15 | 24 |
| 6-Inch Washboard | 5 | 8 |

TABLE 774.1-II. Road, endurance test schedule.

| Road Course (Aberdeen Proving Ground, Maryland) | Distance | | Maximum Speed | |
|---|---|---|---|---|
| | mi | km | mph | km/hr |
| Paved highway (Perryman Paved) | 250 | 402 | 50 | 80 |
| Level cross-country (Perryman 1) | 250 | 402 | 20 | 32 |
| Hilly cross-country (Churchville B) | 125 | 201 | 20 | 32 |
| Belgian Block (Munson Test Area) | 15 | 24 | 20 | 32 |
| Totals | 640 | 1029 | | |

# METHOD 801.1

## ALTERNATE/EMERGENCY FUEL TEST

801.1.1 General. Some power systems may be required to operate using alternate or emergency fuels instead of the primary fuel(s). A power system's primary fuel permits full design performance. An alternate fuel provides acceptable operational performance in comparison; though it might have environmental limitations or is unavailable in tactical areas. The alternate fuel shall not degrade power system performance below its minimum specified requirements. Degraded reliability or durability is not acceptable. An emergency fuel is only used when the primary or alternate fuel is not available. Using an emergency fuel shall not reduce the power system's operating life. When an emergency fuel is used, severe performance degradation is permissible.

801.1.2 Apparatus. Any digitizing testing and evaluating system used during this Method shall meet the requirements of 4.4. Use apparatus to perform the following Methods:

a. METHOD 710.1, High Temperature Test.

b. METHOD 701.2, Starting and Operating Test (Basic Cold Battery Start, -25ºF).

c. METHOD 690.1, Endurance Test.

801.1.3 Procedure.

a. Perform the following tests using the alternate/emergency fuel:

1. METHOD 710.1, High Temperature Test.

   i. Perform the test at the temperature required by the procurement document.

   ii. Only perform METHOD 608.1, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term) in 710.1.3.2g. In addition to the required data, record all thermal and pressure instrumentation as specified in 710.1.3.1 at the same time for the stabilization portion of this test.

2. METHOD 701.2, Starting and Operating Test (Basic Cold Battery Start, -25ºF).

   i. Perform the test at the temperature required by the procurement document, if not at -25ºF.

   ii. Replace the Methods listed in 701.2.3.2i with "METHOD 608.1, Voltage and Frequency Regulation, Stability and Transient

Response Test (Short Term). In addition to the required data, record all thermal instrumentation as specified in 701.2.3.1 at the same time for the stabilization portion of this test."

3. METHOD 690.1, Endurance Test.

    i. Perform the endurance test for 300 hours.

801.1.4 Results. Compare the results to the procurement requirements for METHOD 710.1 and METHOD 701.2. Acceptance requirement for METHOD 690.1 shall be zero relevant or critical failures.

801.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. The temperature at which the high temperature test (METHOD 710.1) is to be performed.

b. The temperature at which the low temperature test (METHOD 701.2) is to be performed, if not at -25ºF.

c. Requirements necessary to evaluate METHOD 710.1.

d. Requirements necessary to evaluate METHOD 701.2.

e. Requirements necessary to evaluate METHOD 690.1.

# METHOD 802.1

## SAFETY AND HEALTH TEST

802.1.1 General. The power system shall not pose an unsafe or hazardous condition to personnel.

802.1.2 Apparatus. No specific apparatus is required.

802.1.3 Procedure.

802.1.3.1 Preliminary safety and health assessment. Perfrom a preliminary safety and health assessment upon receipt of the test units. This shall establish the safety of the units so that hazards to test participants can be minimized. As a minimum this preliminary assessment shall include the following essentials:

a. Conduct a thorough examination during the initial inspection and service test to identify all obvious safety problems. Based on a visual examination of the units, complete the Safety Checklist (TABLE 802.1-I) by the test director and, if available, a qualified safety engineer. The limited visual inspections will likely expose only obvious safety problems. Thus, these inspections ensure more thorough safety/health evaluations occur during the balance of testing. This review ensures the manuals contain sufficient safety and health information. Specific areas of interest include: data and warning plates; and noise, electrical shock or other hazard warnings. Other areas include proper grounding procedures, schematics and lifting/tie-down diagrams. Include these and any other pertinent safety/health information in the manual too. Perform some limited safety-related tasks, if necessary, to ensure that the test items are safe for further testing.

b. During the initial inspection, perform an initial safety review using the safety checklist contained in TABLE 802.1-I. Answer the appropriate questions insofar as possible without further testing. Provide detailed comments and answers for each applicable question of the safety checklists for electrical and mechanical hazards. Do not limit responses to only the items appearing on the checklist; for any other safety and health hazards, record and incorporate them into this subtest.

802.1.3.2 Comprehensive safety and health assessment. Conduct a comprehensive safety and health assessment throughout the entire test program. This assessment shall include:

a. Systematic observations and analysis of the test units prior to and throughout all phases of the entire test to identify and investigate any actual or potential hazards to personnel and equipment that may result from operation and maintenance. Document with a detailed description all safety hazards identified during operation, maintenance, and all other phases of operation.

b. To ensure that the checklist of TABLE 802.1-I has been completed and that all hazards have been identified, continuously monitor the test units for hazards during all phases of testing and maintenance. By the end of testing, ensure all items on the safety checklist have been answered.

c. Limitations or compromises on operating performance and maintenance because of safety considerations.

d. Examination of safety instructions and warning plates for adequacy and appropriate location.

e. Examination of operation and service manuals for adequate safety guidance concerning operation and maintenance.

f. Classification of all safety hazards in accordance with MIL-STD-882 with recommendations for appropriate corrective measures and ways to either reduce or eliminate the hazard severity and hazard probability.

802.1.4 Results.

a. List all mechanical and electrical hazards. Identify all hazards that require warning labels/placards.

b. Review and assess each NO answer reported in the checklist of TABLE 802.1-I and any other hazards identified to determine the degree of noncompliance with the criteria. Use the hazard classification (including hazard severity and hazard probability) outlined in MIL-STD-882 to classify all identified safety hazards into hazard level categories. Categorize the hazards as a deficiency, shortcoming, or suggested improvement using TABLE 802.1-II.

c. Thoroughly analyze to determine the extent of the problems and their impact on the operators, maintainers, and other personnel associated with the units all problems recorded that have an effect on safety. Evaluate and propose corrective actions for noncompliance with specific elements of the criteria. Make appropriate recommendations regarding methods to control, downgrade, or eliminate actual or potential hazards so that the necessary changes can be incorporated before field deployment.

802.1.5 Procurement document requirements. The following items must be specified in the individual procurement document:

a. Any special safety and health considerations if not covered by this Method and the TABLE 802.1-I Safety Checklist.

TABLE 802.1-I. Safety checklist.

| No. | Item | Yes | No | NA | Remarks |
|---|---|---|---|---|---|
| 1 | Are all external parts, surfaces, shields, and all other electrically neutral parts at ground potential at all times during normal operation? | | | | |
| 2 | Is the ground connection for all external parts mechanically secured? | | | | |
| 3 | Is there a suitable terminal lug or other ground connection located on the chassis or frame to provide a continuous and permanent path to ground? | | | | |
| 4 | Are grounding rods furnished? | | | | |
| 5 | Are output terminals or other high potentials, in excess of 70 VRMS, sufficiently shielded or guarded to prevent accidental contact by personnel? | | | | |
| 6 | Are energized components located or enclosed so that suitable protection is provided against contact with uninsulated items? | | | | |
| 7 | Are components, conductors, and shielding appropriately located such that overheating, arching, shorting, and contact with moving parts is avoided? | | | | |
| 8 | Are wires and cables adequately supported and terminated to prevent shock and fire hazard? | | | | |
| 9 | Are wires and cables properly protected against rubbing at access ports by insulated bushings? | | | | |
| 10 | Is the test unit provided with warning placards or caution plates mounted conspicuously adjacent to any condition presenting a potential hazard to personnel (such as high voltage, rotating parts, sharp corners, etc.)? | | | | |
| 11 | Are electrical connectors designed to ensure that only the correct plug can be inserted into its receptacle and not into a wrong receptacle? | | | | |
| 12 | Where design considerations require plugs and receptacles of similar configurations, are mating plugs and receptacle suitably coded or marked to indicate the correct mating connection? | | | | |
| 13 | Are exposed connector pins energized after being disconnected? | | | | |
| 14 | Are controls located away from high voltage areas? | | | | |
| 15 | Are emergency controls placed in readily accessible positions? | | | | |

TABLE 802.1-I. Safety checklist – Continued.

| No. | Item | Yes | No | NA | Remarks |
|---|---|---|---|---|---|
| 16 | Is the main contactor button in an easily accessible location? | | | | |
| 17 | Does a battle short switch (to bypass the safety interlocks) exist on the main control panel? | | | | |
| 18 | Is the battle short switch designed with a readily visible indicator light to show that it is on? | | | | |
| 19 | Are the following protective devices present with suitable indicators to safeguard against operator injury and/or equipment failure?:<br><br>Low oil pressure<br>High coolant temperature<br>Overspeed<br>Low fuel<br>Short circuit<br>Overload<br>Under voltage<br>Under frequency<br>Reverse power<br>Over voltage | | | | |
| 20 | Are DC power connections clearly marked for polarity? | | | | |
| 21 | Does a DC circuit breaker exist that can cut off all power to the entire system? | | | | |
| 22 | Are potential electrical hazards adequately treated in the instruction manual? | | | | |
| 23 | Are operator means of detecting hazardous conditions adequate? | | | | |
| 24 | Are circuit breakers and all control panel instruments and controls properly labeled? | | | | |
| 25 | Does the convenience outlet have provisions for automatic grounding? | | | | |
| 26 | Are adjustment screws or other commonly worked-on parts located away from unprotected high voltages? | | | | |
| 27 | Are tools to be used near high voltages, such as the load terminal wrench, adequately insulated? | | | | |
| 28 | Is the grounding conductor of the equipment electrically insulated from the AC power return (neutral)? | | | | |
| 29 | Are internal controls located at safe distances from dangerous voltages? | | | | |

TABLE 802.1-I. Safety checklist – Continued.

| No. | Item | Yes | No | NA | Remarks |
|---|---|---|---|---|---|
| 30 | Are protective guards sufficiently separated from exposed conductors to prevent shorting or arcing? | | | | |
| 31 | Are components that sustain high operating temperatures during normal operation (such as exhaust pipes, turbochargers, radiators, etc.) sufficiently protected to prevent accidental contact by personnel? | | | | |
| 32 | Are these components adequately identified by warning plates? | | | | |
| 33 | Are the materials used in the housing including noise attenuating material inherently nonflammable and nonexplosive? | | | | |
| 34 | Do exposed gears, cams, levers, fans, belts, or other reciprocating, rotating, or moving mechanical parts have adequate safety covers? | | | | |
| 35 | Are doors, hinged covers, panels, and any other exposed sharp projections or overhanging edges presenting a potential safety hazard rounded to prevent injury to personnel? | | | | |
| 36 | Are fasteners and methods of securing doors and peripheral ancillary components sufficiently strong to prevent breakaway during normal use? | | | | |
| 37 | Is the method of opening doors or covers evident from the construction of the cover? If not, is an instruction plate permanently attached to the outside of the cover? | | | | |
| 38 | Is it evident when a cover is in place but not secured? | | | | |
| 39 | Are tasks of operation and maintenance such that they do not require excessive physical strength? | | | | |
| 40 | Can maintenance be accomplished with shielding in place? | | | | |
| 41 | Do external or internal surfaces that expand during maintenance have sharp edges? | | | | |
| 42 | Is the center of gravity and weight of the test unit distinctly marked? | | | | |
| 43 | Are weight capacities indicated on tie-downs, lifting points, etc.? | | | | |
| 44 | Is the test unit provided with sufficient caution plates to warn maintenance personnel of potential safety hazards? | | | | |
| 45 | Is the control panel adequately illuminated for safe and efficient operation? | | | | |

TABLE 802.1-I. Safety checklist – Continued.

| No. | Item | Yes | No | NA | Remarks |
|---|---|---|---|---|---|
| 46 | Have fire-extinguishing methods been included in the technical publications? | | | | |
| 47 | Are potential mechanical hazards adequately treated in the draft instruction manual? | | | | |
| 48 | Do floor surfaces provide adequate nonslip characteristics? | | | | |
| 49 | Are lifting rings or slings provided? | | | | |
| 50 | Are climbing rings, handholds, rails, etc., provided where needed? | | | | |
| 51 | Do doors and hinged covers have positive-action hold-open devices? | | | | |
| 52 | Are handles recessed rather than extended where they might be hazardous? | | | | |
| 53 | Are doors and other openings free of hazards from improperly designed catches, hinges, supports, fasteners, and stops? | | | | |
| 54 | Are fuel lines and their connection fittings routed away from electrical wiring, terminal connections and hot surfaces? | | | | |
| 55 | When glass is used is it glare proof and shatter proof? | | | | |
| 56 | Does the ventilating system provide for operator safety by ducting excess heat liberated by the radiator cooling air or other hot air outlets to the exterior of the power system? | | | | |
| 57 | Are adequate precautions made to prevent exposure of operators and maintainers to exhaust gases or other toxic fumes? | | | | |
| 58 | Is the air intake isolated or at a sufficient distance from the exhaust? | | | | |
| 59 | Does the instruction and maintenance manual specify type of cleaning fluid and precautions to be taken when cleaning the equipment? | | | | |

TABLE 802.1-II. Hazard probability versus hazard severity.

| | HAZARD PROBABILITY | | | | | |
|---|---|---|---|---|---|---|
| | **FREQUENT** | **PROBABLE** | **OCCASIONAL** | **REMOTE** | **IMPROBABLE** | **ELIMINATED** |
| SPECIFIC INDIVIDUAL ITEM | Likely to occur frequently | Will occur several times in life of item | Likely to occur sometime in the life of item | Unlikely but possible to occur in the life of an item | So unlikely it can be assumed the occurrence may not be experienced | eliminated |
| FLEET OR INVENTORY | Continuously experienced | Will occur frequently | Will occur several times | Unlikely but can reasonably be expected to occur | Unlikely to occur but possible | eliminated |
| HAZARD SEVERITY | A | B | C | D | E | eliminated |
| I - CATASTROPHIC<br>May cause death or system loss | Deficiency | Deficiency | Deficiency | Deficiency | Shortcoming | eliminated |
| II - CRITICAL<br>May cause severe injury occupational illness, or major system damage | Deficiency | Deficiency | Deficiency | Shortcoming | Suggested improvement | eliminated |
| III - MARGINAL<br>May cause minor injury, minor occupational illness or minor system damage | Deficiency | Shortcoming | Shortcoming | Suggested improvement | Suggested improvement or Acceptable | eliminated |
| IV – NEGLIGIBLE<br>May cause less than minor injury occupational illness or system damage | Shortcoming | Suggested improvement | Acceptable | Acceptable | Acceptable | eliminated |

METHOD 803.1

HUMAN FACTORS ENGINEERING TEST

803.1.1 General. The power system must satisfy general human engineering design criteria and practices in accordance with MIL-STD-1472 and as specified in the procurement document.

803.1.2 Apparatus. Use the following equipment: photographic and video equipment, tape measure, ruler, and illumination meter (lighted display).

803.1.3 Procedure.

803.1.3.1 Control, display, labeling. Observe all controls, displays, and labeling with respect to Human Factors Engineering (HFE) design practices based on 5.1, 5.2, 5.4, and 5.5 of MIL-STD-1472. Take control separation and control dimensional measurements to determine if any design problems exist. Observe the ability of the operator to successfully operate the power system while wearing regular, arctic, and Mission Oriented Protective Posture Level IV (MOPP-IV) gear as well as the operator's ability to operate the power system at night.

803.1.3.2 Workspace and maintenance access. Observe maintenance access openings and workspaces with respect to the ability of the crew to perform maintenance and to determine compatibility with anthropometrical dimensions for the 5th through 95th percentile personnel while outfitted in combat uniform, arctic, and MOPP-IV protective ensembles.

803.1.3.3 Subjective assessment.

a. Questionnaires/interviews. Administer human factors questionnaires to personnel assigned to the testing program. Questionnaires shall primarily pertain to operating and maintaining the equipment. Devote a section of each questionnaire to task performance while wearing MOPP-IV and arctic gear. Administer questionnaires, (TABLE 803.1- II), near the end of the test cycle to assure that all personnel are thoroughly experienced with system operations before completing the forms. Conduct interviews to determine the test participant's opinions on the overall operation, maintenance, and performance of the power system.

b. Checklists. Complete checklists (TABLE 803.1-III) by an HFE engineer on the following elements of system design:

   1. HFE design – controls, displays, and markings.

   2. Maintainability.

c. General HFE Observations. Make observations throughout all testing to gain additional information on any HFE-related problems. Document comments and informal interviews, in addition to HFE observations, throughout to provide subjective input to assess the power system. Use these interviews, comments, and observations to augment data from other HFE subtests supplements and integrate them into the analysis of the power system.

803.1.3.4 Anthropometrics and demographic data.

a. Anthropometrics data. Take anthropometrical measurements (standard distribution presented in TABLE 803.1-I) of test personnel who participate in daily operation, maintenance, and performance exercises.

TABLE 803.1-I. Distribution of anthropometrics measurement data by uniform type.

| Measurements | 5th Percentile | | | | 95th Percentile | | | |
|---|---|---|---|---|---|---|---|---|
| | Regular | | Arctic | | Regular | | Arctic | |
| | cm | in | cm | in | cm | in | cm | in |
| Stature (nude) | 163.8 | 64.5 | - | - | 186.0 | 73.2 | - | - |
| Functional Reach | 72.6 | 28.6 | 77.7 | 30.6 | 90.9 | 35.8 | 95.5 | 37.6 |
| Sitting height, erect | 85.1 | 33.5 | 87.9 | 34.6 | 97.0 | 38.2 | 101.6 | 40.0 |
| Eye height, sitting | 72.6 | 28.6 | 74.7 | 29.4 | 84.6 | 33.3 | 85.9 | 33.8 |
| Knee Height, sitting | 49.8 | 19.6 | 56.4 | 22.2 | 58.7 | 23.1 | 64.0 | 25.2 |
| Buttock-Knee length | 54.9 | 21.6 | 60.00 | 23.6 | 64.3 | 25.3 | 67.3 | 26.5 |
| Hip Breadth, standing | 30.7 | 12.1 | 41.1 | 16.2 | 38.4 | 15.1 | 48.8 | 19.2 |
| Shoulder Breadth, sitting | 41.4 | 16.3 | 47.5 | 18.7 | 49.8 | 19.6 | 55.9 | 22.0 |
| Buttock-popliteal length | 46.0 | 18.1 | 43.7 | 17.2 | 54.6 | 21.5 | 52.0 | 20.5 |
| Hand Length | 17.5 | 6.9 | 20.8 | 8.2 | 20.6 | 8.1 | 23.9 | 9.4 |
| Palm Length | 8.0 | 3.1 | 12.7 | 5.0 | 9.7 | 3.8 | 12.2 | 4.8 |
| Weight (kg) | 57.3 | - | - | - | 91.6 | - | - | - |

b. Demographic data. Compile demographic data of the same test participants and include the following:

1. Sex.

2. Job position (for this test).

3. Length of experience (in job position).

4. Age.

803.1.3.5 Operator/maintainer performance tasks. Detemine the ability of the test participants to perform critical maintenance tasks while outfitted in MOPP IV and arctic protective ensembles by comparing performance times required to complete the following tasks:

a. Checking, filling, and draining engine oil.

b. Replacing engine oil filter(s).

c. Replacing air filter element.

d. Connecting load cable.

e. Replacing fuel filter(s).

f. Checking, filling, and draining hydraulic fluid (if equipped).

g. Replacing hydraulic fluid filter(s) (if equipped).

h. Other common field maintenance actions such as filling fuel tank and radiator, replacing battery, and adjusting belts, etc.

Record excessive maintenance times or inability to perform any critical maintenance tasks.

803.1.3.6 Manual readability. Determine the reading grade level (RGL) of the operation and maintenance manual in accordance with MIL-STD-40051-2, Preparation of Digital Technical Information for Page-Based Technical Manuals (TMs). Use an adequate number of text samples to determine the overall grade level (OGL).

803.1.3.7 Data required. Obtain the following data.

a. Control separation and dimensional measurements.

b. Ability of operators to operate the power system while wearing regular, arctic, and MOPP-IV gear.

c. Anthropometric and demographic data of test participants.

d. Results of interview and questionnaires administered to test personnel.

e. Results of completed checklists.

f. An assessment of controls and displays.

g. The adequacy of New Equipment Training (NET).

h. RGL and OGL of the operation and maintenance manuals.

i. Photographs and videotapes of HFE problems associated with the setup, operation, or maintenance of the power system.

j. Performance times of critical maintenance tasks while maintainers are outfitted in arctic and MOPP-IV ensembles.

803.1.4 Results.

a. Summarize qualitative results of observations, checklists and questionnaires and present them in narrative and tabular form.

b. Present the degree to which the power systems conform or do not conform to HFE standards and requirements. Support instances of nonconformance by measurements and photographic illustrations. Assess the causes and consequences of nonconformance with regard to the effect on mission performance. Assess any degradation of the systems' man-item relationship with regard to safety and recommend corrective action. Assess human performance reliability in terms of frequency and consequence of human error committed during preparation, operation, and maintenance of the power system. Include a structured interview follow-up of all unfavorable/negative comments to arrive at a description of the cause and possible corrective action in all subjective data analysis.

c. The following shall constitute failure of this test:

   1. Controls, displays, or labeling that do not conform to 5.2, 5.4, and 5.5 of MIL-STD-1472 in relation to appearance, spacing, size, or location.

   2. Inability to successfully operate or maintain the sets when personnel are wearing regular, arctic, or MOPP-IV gear.

   3. Workspace and maintenance access openings that do not allow personnel, with anthropometrical dimensions between the 5th through the 95th percentile, to operate or perform maintenance.

   4. Human factors not in accordance with procurement document requirements.

803.1.5 Procurement document requirements.

a. Human factor requirements other than as specified herein.

b. Definition of failure if other than as in 803.1.4c.

TABLE 803.1- II. HFE questionnaire.

How would you rate the adequacy of the following?

Rating Scale

6 Excellent
5 Very Good
4 Adequate
3 Not Quite Adequate
2 Poor
1 Extremely Poor

| Human Factors Engineering - Adequacy | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|
| 1. Before, during, and after operation checklist. | | | | | | |
| 2. Display panels. | | | | | | |
| 3. Space provided to service power system. | | | | | | |
| 4. Accessibility of hand controls. | | | | | | |
| 5. Illumination of instruments during night operation. | | | | | | |
| 6. Protection of operator from moving parts by guards and warning panels. | | | | | | |
| 7. Lifting provisions. | | | | | | |
| 8. Access for using test equipment. | | | | | | |
| 9. Standard tools and test equipment. | | | | | | |
| 10. Technical manuals for operations and maintenance. | | | | | | |
| 11. Based upon the previous questions, rate the OVERALL ADEQUACY of the power system. | | | | | | |

TABLE 803.1-II. HFE questionnaire – Continued.

How would you rate the adequacy of the following?

Rating Scale

6 Excellent
5 Very Good
4 Adequate
3 Not Quite Adequate
2 Poor
1 Extremely Poor

| Human Factors Engineering - Tasks | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|
| 1. Readings warnings or instruction labels. | | | | | | |
| 2. Connecting and disconnecting power cables. | | | | | | |
| 3. Operation and maintenance while wearing arctic clothing. | | | | | | |
| 4. Operation and maintenance while wearing MOPP-IV gear. | | | | | | |
| 5. Reading and understanding the material presented in the technical manuals. | | | | | | |
| 6. Set up for operation. | | | | | | |
| 7. Operation during hours of darkness. | | | | | | |
| 8. Based upon the previous questions, rate the OVERALL EASE OF OPERATION. | | | | | | |

TABLE 803.1-II. HFE questionnaire – Continued.

Please rate how often the following occur?

Rating Scale

6 Almost Never
5 Very Seldom
4 Seldom
3 Often
2 Very Often
1 Almost Always

| Human Factors Engineering - Intensity | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. The vibration level during operation. | | | | | | |
| 2. The noise level during operation. | | | | | | |
| 3. Exhaust fumes during operation. | | | | | | |

| Human Factors Engineering - Frequency | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Requirement for special tools and test equipment. | | | | | | |
| 2. Glare on operating instruments and gauges. | | | | | | |

TABLE 803.1-III. HFE checklists.

| Yes - Adequate    No - Inadequate    NA - Not Applicable | | | | |
|---|---|---|---|---|
| No. | Items | Yes | No | Remarks |
| | ***HFE Design - Controls, Displays, and Marking*** | | | |
| **1** | **Controls** | | | |
| a | Are all adjustments located on single panel? | | | |
| b | Are controls placed on the panel in the order they will normally be used? | | | |
| c | When controls are used in a fixed procedure, are they numbered to indicate? | | | |
| d | Are controls labeled with functional statements? | | | |
| e | Are control-position markings descriptive rather than coded or numbered? | | | |
| f | Are control scales fine enough to permit accurate setting? | | | |
| g | Except for detents or selector switches, do the controls have smooth, even resistance to movements? | | | |
| h | Are concentric knobs adequately coded to avoid confusion? | | | |
| i | Are adjustment controls easy to set and lock? | | | |
| j | Do all physical adjustment procedures provide visual, auditory, or tactical feedback? | | | |
| k | Are controls free of excessive backlash that could require needless readjustment? | | | |
| l | Are primary and emergency controls easily identifiable both visually and nonvisually? | | | |
| m | Can controls be operated by personnel wearing arctic and MOPP-IV gear? | | | |
| n | The method used to prevent accidental activation of the control, if any does not increase the time required to operate the control to such an extent that it is unacceptable. | | | |

TABLE 803.1-III. HFE checklists – Continued.

Yes - Adequate    No - Inadequate    NA - Not Applicable

| No. | Items | Yes | No | Remarks |
|---|---|---|---|---|
| **2** | **Displays** | | | |
| a | When this equipment is placed in ways that it will typically be used, can the display be easily read? | | | |
| b | The information presented is necessary for the decisions or actions required of the operator. | | | |
| c | The information is presented in the most immediately meaningful form, i.e., no interpretation or decoding is required. | | | |
| d | The information is displayed to the accuracy required by the decisions or actions of the operator. | | | |
| e | Are display scales limited to only that information needed to make decisions or to take some action? | | | |
| f | Information is current, that is, lag is minimized. | | | |
| g | Failure is clearly shown or the operator is otherwise warned. | | | |
| h | The contrast ratio and illumination of controls and/or displays are sufficient under all expected light conditions. | | | |
| i | A warning device is provided to indicate significant deviations from normal operating conditions. | | | |
| ***3*** | ***Miscellaneous*** | | | |
| a | Vibration and noise are kept below levels that might impair the efficiency of personnel. | | | |
| b | Visibility provides the maximum field of view possible in consonance with station, task requirement, and body conformation. | | | |
| c | Illumination of controls and displays is sufficient for the operators to carry out necessary tasks. | | | |
| d | Vibrations do not affect operator performance in reading dials and manipulating controls. | | | |

TABLE 803.1-III. HFE checklists – Continued.

Yes - Adequate   No - Inadequate   NA - Not Applicable

| No. | Items | Yes | No | Remarks |
|---|---|---|---|---|
| e | No material within the operator's vision is capable of reflecting glare sufficiently to impair vision during day or night operation. | | | |
| | ***Maintainability*** | | | |
| ***1*** | ***Handles*** | | | |
| a | When possible, handles are provided on covers, drawers, and components to facilitate handling. | | | |
| b | When handles cannot be provided hoist and lift points are clearly marked. | | | |
| ***2*** | ***Covers*** | | | |
| a | Method of opening a cover is evident from the construction of the cover itself. If not, an instruction plate is permanently attached to the outside of the cover. | | | |
| b | Hinges are used where possible to reduce the number of fasteners required. | | | |
| c | When a hinged cover is used, a space equal to the swept volume of the cover is provided (e.g., opening of the cover is not obstructed by bulkheads brackets, etc.). | | | |
| d | Structural members, other components, etc., do not interfere with removal of a cover. | | | |
| e | It is evident when the cover is in place but not secured? | | | |
| f | If instructions applying to a covered unit are on a hinged door, the lettering is properly oriented for reading when the door is open. | | | |
| g | A minimum number and type of fasteners are used, commensurate with requirements for stress, bonding, etc. | | | |
| h | When possible, the same size and type of fasteners are used for all covers, cases, and access doors. | | | |
| i | Captive nuts and bolts are used where feasible. | | | |
| ***3*** | ***Location of Replaceable Components*** | | | |

TABLE 803.1-III. HFE checklists – Continued.

Yes - Adequate  No - Inadequate  NA - Not Applicable

| No. | Items | Yes | No | Remarks |
|---|---|---|---|---|
| a | Large components which are difficult to remove are mounted so that they do not prevent access to other components. | | | |
| b | Components are placed to allow sufficient space for use of test equipment and other required tools without difficulty or hazard. | | | |
| c | All throwaway components are accessible without removal of other components. | | | |
| d | Structural members of the frame do not prevent access to components. | | | |
| e | Delicate components are so located or guarded that they will not be damaged while the unit is being handled or worked on. | | | |
| f | Sensitive adjustments are so located or guarded that they cannot be accidentally disturbed. | | | |
| g | Internal controls are located at a safe distance from dangerous voltages or access to dangerous voltages is prevented by suitable barriers. | | | |
| ***4*** | ***Conductors and Cables*** | | | |
| a | Conductors are bound into cables and held by means of lacing twine or other acceptable means. | | | |
| b | Long conductors or cables, internal to equipment, are secured to the chassis by cable clamp. | | | |
| c | Cables are long enough so that each functioning component can be checked in a convenient place or, if this is not feasible, extension cables/devices are provided. | | | |
| d | Cables are long enough to permit jockeying or movement of components when it is difficult to connect or disconnect other cables. | | | |
| e | Electrical cables are not routed below fluid lines. | | | |
| f | Cables are routed so they cannot be walked on or used for handholds. | | | |

TABLE 803.1-III. HFE checklists – Continued.

Yes - Adequate No - Inadequate NA - Not Applicable

| No. | Items | Yes | No | Remarks |
|---|---|---|---|---|
| g | Cables are easily accessible for inspection and repair. | | | |
| h | Cables are so routed that they need not be bent or twisted sharply or repeatedly. | | | |
| i | Input and output cables, with the exception of test cables, do not terminate on a control-display panel. | | | |
| j | If test cables terminate on control-display panels, test receptacles are located so that their associated cables do not interfere with controls and displays. | | | |
| ***5*** | ***Connectors*** | | | |
| a | One-turn or other quick-disconnect plugs are used. | | | |
| b | When dirt and moisture are a problem, plugs have an attached cover. | | | |
| c | Connectors are located far enough apart so that they can be grasped firmly for connection and disconnection. | | | |
| d | Plugs are designed so that it is impossible to insert the wrong plug in a receptacle. | | | |
| e | Socket rather than plug contacts are "hot". | | | |
| f | Test points to determine that a unit is malfunctioning are provided. | | | |
| g | Appropriate test provided when a component is not completely self-checking. | | | |
| ***6*** | ***Fuses and Circuit Breakers*** | | | |
| a | Fuses and circuit breakers are so located that they can be easily seen and quickly replaced or reactivated by personnel wearing clothing appropriate to environment of interest. | | | |
| b | No special tools are required for fuse replacement. | | | |
| ***7*** | ***Tools*** | | | |
| a | Variety of tools is held to a minimum. | | | |
| b | As few special tools as possible are required. | | | |

TABLE 803.1-III. HFE checklists – Continued.

Yes - Adequate    No - Inadequate    NA - Not Applicable

| No. | Items | Yes | No | Remarks |
|---|---|---|---|---|
| c | Tools to be used near high voltage are adequately insulated. | | | |
| d | Metal handles are avoided on tools likely to be used in extreme cold or heat. | | | |
| ***8*** | ***Lubrication*** | | | |
| a | Equipment containing mechanical components either has provision for lubrication without disassembly or does not require lubrication. | | | |
| b | When lubrication is required, the type of lubricant to be used and the frequency of lubrication are specified by a label at or near the lubrication point. | | | |

## CONCLUDING MATERIAL

Custodians:
Army – CR4
Navy – YD
Air Force – 99

Preparing activity Army – CR4

(Project Number 6115-2016-001)

Review activities:
Army – AT, MI, TE
Navy – AS, MC
Air Force – 71
DLA – GS

NOTE: The activites listed above were interested in this document as of the date of this document. Since the organization and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.