

MIL-STD-1576 (USAF)

31 JULY 1984

MILITARY STANDARD

**ELECTROEXPLOSIVE SUBSYSTEM
SAFETY REQUIREMENTS AND TEST
METHODS FOR SPACE SYSTEMS**



NO DELIVERABLE DATA REQUIRED BY THIS DOCUMENT

AREA SAFT

MIL-STD-1576 (USAF)
31 July 1984

DEPARTMENT OF THE AIR FORCE
Washington, D C 20330

Electroexplosive Subsystems Safety Requirements and Test Methods for Space Systems

MIL-STD-1576 (USAF).

1. This Military Standard is approved for use by the Department of the Air Force, and is available for use by all Departments and Agencies of the Department of Defense.
2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Hq SD/ALM, Box 92960, Los Angeles, CA 90009 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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FOREWORD

This Standard establishes the general requirements and test methods for the design and development of electroexplosive subsystems to preclude hazards from unintentional initiation and from failure to fire. These requirements apply to all subsystems utilizing electrically initiated explosive or pyrotechnic components.

This Standard applies to all space vehicle systems (e.g., launch vehicles, upper stages, boosters, payloads, and related systems).

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1103	X-Ray Radiographic Inspection	1
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1404	Neutron Radiographic Inspection	1

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2201	Bridgwire Resistance	1
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1.0 SCOPE

1.1 Purpose The purpose of this document is to insure the safety of personnel, launch site facilities, and space vehicles from the hazards resulting from electroexplosive subsystem unintentional initiation or failure to fire. The requirements and test methods contained in this document are not intended to insure all electroexplosive subsystem performance requirements except in those cases where failure to perform would create a hazard to the items listed above. The electroexplosive subsystem is composed of all components from the power source to, and including, the EED (electroexplosive device); Safe and Arm devices, Arm/Disarm switches, relays and all electrical wiring used to monitor, control, arm and fire ordnance are specifically included. This Standard applies to all space vehicle systems (e.g., launch vehicles, upper stages, boosters, payloads, and related systems using EEDs).

1.2 Test Methods. The test methods described herein have been prepared to:

- a. Specify laboratory test conditions for electroexplosive subsystems and components which will produce test results that are equivalent to those which would be experienced in the actual operational environment and which will permit reproducibility of test results.
- b. Describe all test methods for electroexplosive subsystems and components needed to ensure compliance with the requirements of the specification.
- c. Provide Test Method 2208 as a Standard method for RF dudding evaluation if required by the procuring activity.

1.2.1 Revision of Test Methods. Revisions of each test method shall be indicated by a revision number following the method number. For example, the first revision of Test Method 1101 would be 1101.1, the second revision would be 1101.2, et cetera.

1.3 Application. This Standard is applicable to the entire electroexplosive subsystem life cycle, up to the time when the electroexplosive subsystem no longer presents a hazard to personnel, launch site facilities and manned or reusable space systems. This Standard also applies to expendable launch vehicles which present these types of hazards.

- a. This Standard is intended to be used by procuring activities for establishing all of the electroexplosive subsystem safety requirements to be included in specifications for the design and development of new hardware for new or old space systems.
- b. This Standard is intended to be used by procuring activities and government safety organization for a safety evaluation of previously used hardware on new space systems as well as for a safety evaluation of new hardware on new or old space systems.

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- c. This Standard is not intended to be used by procuring activities for establishing all of the performance (as opposed to safety) requirements to be included in specifications for the design and development of new ordnance system hardware for new or old space systems, but it can be used to establish many electroexplosive subsystem performance requirements. This Standard does not address elements of explosive trains which exist beyond an EED, except for S&A configurations.
- d. This Standard is intended to be used by space system procuring activities in lieu of MIL-STD-1512, "Electroexplosive Subsystems, Electrically Initiated, Design Requirements and Test Methods." MIL-STD-1512 contains requirements applicable to non-space systems, such as aircraft weaponry, and has not been superseded by this Standard.

1.4 Minimum requirements. When the scope and magnitude of a program does not warrant imposition of all the requirements specified herein, the procuring activity shall obtain approval from the appropriate government safety organization(s) and shall specify to the contractor the minimum acceptable program requirements.

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2.0 REFERENCED DOCUMENTS

2.1 Issues of Documents. The following documents in effect on the date of invitation for bids or request for proposal form a part of this Standard to the extent specified herein (parenthetical references are to the text where the document is implemented):

SPECIFICATIONSFederal

QQ-B-575 Braid, Wire, (Copper, Tin-coated, or Silver Coated, Tubular, or Flat) (5.2)

Military

DOD-E-8983 Electronic Equipment, Aerospace, Extended Space Environment, General Specification For (3.1.38, 4.5.1, 6.9.1, 6.9.2)

DOD-E-83578 Explosive Ordnance for Space Vehicles, General Specification For (3.1.38, 4.5.1, 6.9.1, 6.9.2)

STANDARDSFederal

FED-STD-228 Cable and Wire, Insulated; Methods of Testing (5.2)

FED-STD-595 Colors (5.12.6)

Military

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts (Method 1111)

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic) (Method 1404).

MIL-STD-453 Inspection, Radiographic (Method 1103)

MIL-STD-1167 Ammunition Data Card (4.6)

MIL-STD-1168 Lot Numbering of Ammunition (4.6)

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MIL-STD-1512	Electroexplosive Subsystems, Electrically Initiated, Design Requirements and Test Methods (1.3.d, Appendix 50.2.1, 50.2.1.3)
MIL-STD-1546	Parts, Materials, and Processes Standardization, Control and Management Program for Spacecraft and Launch Vehicles (3.1.38, 4.5.1, 4.5.3, 4.5.4, 6.9.1, 6.9.2)
MIL-STD-1547	Technical Requirements for Parts, Materials, and Processes for Spacecraft and Launch Vehicles (6.8.3)

PUBLICATIONS

DOD 5154.4S	Ammunition and Explosive Safety Standards (6.5)
DOD ADL-TD-3	DOD Authorized Data List (6.11)
AFTO 11A-1-47	Explosive Hazard Classification Procedures (6.5)

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the contracting activity or as directed by the contracting officer).

2.2 Other Publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E-545	Determining Image Quality in Thermal Neutron Radiographic Testing (Method 1404)
SNT-TC-1	Personnel Qualification and Certification in Nondestructive Testing (Method 1404)

(Application for copies of ASTM publications should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103).

M-C2210-1	Monograph on Computation of RF Hazards, Monograph M-C2210-1, Franklin Research Center (Method 4303, Appendix 20.)
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(Application for copies of this publication should be addressed to the Franklin Research Center, 20th Street and Race, Philadelphia, Pennsylvania 19103)

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W. J. Dixon and F. J. Massey, "Introduction to Statistical Analysis," McGraw-Hill, N.Y., N.Y., 1957. (Method 2203) (Reference Only)

AMP 101-1R, SRC-P No. 40 "Statistical Analysis for a New Procedure in Sensitivity Experiments," Bruceton Laboratory, Princeton New Jersey, July 1944 (Method 2203) (Reference Only)

W.J. Dixon and A. M. Mood, "A Method for Obtaining and Analyzing Sensitivity Data," Journal of American Statistical Association, March, 1948. (Method 2203) (Reference Only)

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

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3.0 DEFINITIONS

3.1 Terms used. The following are definitions of terms as used in this Standard:

3.1.1 Arm/Disarm (A/D) Device. An Arm and Disarm Device is an electrically or mechanically actuated switch which can make or break one or more electro-explosive firing circuits. A/D devices do not physically interrupt the explosive train.

3.1.2 Arm Plug. A plug that makes the firing circuit continuous when inserted in a connector.

3.1.3 Bridgewire. A bridgewire is defined as a resistance element within the electroexplosive device which is the final electrical element at the electrical/explosive interface.

3.1.4 Catastrophic Hazard. A catastrophic hazard is a hazard that has the potential for personnel fatality, loss of launch site facilities, or loss of reusable or manned launch vehicles. This definition also applies to expendable launch vehicles which present these types of hazards.

3.1.5 Conductive Mix. A conductive mix refers to the thermal conductivity of the prime mix of an EED. Prime mixes with high thermal conductivity are used to conduct heat away from a bridgewire to permit higher no fire current levels. See paragraph 3.1.6.

3.1.6 Conductive Mix EED. A conductive mix EED is one that does not use a bridgewire of any type. The firing power flows through the mix itself and heats the mix directly for firing.

3.1.7 Critical Hazard. A critical hazard is a hazard that has the potential for personnel injury, damage to launch site facilities, or damage to reusable or manned launch vehicles. This definition also applies to expendable launch vehicles which present these types of hazards.

3.1.8 Dudding. Dudding is the process of permanently degrading an electro-explosive device to a state where it cannot perform its designed function.

3.1.9 Electroexplosive Device (EED). The electroexplosive device is the first device in an explosive train which is designed to transform an electrical input into an explosive reaction. Detonators, electrical matches, squibs, Exploding Bridge Wire (EBWs) devices, and electrical initiators are examples of EEDs.

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3.1.10 Electroexplosive Subsystem (EES). The term electroexplosive subsystem is intended to include all components from the power source to, and including, the EED. Safe & Arm devices, Arm/Disarm switches, relays and all electrical wiring used to monitor, arm and fire ordnance functions are specifically included.

3.1.11 Electromagnetic Environment. Electromagnetic environment is defined as the electromagnetic energy (radiated and conducted) to which the electroexplosive subsystem will be subjected.

3.1.12 Exploding Bridgewire (EBW) Device. An exploding bridgewire device is defined as an electroexplosive device in which the bridgewire is designed to be exploded (disintegrated) by a high energy electrical discharge which in turn causes the explosive charge to react.

3.1.13 Exploding Foil Device. An exploding foil initiator shall be considered to have the same functional characteristics and requirements as the exploding bridgewire device except that the exploding foil accelerates a disc which strikes and shock-initiates the explosive mix.

3.1.14 Explosive Train (Explosive Transfer Assembly). An arrangement of a series of explosive or combustible elements used to perform or transfer energy to perform an end function. When an explosive train is used to transfer energy from one point to an end function it may be called an "explosive transfer assembly".

3.1.15 Firing Circuit. A firing circuit is composed of the firing source circuit, the firing output circuit, the firing control circuit and the monitor circuit. (See Typical Firing Circuit Diagram, Figure 1).

3.1.16 Firing Control Circuit. A firing control circuit is defined as that part of the electroexplosive subsystem which actuates the arming and firing devices. (See Typical Firing Circuit Diagram, Figure 1).

3.1.17 Firing Output Circuit. A firing output circuit is defined as that part of the firing circuit between the EED and the switching device which causes the EED to fire. (See Typical Firing Circuit Diagram, Figure 1).

3.1.18 Firing Source. A firing source is defined as the junction in the electrical system which provides energy to EED loads exclusively. This source is typically a dedicated ordnance bus. (See Typical Firing Circuit Diagram, Figure 1).

3.1.19 Firing Source Circuit. A firing source circuit is defined as that part of the firing circuit from the firing source to the firing output circuit. (See Typical Firing Circuit Diagram, Figure 1).

3.1.20 Host Vehicle. Space systems consist of host vehicles and payloads, in other words, carriers and the items to be carried. For example, the first stage of a launch vehicle is the host vehicle for the second stage; the second stage of a launch vehicle is the host vehicle for the third stage; etc.

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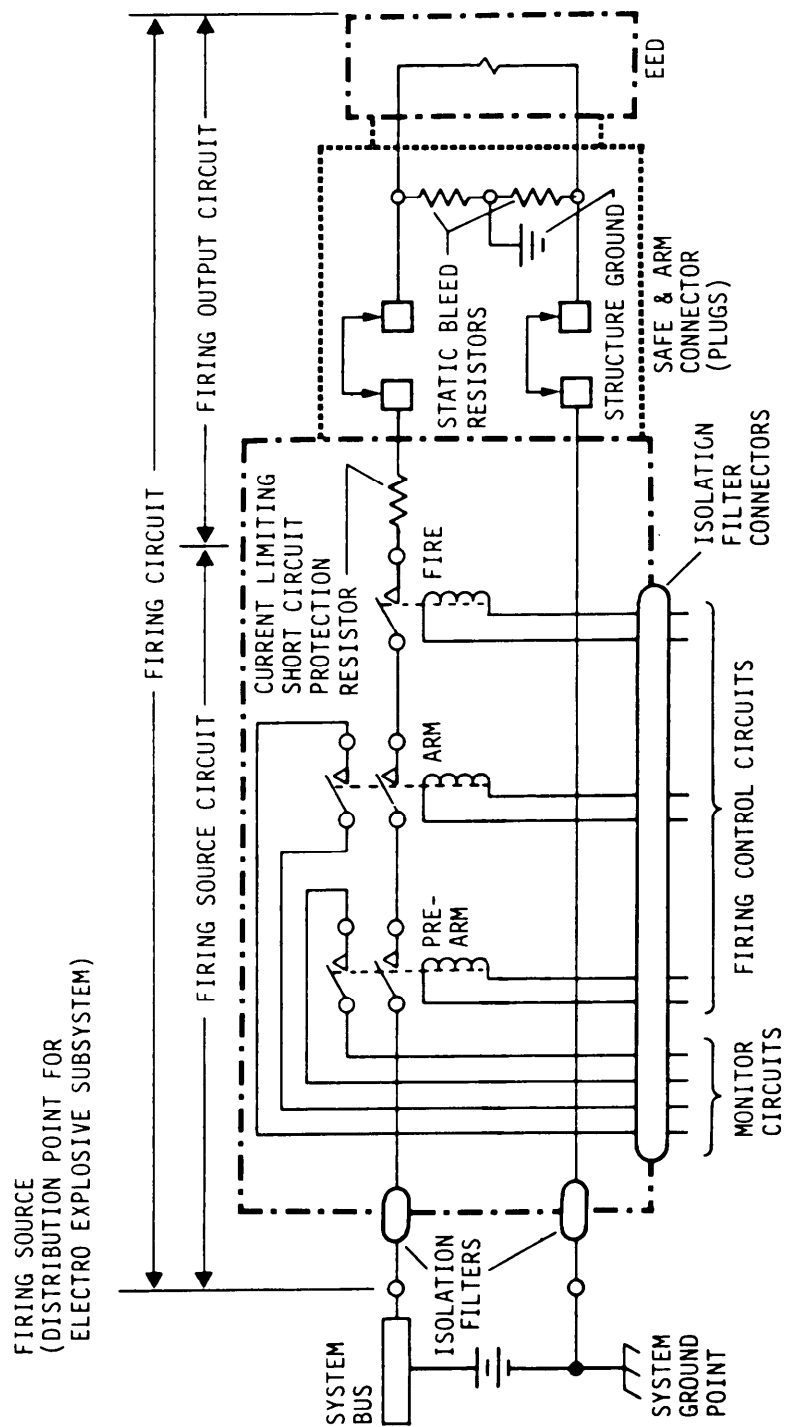


Figure 1
TYPICAL FIRING CIRCUIT DIAGRAM

NOTE: This is a typical circuit for purposes of illustration of the various parts of the electroexplosive subsystem and is not intended as a required design.

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3.1.21 Isolation Filter/Isolation Filter Connection, Radio Frequency (RF).

- a. Isolation Device: Any device which prevents conduction of electromagnetic energy into a shielded system. Selection of isolators take into consideration the variation in source and load impedances with frequency and physical placement of the isolator in the system.
- b. Absorbitive Device: A type of isolation device that precludes propagation of electromagnetic energy through the device. The minimum isolation provided by such a device is independent of the source and load impedance for the device. A conventional filter or other device can be used as an absorbitive isolator provided that the rated minimum isolation is independent of source and load impedances.

3.1.22 Maximum No-Fire Level. Maximum no-fire level is defined as the maximum DC or RF level at which an electroexplosive device shall not fire with a probability of .999 at a confidence level of 95 percent as determined by Test Method 2203 (Bruceton testing).

3.1.23 Minimum All-Fire Level. Minimum all-fire is defined as the least DC current which causes initiation with a probability of .999 at a confidence level of 95 percent as determined by Test Method 2203 (Bruceton testing).

3.1.24 Monitor Circuit. A monitor circuit is defined as that part of the electroexplosive subsystem which indicates the status of the firing circuits. (See Typical Firing Circuit Diagram, Figure 1).

3.1.25 NASA Standard Initiator (NSI). An EED approved or supplied by NASA with the part number SEB 26100001.

3.1.26 Non-Standard Parts, Materials and Processes. A part, material, or process other than program standard parts, materials, and processes as defined in 3.1.38.

3.1.27 Optical Coverage. Optical coverage is the percentage of the surface area of the cable core insulation covered by a shield.

3.1.28 Payload. Any item which is carried upon a host vehicle which is not an integral part of the host vehicle.

3.1.29 Production Lot. A group of assemblies or devices of a single type and size fabricated at one place in a continuous manufacturing process using the same tooling and the same material batches.

3.1.30 Rotor Lead. An explosive component used in some S&A designs to transfer detonation from the EED to the next explosive charge in the train.

3.1.31 Safety Critical Function. A safety critical function is any function performed or supported by the electroexplosive subsystem which can cause a critical or catastrophic hazard either by inadvertent firing or failure to fire.

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3.1.32 Safe and Arm (S & A) Device. These devices provide for a) mechanical interruption (safe) or alignment (arm) of the explosive train, b) electrical interruption (safe) or connections (arm) of the firing circuit, and c) shorting and grounding of the EED leads in the safe mode.

3.1.33 Safe Plug. A plug that shorts EED pins together and connects to ground through a resistor which provides electromagnetic and electrostatic protection as appropriate. Safe plugs, by definition, are used in conjunction with Arm Plugs.

3.1.34 Safe/Arm Plug. Safe/Arm plug is a single plug which when installed is intended as an Arm Plug and when removed, built-in features of the firing circuit perform the same function as a Safe Plug.

3.1.35 Safety Device. A safety device is a device which by interruption of the firing circuits or explosive train is intended to prevent the inadvertent ignition of any explosive device prior to its intended operation. The following are safety devices: safe and arm devices, safe/arm plugs, arm/disarm devices, switches and relays.

3.1.36 Service Life. The service life of an explosive component begins with the successful completion of acceptance testing and extends through its final usage or disposal.

3.1.37 Single Point Ground. A single point ground is a feature of a power distribution network wherein each conductively isolated segment (i.e., transformer-coupled or supplied from a separate source) of the distribution network has only one physical connection to ground. A 10k ohm or greater resistor placed between a circuit segment and ground does not violate the single point ground concept.

3.1.38 Solid State Relay. A semiconductor device with isolated input and output which operates by means of electronic components and without moving parts. Its primary function is to open and close electrical circuits in response to electrical controlling signals to effect the operation of other devices in the same or another electrical circuit.

3.1.39 Standard Parts, Materials and Processes. A program standard part, material, or process is one which is completely defined by and meets the engineering requirements of this Standard or which is selected from:

- a. The parts as defined by MIL-STD-1546, or
- b. Parts, materials and processes certifiable to specifications listed in the general equipment specification DOD-E-8983 or ordnance specification DOD-E-83578, or
- c. An explicit list of parts, materials and processes identified in the contract as program standard parts, materials and processes.

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3.1.40 Static Bleed Resistor. Resistors which are placed between firing circuits and ground to prevent the build-up of static electricity on circuits.

3.1.41 Switches and Relays. These devices open or close circuits when acted upon by external stimuli such as electrical signal, physical force, material proximity, etc. These devices are normally contained in safety devices, but may be used independently for making or breaking (interrupting) the firing circuit. Switches and relays may be electromechanical or solid state.

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4.0 GENERAL REQUIREMENTS

4.1 General Design. Requirements peculiar to electroexplosive subsystems are covered in this Standard.

- a. Those general requirements not peculiar to electrical components of electroexplosive subsystems shall be in accordance with applicable Standards as specified by the procuring activity.
- b. Electroexplosive subsystems shall meet design requirements under specified environmental conditions. Environmental conditions are specified in either the individual design requirements or in test requirements. When designing to meet the environmental conditions in test requirements, one must consider not only a specific test method, but also the environmental conditioning the device receives due to the sequence in which test methods are accomplished.

4.2 Fault Tolerance.

4.2.1 General Requirements. The design of an electroexplosive subsystem performing a safety critical function (as defined in paragraph 3.1.31) shall tolerate a minimum number of credible failures or operator errors according to the following criteria:

- a. If loss of function is safety critical or catastrophic, the design of the electroexplosive subsystem shall preclude single point failures and shall include at least two electroexplosive devices (EEDs).
- b. If inadvertent firing is safety critical, the design of the electroexplosive subsystem shall provide a condition such that no single failure or single operator error can cause a critical hazard and no combination of two failures or operator errors can cause a catastrophic hazard.

4.2.2 Implementation. This Standard shall be used to prepare requirements for inclusion in contract work statements. The contractor shall impose all requirements on his subcontractors, suppliers, and vendors to the extent of applicability.

- a. Safety devices shall be used in each electroexplosive subsystem to provide an electrical interrupt between each EED and its firing source.
- b. Safety devices shall be designed to be reversible (i.e., from the arm to safe position) when performing safety critical functions. This requirement applies to devices that can be activated prior to deployment from a manned vehicle, and in any situation in which danger to personnel and property exists.

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- c. S&A devices, or EBW firing units as well as other devices intended to interrupt the explosive train, shall be used to prevent inadvertent Solid Rocket Motor ignition and destruct initiation.

4.2.3 Extent of Applicability. Each provision of this Standard shall be considered as applicable to each EED and subsystem.

- a. Requests for deviation, waiver, or supplementary requirements, shall be individually submitted to the procuring activity for approval.
- b. Where a requirement of this Standard would necessitate duplication wholly or in part, of valid design, analysis, test, or other such valid activity already specified by the procuring activity, those requirements, functions, and efforts shall be identified and utilized in demonstrating compliance with the respective requirements specified herein. Duplication is not required.
- c. The design and testing of electroexplosive subsystem elements which have been previously approved shall require an evaluation for each subsequent usage. This is of particular concern with respect to previously approved EEDs (e.g., the NASA Standard Initiator) and S&A devices. Subsequent usage of previously approved devices shall require a comparison of the device's design and test specifications with this Standard's design and test requirements. This comparison will yield three categories:
 - 1. Agreement between a design or test specification of the previously approved device with the corresponding requirement of this Standard, and documentation to that effect.
 - 2. Disagreement between a design or test specification of the previously approved device with the corresponding requirement of this Standard (e.g., the NSI does not meet the insulation resistance requirements of this Standard nor do all NSIs go through the complete acceptance test program in Table III or through the aging or surveillance test program of Tables IV or V). Additional testing (of each manufacturing lot) shall be conducted to comply with the requirements of this Standard or documentation of the procuring activity's unconditional approval of each deficient area is required prior to any subsequent usage.
 - 3. Comparisons which can only be made between the device's design and test specification and the procuring activity's design and test requirements for each application (e.g., the environmental testing of the NSI may not be sufficient to demonstrate environmental survivability of the NSI in a particular application or the NSIs case material may not be compatible with its mating connector in a particular application). Documentation that the intended application is within the design and test requirements of the previously approved device is required.

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- d. Requirements herein, that are relative to unintentional initiation, shall be applicable to all electroexplosive subsystems, unless otherwise specified by the procuring activity. If inadvertent initiation is not safety-critical in itself and would not require a hazardous activity (e.g., vehicle demating) to be performed as a result of that inadvertent initiation, these requirements need not apply. Requirements herein that are relative to failure-to-fire shall be applicable only if the resulting non-function is safety critical, unless otherwise specified by the procuring activity.
- e. The design and test requirements imposed by this Standard are applicable for all low voltage hot bridgewire initiators, but are not sufficient for all types of initiators, e.g., Exploding Bridgewire (EBW) devices, Exploding Foil devices, Percussion Activated devices, etc. The procuring activity will tailor this Standard and impose additional requirements for the design, selection and test of these items. These items may be considered for use, but they shall not be selected for use without prior approval and direction from the procuring activity.
- f. Conflicts between this document and other direction in the contract shall be brought to the attention of the procuring agency for resolution.

4.3 Bonding. The DC bonding resistance between connection points of the shielded system, metallic enclosures, and structural ground shall be 2.5 milliohms or less.

4.4 Electroexplosive Subsystems Electromagnetic Compatibility (EMC).

4.4.1 Inadvertent Activation.

- a. The electroexplosive subsystem shall be designed to limit the power produced at each EED by the electromagnetic environment acting on the subsystem to a level at least 20dB below the maximum pin-to-pin DC no-fire power of the EED.
- b. The electroexplosive subsystem shall be designed to limit the power produced at each device in the firing circuit that can complete any portion of the firing circuit to a level at least 6dB below the minimum activation power for each of the safety devices.

4.4.2 Direct Coupling to the EED and EES. EED's shall not fire in either the pin-to-pin or the pin-to-case mode due to direct coupling of the specified electromagnetic environment into the EES.

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4.5 System Effectiveness Requirements.

4.5.1 Parts, Materials, and Processes (PMP). All PMP for use in the manufacture of electroexplosive subsystems shall comply with the requirements and provisions of this Standard and shall come under the cognizance of the procuring activity to the extent specified herein.

- a. Ordnance PMP. All ordnance PMP used in electroexplosive subsystems shall comply with the requirements as specified herein. Ordnance PMP which is not explicitly controlled by this Standard shall comply with the requirements and provisions of DOD-E-83578 or the approved PMP contractual document.
- b. Non-Ordnance PMP. All non-ordnance PMP used in electroexplosive subsystems shall comply with the requirements of
 - 1) this standard,
 - 2) MIL-STD-1546 or the Approved PMP Contractual Document, or
 - 3) DOD-E-8983

in that order of precedence.

4.5.2 Program PMP Selection List. The contractor shall ensure that all PMP used in the electroexplosive subsystem are included in the program approved PMP selection list. When a program approved PMP list is not required by contract, the contractor shall maintain a list of PMP used in the electroexplosive subsystem and this list shall be approved by the procuring activity. The approved PMP list shall distinguish between Program standard and non-standard PMP. Non-standard PMP shall be handled in accordance with paragraph 4.5.4.

4.5.3 Program PMP Approval. When it is determined by the designer that the design of the electroexplosive subsystem required by the contract cannot be accomplished with program approved PMP, the designer shall take action to have the required PMP added to the program approved list (See 4.5.2). Approval of newly identified items shall be obtained using guidelines controlled by and procedures specified in MIL-STD-1546 or as otherwise specified by the procuring activity. Requests for approval shall include engineering analysis and test reports demonstrating that the newly identified item has performance, reliability, and quality characteristics satisfactory for the intended application. Contractor-prepared specifications and specification changes for PMP shall be reviewed and approved per the requirements of MIL-STD-1546 or otherwise specified by the procuring activity.

4.5.4 Non-Standard PMP Approval. Non-standard PMP shall not be used unless approved per the procedures established by MIL-STD-1546, or as otherwise established by the procuring activity.

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4.5.5 Life.

- a. The electroexplosive subsystem shall have sufficient service life to ensure reliable operation at the appropriate points in the mission timelines.
- b. The contractor shall identify age-sensitive parts and materials and submit a surveillance plan to the procuring activity for review and approval. This plan shall address periodic surveillance requirements of age-sensitive parts and materials for service life requirements. The expected EED service life shall be demonstrated in accordance with Table IV or Table V.

4.5.6 Reliability. The design reliability of the electroexplosive subsystem shall be at least .999 (with 90 percent confidence based on the chi-square statistic of the ratio of the variance of the sample lot to the population variance) for safety critical functions both for the condition where (a) failure-to-fire is a hazard, and (b) inadvertent firing is a hazard (see paragraph 6.6).

Note: The use of solid state devices as series inhibits and their associated impact upon overall subsystem reliability will be evaluated by the procuring activity on a case-by-case basis.

4.5.7 Materials Compatibility. All materials (metallic and non-metallic) including detonable, deflagratable, pyrogen, and propellant substances shall be compatible with each other and with the components, materials, and chemicals which they could contact. For continued exposure to the predicted environmental conditions, there shall be no degradation in performance or increased sensitivity which may result in a hazard.

4.5.8 Human Factors. The electroexplosive subsystem shall be designed to enhance functional performance and to minimize hazards to personnel involved in assembling, transporting, installing, removing, maintaining, and testing systems involving the use of electroexplosive devices. As a minimum, the design shall include, but not be limited to, the following requirements:

- a. Ensure all circuits are capable of being physically disconnected between the ordnance device and its power supply as close to the ordnance item as possible throughout all phases of ground operation.
- b. Ordnance items and associated circuitry shall be accessible to facilitate electrical checkout and final electrical connection as late as possible in the spacecraft or vehicle processing sequence.
- c. Safe and arm indications on S & A devices shall be visible in a completely assembled configuration.
- d. Safing pins shall be capable of installation into, and removal from, a completely assembled spacecraft or vehicle.

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- e. Ordnance circuits shall be capable of being manually safed during any phase of ground operation.
- f. If the S & A is to undergo a cycling verification test during any phase of ground operations, there shall be a capability to access and disconnect the explosive train from the safe and arm device.

4.6 Traceability. In order to provide traceability of explosive components from manufacture through usage or disposal, numbering of components shall be per MIL-STD-1168 and documented per MIL-STD-1167. Equivalent numbering systems may be used if approved by the procuring activity.

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5.0 DETAIL DESIGN CRITERIA5.1 Power Source.

- a. Separate and dedicated power distribution points shall be used for the electroexplosive subsystem firing sources. A firing source can share the same power source with other loads, but all currents flowing from the firing source point shall be for firing circuits only.
- b. If the host vehicle supplies power to the Firing Source Circuit, one of the following options shall be employed:
 - 1) The return side of the Firing Source Circuit shall not be grounded on the payload side of the interface, and shall be isolated from payload structure by at least 10k ohms measured at 1.5 times the bus voltage or greater, or equivalent isolation.
 - 2) Isolation transformers shall be employed in the Firing Source Circuit to provide at least 10k ohms isolation between the payload return circuit and the host vehicle return circuit when measured at 1.5 times the bus voltage or greater.

5.2 Shields.

- a. The firing circuit including the EED shall be completely shielded, or shielded from the EED back to a point in the firing circuit at which isolators eliminate RF entry into the shielded portion of the system. Isolators which provide 20 dB attenuation (regardless of source and load impedances) at all frequencies of the expected electromagnetic environment shall be considered acceptable. The adequacy of the RF protection provided by these isolators can also be demonstrated by test or analysis for each specific usage (i.e., the necessary protection is dependent on the configuration of unshielded circuits connected at this point and the expected electromagnetic environment).
- b. Cable shielding shall provide a minimum of 85 percent of optical coverage. The method for determining optical coverage shall be in accordance with FED-STD-228 or Federal Specification QQ-B-575.
- c. With the exception of cable shielding there shall be no gaps or discontinuities in the shielding, including the termination at the back faces of the connectors, nor apertures in any container which houses elements of the firing circuit.
- d. Shields terminated at a connector shall provide 360° continuous shield continuity without gaps.

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- e. Shields shall not be used as intentional current-carrying conductors, but may be multiple-point grounded to structure.
- f. Multiple point grounding of shields to structure is recommended.

5.3 Shielding Caps. All electroexplosive devices and safe and arm devices shall have shielding caps attached during storage, handling, transporting, and installation. The shielding cap shall have a solid metal outer shell which makes electrical contact with the EED case in the same manner as the mating connector for the EED.

5.4 Cables.

- a. Electrical cables may be fabricated such that several electro-explosive subsystem circuits are contained in a common shielded cable bundle, provided that the requirements of paragraph 5.7.2a are met.
- b. There shall be no splices used to join elements of ordnance cables.
- c. A connector shall be provided wherever mating or demating of a circuit is required.
- d. All cable runs shall be routed as close to metal structure as feasible.

5.5 Insulation Resistance.

- a. All current-carrying components and conductors shall be electrically insulated from each other and system ground.
- b. The insulation resistance between all insulated parts, at a potential of 500V, minimum, DC, shall be greater than 2 megohms after exposure to the environment specified herein. (For the NSI, the potential shall not exceed 250V, DC and only one 250V, DC test shall be permitted. All other NSI testing should be at 50V, DC).

5.6 Post Firing Short-Circuit Protection. Electroexplosive subsystem shall include positive protection for line-to-line and line-to-ground shorts which may develop within a fired EED. Relays, fuses or current limiting resistors may be used to satisfy this requirement.

5.7 Firing Circuits.

5.7.1 Wiring.

- a. Shielded twisted pairs shall be used unless other configurations can be shown to be more effective.

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- b. Any grounding of the firing circuits shall be done at one point only. The return path, on all circuits, shall be selected to minimize voltage buildup and transients on the firing circuit return with respect to the single point ground.
- c. Ungrounded firing output circuits shall be connected to structure by static bleed resistors.
- d. Structural ground shall not be used as return for ordnance circuitry.
- e. The source circuits shall terminate in a connector with socket contacts.
- f. The design shall preclude sneak circuits and unintentional electrical paths.

5.7.2 Electrical Isolation.

- a. Firing circuits that do not share a common fire command shall be electrically isolated from one another such that current in one firing circuit does not induce a current greater than 20 dB below the no-fire current level in any firing output circuit.
- b. Control circuits shall be electrically isolated so that a stimulus in one circuit does not induce a stimulus greater than 20 dB of the actuation level in any firing circuit.

5.7.3 Physical Separation. Firing output circuits shall be physically separated from all other types of circuits.

5.7.4 Electrostatic Protection. Electroexplosive devices shall be protected from electrostatic hazards by the placement of resistors from line-to-line and from line-to-ground (structure). The placement of line-to-structure static bleed resistances is not considered to violate the single-point ground requirements of this Standard as long as the parallel combination of these resistors are 10k ohms or more.

5.7.5 Monitor Circuits (Portable or Built-In).

- a. Application of operational voltage to the monitor circuit shall not compromise the safety of the firing circuit nor cause the electroexplosive subsystem to be armed.
- b. Monitoring currents shall be limited to one-tenth of the no-fire current level of the EED or 50 milliamps whichever is less.
- c. Monitor circuits and test equipment that applies current to the bridgewire shall be designed to limit the open circuit output voltage to one volt.
- d. Fault tolerance requirements of paragraph 4.2 shall apply to monitor circuits and associated equipment.

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5.7.6 Control Circuits. It must be demonstrated that command and control interfaces with the host vehicle that are used for any arming or firing functions in the payload cannot be actuated or triggered by return currents flowing in the host vehicle or payload structure. Use of differential drivers and receivers, transformers or optical couplers, or other floating control circuits are possible means of accomplishing this.

5.8 Connectors.

5.8.1 Type. All connectors used with the electroexplosive devices shall:
a) be approved by the procuring activity, b) have a stainless steel shell or suitable electrically conductive finish, c) complete the shell-to-shell connection before the pins connect, and d) provide for 360° shield continuity.

5.8.2 Pin Assignments.

- a. The circuit assignments and isolation of pins within any EES circuit connector shall be such that any single short circuit occurring as a result of a bent pin or contamination will not result in more than 50 milliamperes or one-tenth of the no fire current whichever is less applied to any electroexplosive device.
- b. There shall be only one wire per pin, and in no case shall a connector pin be used as a terminal or tie-point for multiple connections.
- c. Spare pins are prohibited in connectors which are part of firing output circuitry.

5.8.3 Locking. Connectors shall be selected such that they are not subject to demating when exposed to the maximum anticipated environment. Connectors that twist and lock into position are preferred.

5.8.4 Mismating. Firing circuit connectors shall not be capable of being mated.

5.8.5 Separate Connectors. Where redundant circuits are required to meet fault tolerance requirements, separate connectors shall be used.

5.9 Firing Switches and Relays.

- a. Electromechanical and solid-state switches and relays shall be capable of delivering the maximum firing circuit current for a time interval equal to ten times the duration of the intended firing pulse.
- b. These switches and relays shall be capable of breaking the post-fire short circuit current without exceeding any steady-state or transient limits of the solid-state or electromechanical device used.
- c. The use of a solid-state device to provide isolation between the firing circuit and ground/structure requires specific approval from the procuring activity.

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5.10 Mechanical Requirements.

5.10.1 Mounting. Relays that are series inhibits shall be mounted on axes to minimize the potential of vibration or shock activating more than one of the relays simultaneously.

5.10.2 Mechanical Integrity. The EEDs, when installed in higher level devices such as pin pullers, wire cutters, gas generators, etc., shall be designed to withstand the maximum back pressure from the operation of these upper level devices.

5.11 Electroexplosive Devices Electrical Design Requirements.5.11.1 Hot Bridgewire.5.11.1.1 No-fire Sensitivity.

- a. Unless otherwise specified electroexplosive devices shall be designed to withstand a constant direct current firing pulse of up to 1 ampere and 1 watt power (minimum) for a period of 5 minutes (minimum) duration without initiation or deterioration of performance (dudding). The DC no-fire shall be determined by Test Method 2203 (Bruceton Test) at room temperature (25 degrees C). The EED should be held in a mounting device to minimize heat transfer away from the initiator. Test Method 2203 (Bruceton test) shall indicate that the 0.1% firing level (with 95% confidence) is 1 ampere or more.
- b. EEDs shall not fire, dud, or deteriorate in performance as a result of being subjected to an electrostatic discharge of 25,000 volts from a 500 picofarad capacitor applied in the pin-to-case mode with no series resistor and in the pin-to-pin mode with a 5K ohm resistor in series. EEDs using an external spark gap require procuring activity approval.

5.11.1.2 Minimum All-Fire Current. The minimum all-fire current levels as determined by Test Method 2203 (Bruceton test) shall be at 99.9 percent firing level with a 95 percent confidence level.

5.11.1.3 Capacitor Discharge Firing. The requirements for determining the firing characteristics of EEDs to be used in capacitor discharge firing systems shall be specified by the procuring activity.

5.11.2 Carbon Bridge EEDs. Electroexplosive devices using carbon bridges are prohibited.

5.11.3 Conductive Mix EEDs. Conductive mix EEDs that do not utilize a bridgewire are prohibited.

5.11.4 Temperature Endurance.

- a. EEDs shall not autoignite when exposed to thermal environments that are 30°C above the maximum predicted temperature during worst case service life.

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- b. EEDs shall not decompose when exposed to thermal environments that are 30°C above the maximum predicted temperature and 10°C below the minimum predicted temperature during worst case service life, if decomposition or failure to function can create a hazard.

5.12 Safe and Arm (S&A) and Arm and Disarm (A/D) Devices.

5.12.1 Electrically Actuated.

- a. These devices shall incorporate a means of remote electrical arming and disarming from any barrier position.
- b. Remote and manual disarming shall be accomplished without passing through the arm position.
- c. The devices shall not be capable of being manually armed, but shall be capable of being manually disarmed.
- d. The devices shall remain mechanically secured in the selected position under all operational environments without the application of any electrical signal.
- e. There shall be no current flow exceeding 2 milliamperes in the disarm or safe command circuit during the arming cycle nor in the arm command circuit during disarm or safing.

5.12.1.1 Cyclic Life. All electrically actuated electroexplosive subsystem devices shall be designed to withstand repeated cycling from the armed to the disarmed positions for at least 1000 cycles without any malfunction, failure, or deterioration in performance. During this cyclic period, the devices shall be capable of being manually disarmed after any cycle.

5.12.1.2 RF Susceptibility. The protection for the EEDs shall be provided by a metallic enclosure which provides 360 degrees of coverage.

5.12.1.3 Electrical Arming and Safing Time. The time required to arm or to safe a safe and arm device, electrically actuated arm and disarm device, or other approved safing and controlling device(s) shall not exceed 1 second after application of the actuation signal.

5.12.1.4 Electrical Contacts. Electrical switching contacts shall be designed such that the specified vibration environment shall not cause an inadvertent make or break (chatter). Contacts which physically prevent closure (e.g., wiping type, disc-mounted) in the unarmed position are the preferred type of contact.

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5.12.2 Mechanically Actuated S&As

- a. These devices shall incorporate the same features as electrically actuated devices except that arming and safing is performed mechanically. Normally these devices are armed by a lift-off lanyard or by stage separation. Electrically actuated devices shall be used unless justification for mechanical actuation is provided and approved by the procuring activity.
- b. These devices shall be designed to withstand repeated cycling from the armed to the safe position for at least 300 cycles without malfunction, failure, or deterioration in performance.

5.12.3 Safety Provisions.

5.12.3.1 S&A Safety Provisions. The provisions that follow apply to all devices using mechanical barriers.

- a. The safe and arm device shall contain a mechanical safety barrier between the EED and the explosive train when the S&A is in the safe (disarmed) position.
- b. In the armed position, the safe and arm safety barrier shall be aligned to permit ignition or detonation of the explosive train.
- c. In the safe (disarmed) position, inadvertent ignition of the EED shall not result in ignition or detonation of the subsequent explosive elements including any explosives within the S&A. This shall be demonstrated during the development stage using three mechanically and explosively similar devices in the 50 degree from safe position for rotating barriers and midway between the safe and the armed position for sliding barriers in accordance with Barrier Test Method 2410.
- d. In the safe (disarmed) position, both power and return lines shall be disconnected.
- e. In the safe (disarmed) position, the EEDs shall be shorted and the short should be grounded through an appropriate resistance. If the resistor(s) remain connected to the firing circuit in the arm position, it shall be a minimum of 10K ohms.
- f. Establishing and breaking circuit continuity, and shorting and unshorting of the electrical initiators shall be accomplished by actuation of the device to align and disalign the EEDs with the rest of the explosive train.
- g. Transition of the barrier from the safe to the arm position for a rotating barrier shall require a minimum of 90 degrees rotation of the mechanical barrier.

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- h. The devices shall be designed to meet all performance requirements after the application of maximum operational arming voltages continuously for periods of up to 5 minutes with the safing pin installed. Stalling shall not create a hazardous condition when arming voltages are applied continuously for one hour with the safing pin installed.

5.12.3.2 Arm/Disarm (A/D) Safety Provisions. Arm/Disarm devices shall contain provisions for establishing and breaking circuit continuity, and shorting and unshorting the EED circuits.

5.12.4 Safe & Arm Lock/Safing Pin.

- a. All S&A devices shall have a positive mechanical lock and a safing pin.
- b. The mechanical lock within the device shall prevent inadvertent transfer from the unarmed (safe) to the armed position (and vice versa) under specified environmental conditions.
- c. The safing pin shall prevent inadvertent transfer from the unarmed (safe) to the armed position when an arming signal is applied.
- d. The safing pin shall be capable of installation into and removal from the device after the device is installed.
- e. The safing pin shall provide a means of attaching warning streamers.
- f. Mechanical retention of the safing pin shall be possible only when the S&A device is in the safe position.
- g. The safing pin shall be secured in position in the device by use of a detent or similar feature. Strength of the detent shall be sufficient to require at least three pounds but not more than 10 pounds for removal of the safing pin. For a rotating device, the torque shall be at least three inch-pounds but not more than 10 inch-pounds.
- h. A mechanism shall be incorporated which will prevent removal of the safing pin if the arming circuit is energized. The mechanism shall be capable of withstanding an applied force of at least 100 lbs. tension or a torque of at least 100 in-lbs. without failure.

5.12.5 Safe & Arm Safing Pin Streamer. All safing pins when installed shall be marked by a red streamer.

5.12.6 Status Indication.

- a. An integral part of the S&A design shall include a means for direct visual and remote monitoring of the arm or safe status.

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- b. The visual indicator shall be clearly and readily discernible at a minimum angle of 15 degrees from a line-of-sight normal to the center of the indicator.
- c. The safe condition shall be indicated by a white (FED-STD-595 color No. 27875) letter S on a green (FED-STD-595 color No. 24108) background, and the armed condition shall be indicated by a black (FED-STD-595 color No. 27038) letter A on a red (FED-STD-595 color No. 21105) background.
- d. Letters shall be readable from 5 feet considering the worst case illumination anticipated.
- e. Safe status shall not be indicated (visual or remote) until the barrier is within 10 degrees of the safe position for rotating barriers and within 10% of travel from the safe position for sliding barriers.

5.12.7 Safe & Arm Simulator Resistors.

- a. S&A devices may contain a simulator resistor across each of the firing line circuits to permit testing of the firing circuit without energizing the electrical initiators.
- b. The application of operational voltages to the resistor for a duration of 20 seconds, minimum, shall not cause degradation in performance of the device.
- c. Application of operational voltage for times in excess of 20 seconds shall not create a hazardous condition.

5.12.8 Safe & Arm Components.

5.12.8.1 EEDs. All EEDs used in the S&A devices shall be qualified and accepted as components in compliance with the requirements of this Standard.

5.12.8.2 Safe & Arm Rotor Leads. All lots of S&A rotor leads shall be acceptance tested as a separate component in compliance with the requirements of this standard. Rotor leads shall be qualified as an installed component in the S&A device.

5.13 Safe and Arm Plug Devices.

- a. Firing circuits that use Arming Plugs shall be designed to electrically interrupt the EED side of the firing circuit. They shall provide for the electrostatic protection of the EED as specified in Paragraph 5.7.4, with the Arm Plug removed. This protection may be achieved by installing a Safe Plug in the Arm Plug receptacle, or by intrinsic design of the firing circuits. If a safe plug is not required, a suitable conductive cap shall cover the Arm Plug receptacle.

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- d. Arm and Safe Plugs or caps shall be designed to be positively identifiable by color, shape and name. The natural (unpainted) body color of the Arm Plug is required. The Safe Plug or cap should be green and shall have a red remove-before-flight streamer attached. They shall be marked Arm and Safe respectively.
- c. The design of the device and the firing circuit shall ensure easy access for plug installation and removal during assembly and checkout in all prelaunch and post-launch processing facilities.
- d. Monitor and control circuits shall not be routed through Safe Plugs.
- e. These devices shall meet all the shielding requirements of paragraph 5.2.

5.14 Environmental Requirements. Electroexplosive subsystems shall be capable of performing in the prescribed manner when fired in the operational environment after surviving the normal sequence of predicted transportation and handling, storage, prelaunch, launch, ascent and flight conditions. They must not inadvertently initiate after exposure to the predicted environmental extremes of re-entry, landing, and post landing conditions where applicable. Designing components for the predicted environmental extremes shall include design factors of safety or design margins to accommodate variations in production units and in testing.

5.15 Hermetic Sealing.

- a. All EEDs shall be hermetically sealed in such a manner that after being exposed to the environmental conditions in the sequences specified herein, the actual helium leakage rate shall not exceed 5×10^{-6} standard cubic centimeters per second at a differential pressure of one atmosphere, minimum (see Test Method 1111). All non-electric explosive components contained within a safe & arm device which is not hermetically sealed shall be sealed to meet the same requirement.
- b. Organic materials shall not be considered acceptable sealants.
- c. The closure(s) used to obtain hermetic sealing, and for other purposes, shall be designed to yield minimum debris as a result of firing; and the debris, if any, shall not have a detrimental effect on the item into which the initiator fires.

5.16 Data.

- a. Design and test data that demonstrate compliance with this Standard shall be retained as specified by the procuring activity. Data is normally retained for the life of the program, and longer if there is planned usage for future programs.
- b. Data for test plans, procedures and results shall be formatted and delivered as tasked in the test section of the SOW and associated CDRLs.

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6.0 QUALITY ASSURANCE PROVISIONS

6.1 Applicable Tests. Unless otherwise specified by the procuring activity all electroexplosive subsystems and components shall pass the tests specified herein. A cross-reference from Section 4 and 5 requirements to Quality Assurance Provisions is given in Figure 2.

6.2 Responsibility for Tests and Inspections. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection and tests as specified herein. The supplier may use his own or any other facilities suitable for the performance of the inspection and test requirements specified herein, unless disapproved by the procuring activity. The procuring activity reserves the right to perform any of the inspections and tests set forth in this Standard where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

6.3 Test Sequences. Unless otherwise specified by the procuring activity, tests shall be accomplished in sequential order as listed in tables I through VIII.

6.4 Classification of Inspection. The inspection requirements specified herein are classified as follows:

- a. Qualification inspections and tests See 6.7
- b. Lot acceptance sampling inspections and tests See 6.8

6.5 Hazard Classification. Ordnance items shall have a Military Hazard Classification and Compatibility Grouping in accordance with DOD 5154.4S. If not already classified, classification shall be in accordance with AFTO 11A-1-47.

6.6 Safety Reliability Demonstrations. The reliability of the safety features of the electroexplosive subsystem will be considered demonstrated with the successful completion of the required qualification and acceptance testing in accordance with paragraphs 6.7 and 6.8. The capability of the EED output in performing its intended function shall be verified.

6.7 Qualification Inspections and Tests. Qualification inspection of electroexplosive subsystems and components shall be conducted in accordance with the following:

- a. Electroexplosive Devices. Perform the inspections and tests in Tables I and II.
- b. S&A Devices. Perform the inspections and tests in Table VI. S&A EEDs shall be tested in accordance with paragraph 6.7.a.

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- c. Electroexplosive subsystem. Perform the analysis per Test Method 4303.

6.7.1 Requalification Testing. If any of the following events occur in the manufacture and test of previously qualified electroexplosive devices (per paragraph 6.7), a review and analysis shall be made to determine what requalification tests, if any, shall be made. The analysis and any resulting proposed requalification test program shall be approved by the procuring activity.

- a. Critical components or materials are to be obtained from a source not previously qualified.
- b. Changes in methods, critical processes, or change in the production line (different line within the same facility or different facility).
- c. Experience indicates a deficiency in previous test methods.

6.8 Lot Acceptance Sampling, Inspections and Tests. Electroexplosive subsystems, S&A devices and EEDs shall be acceptance tested in accordance with the following:

6.8.1 Electroexplosive Devices. Test per Tables I and III.

6.8.2 Safe and Arm Devices. Test S&A devices per Table VII. Test S&A rotor leads per Table VIII.

6.8.3 Arm/Disarm Devices. Test per applicable section of MIL-STD-1547 or per detail specification as approved by the procuring activity.

6.8.4 Electroexplosive Subsystems. This Standard does not provide test requirements for the installed subsystem. The electroexplosive subsystem is normally tested in accordance with the overall system test plan, or as specified by the procuring activity.

6.8.5 Service Life Tests. Service life of every lot of EEDs shall be verified by conducting tests outlined in Tables IV or V. Service life of S&A rotor leads shall be demonstrated yearly by repeating the acceptance lot sample test program by firing ten rotor leads.

6.9 Systems Effectiveness.

6.9.1 Parts, Materials, and Processes (PMP) Controls.

- a. Ordnance PMP shall be controlled as defined within this Standard. When ordnance PMP are specified, which are not specifically controlled by this Standard, they shall be controlled in accordance with DOD-E-83578, or the approved PMP Contractual Document.

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- b. Non-ordnance PMP shall be controlled per the requirements of
 - 1) this Standard,
 - 2) MIL-STD-1546 or the Approved PMP Contractual Document, or
 - 3) DOD-E-8983

in that order of precedence.

6.9.2 Parts, Materials, and Processes (PMP) Qualification.

- a. Ordnance PMP shall be qualified as defined within this Standard. When ordnance PMP are specified, which are not specifically covered by this Standard, they shall be qualified in accordance with DOD-E-83578, or the Approved PMP Contractual Document.
- b. Non-ordnance PMP shall be qualified per the requirements of
 - 1) this Standard,
 - 2) MIL-STD-1546 or the Approved PMP Contractual Document, or
 - 3) DOD-E-8983

in that order of precedence.

6.10 Electromagnetic Compatibility (EMC) Verification.

- a. It shall be shown by analysis or test that the electroexplosive subsystem meets the requirements of paragraph 4.4.1.a. The analysis/test shall include not only the firing output circuits, but all of the firing circuit elements, in particular the control circuits that can couple power to the EED. The radiated and conducted electromagnetic environment will produce a peak AC power level at the EED and this level must be compared to the maximum DC no fire power level of the EED, which is determined from the square of the DC no fire current times the nominal bridgewire resistance.

NOTE: This verification can be part of the normal EMC Conformance program used for the overall (completely assembled and powered-up) payload systems, e.g., connect an ordnance simulator or power measuring device to the firing output circuit. The monitoring device should be selected to minimize its effects on the overall system. This DC detector must have the capability of detecting pulses at least as short as one millisecond. The ordnance simulator and measuring device should be selected with sensitivities to levels far less than the no fire level of the EED so that a 20dB safety margin can be demonstrated without irradiating the system at damaging levels.

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- b. It shall be shown by analysis or test (see NOTE above) that the electroexplosive subsystem meets the requirements of 4.4.1.b.
- c. If the electroexplosive subsystem is non-compliant with any of the requirements of this Standard which may have an impact on electromagnetic environment susceptibility, or if the electroexplosive subsystem utilizes an EED which the procuring activity considers abnormally susceptible to the electromagnetic environment, then a worst case analysis (in accord with Test Method 4303) shall be performed on all firing circuits for all storage, handling, handheld, checkout and fully assembled configurations of the firing systems that can be exposed to the radiated electromagnetic environment. The worst case analysis must demonstrate that the electromagnetic environment, acting directly on the firing circuit, will produce at the EED in each firing mode (e.g., pin-to-pin, pin-to-case) an RF level less than the maximum RF no-fire level of the EED.

6.11 Documentation. The procuring activity may require specialized documentation prior to the use of explosive items.

- a. Procedures shall be established for the safing and removal of ordnance items.
- b. Where Air Force Explosive Ordnance Disposal support is required, procedures shall be provided in accordance with Explosive Ordnance Disposal Directive (DOD ADL TD-3).

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REQUIREMENT	Quality Conformance Method				METHOD
	E	T	D	A	
	X	E	E	N	
	A	S	M	A	
	M	T	O	L	
4. GENERAL REQUIREMENTS					
4.1 General Design				X	*
4.2 Fault Tolerance					
4.2.1 General Requirements				X	*
4.2.2 Implementation				X	*
4.2.3 Extent of Applicability				X	*
4.3 Bonding		X			*
4.4 Electroexplosive Subsystems					
Electromagnetic Compatibility					
4.4.1 Inadvertent Activation				X	*
4.4.2 Direct Coupling to the EED & EES		X		X	2204, 2207, 4303
4.5 System Effectiveness Requirements					
4.5.1 PMP				X	*
4.5.2 Program PMP Selection List				X	*
4.5.3 Program PMP Approval				X	*
4.5.4 Non-Standard PMP Approval				X	*
4.5.5 Life		X			3403
4.5.6 Reliability				X	*
4.5.7 Materials Compatibility				X	*
4.5.8 Human Factors				X	*
4.6 Traceability				X	*
5. DETAIL DESIGN CRITERIA					
5.1 Power Source				X	*
5.2 Shields	X	X		X	*
5.3 Shielding Caps				X	*
5.4 Cables	X			X	*
5.5 Insulation Resistance		X		X	*
5.6 Post Firing Short-Circuit Protection				X	*
5.7 Firing Circuits					
5.7.1 Wiring				X	*
5.7.2 Electrical Isolation				X	*
5.7.3 Physical Separation				X	*
5.7.4 Electrostatic Protection				X	*
5.7.5 Monitor Circuits				X	*
5.7.6 Control Circuits				X	*

FIGURE 2 (1 of 3)

Cross-Reference of EED Requirements to Quality Assurance Provisions

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REQUIREMENT	Quality Conformance Method				METHOD
	E	T	D	A	
	X	E	E	N	
	A	S	M	A	
	M	T	O	L	
5. DETAIL DESIGN CRITERIA (continued)					
5.8 Connectors					
5.8.1 Type				X	*
5.8.2 Pin Assignments				X	*
5.8.3 Locking				X	*
5.8.4 Mismatching				X	*
5.8.5 Separate Connectors				X	*
5.9 Firing Switches and Relays				X	*
5.10 Mechanical Requirements					
5.10.1 Mounting				X	*
5.10.2 Mechanical Integrity				X	*
5.11 Electroexplosive Device					*
Electrical Design Requirements					
5.11.1 Hot Bridgewire					
5.11.1.1 No-Fire Sensitivity		X			2203
5.11.1.2 Minimum All-Fire Current		X			2203
5.11.1.3 Capacitor Discharge Firing		X		X	*
5.11.2 Carbon Bridge EEDs				X	*
5.11.3 Conductive Mix EEDs				X	*
5.11.4 Temperature Endurance		X			3401
5.12 Safe and Arm and Arm/Disarm Devices					
5.12.1 Electrically Actuated				X	*
5.12.1.1 Cyclic Life		X			*
5.12.1.2 RF Susceptibility	X		X		*
5.12.1.3 Electrical Arming and Safing Time		X			2406
5.12.1.4 Electrical Contacts		X			3113
5.12.2 Mechanically Actuated S&As		X		X	*
5.12.3 Safety Provisions					
5.12.3.1 S&A Safety Provisions			X	X	2410
5.12.3.2 A/D Safety Provisions				X	*
5.12.4 S&A Lock/Safing Pin		X		X	2406
5.12.5 S&A Safing Pin Streamer	X				1101
5.12.6 Status Indication	X				1101
5.12.7 S&A Simulator Resistors			X	X	*
5.12.8 S&A Components				X	*
5.12.8.1 EEDs		X		X	*
5.12.8.2 S&A Rotor Leads		X		X	*

FIGURE 2 (2 of 3)
Cross-Reference of EED Requirements to Quality Assurance Provisions

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REQUIREMENT		Quality Conformance Method				METHOD
		E	T	D	A	
		X	E	E	N	
		A	S	M	A	
5. DETAIL DESIGN CRITERIA (continued)		M	T	O	L	
5.13	Safe and Arm Plug Devices				X	*
5.14	Environmental Requirements		**	**	**	**
5.15	Hermetic Sealing		X			1111
5.16	Data	X				*

* - NOTE: An asterisk in the Method column indicates that no test method has been specifically identified in this Standard. The applicable payload specification and corresponding Quality Assurance Methods will apply in these cases.

** - NOTE: The double asterisk indicates that environments are not separately tested but are a requirement of each test, demonstration, or analysis.

FIGURE 2 (3 of 3)

Cross-Reference of EED Requirements to Quality Assurance Provisions

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Table I

EED LOT ACCEPTANCE (NON DESTRUCTIVE)

TEST	PROCEDURE	QUANTITY
Visual Inspection	Method 1101	100%
Dimensional Check	Method 1102	100%
Bridgewire Resistance *	Method 2201	100%
Leak Test	Method 1111	100%
Static Discharge	Method 2205	100%
Insulation Resistance	Method 2117	100%
Bridgewire Resistance	Method 2201	100%
X-ray	Method 1103	100%
N-ray	Method 1404	100%

* This bridgewire test may be omitted if bridgewire test was conducted after loading and before this stage, and recorded measurements are available.

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Table II

EED Qualification Testing

TEST	PROCEDURE	446 EEDs							
		TESTED AS FOLLOWS							
Non-Dest Test*	Table I	230**	45	45	5	6	5	5	105
RF Impedence	Method 2204	10							
RF Sensitivity Determination	Method 2207	<u>230</u>							
No Fire Bruceton (5 minute constant current)	Method 2203		<u>45</u>						
All Fire Bruceton (30 millisecond constant current)	Method 2203			<u>45</u>					
High Temperature Exposure	Method 3401				<u>5</u>				
Temperature Cycling	Method 3407						5	5	105
Shock	Method 3114							5	105
Vibration	Method 3113								105
Drop Test (6 foot)	Method 3409							5	105
Bridgewire Resistance	Method 2201						5	5	105
Insulation Resistance	Method 2117						5	5	105
Leak Test	Method 1111						5	5	105
X-ray	Method 1103						5	5	105
N-ray	Method 1404						5	5	105
No Fire Verification	Method 2402					6	5	5	105
Ambient Firing Test	At specified All Fire Per Method 2405					<u>6</u>	<u>5</u>	<u>5</u>	
Temperature Firing Tests	Test per Table IIA								<u>105</u>

* All EEDs submitted to qualification must have passed non-destructive acceptance tests of Table I.

** 370 EEDs required for dual bridgewire testing. Total quantity - 586.

NOTE - Double line (230) under number of EEDs tested indicates EEDs are considered destroyed.

NOTE - Firing test requirements for EEDs to be used in a capacitor discharge firing system shall be specified by the procuring activity.

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TABLE IIA

Lot Sample Allocation for Temperature Firing Tests

Firing Temp	All Fire Current	Predicted* Operating Current	22 Amps
Predicted Operating Temperature	15	15	5
High Temperature	15	15	5
Low Temperature	15	15	5

* In the event that firing current cannot be predicted, these EEDs shall be tested at 2 times the specified All Fire Current.

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Table III

EED Lot Acceptance Testing

TEST	PROCEDURE	QUANTITY
Non-Destructive Tests	Table I	100% of lot
Temperature Cycling	Method 3407	Lot Sample *
Shock	Method 3114	Lot Sample *
Vibration (Use qualification level)	Method 3113	Lot Sample *
X-ray	Method 1103	Lot Sample *
N-ray (optional)	Method 1404	Lot Sample *
Bridgewire Resistance	Method 2201	Lot Sample *
Insulation Resistance	Method 2117	Lot Sample *
Leak Test	Method 1111	Lot Sample *
No Fire Verification	Method 2402	Lot Sample *
Firing Tests	Method 2405	Lot Sample* Per Table IIIA

* Entire lot sample, which is 10% of Lot but no less than 30.

NOTE - Firing tests requirements for EEDs to be used in a capacitor discharge firing system shall be specified by the procuring activity.

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TABLE IIIA

Lot Sample Allocation For Firing Tests

	ALL FIRE CURRENT	OPERATING CURRENT*
Predicted Operating Temperature	1/6	1/6
Max. Predicted High Temp.	1/6	1/6
Max. Predicted Low Temp.	1/6	1/6

* In the event that the operating current cannot be predicted the test level current shall be twice the all fire current.

NOTE - 1/6 refers to the division of Lot Sample.

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Table IV

EED Accelerated Aging Test

NOTE: When accelerated aging tests are used to verify the service life requirement of 4.5.5, testing shall be conducted at time of lot acceptance. Successful completion of this testing merits a three year service life assignment. This procedure may be repeated at three year intervals to extend service life indefinitely.

TEST	PROCEDURE	QUANTITY*
Non-Destructive Tests	Table I	10
High Temperature Storage	Method 3403	10
Shock	Method 3114	10
Vibration (Use qualification level)	Method 3113	10
X-ray	Method 1103	10
N-ray	Method 1404	10
Bridgewire Resistance	Method 2201	10
Insulation Resistance	Method 2117	10
Leak Test	Method 1111	10
No Fire Verification	Method 2402	10
Firing Tests at Specified All Fire Current		
- At Predicted Operating Temp.	Method 2405	4
- At Max. Predicted High Temp.	Method 2405	3
- At Max. Predicted Low Temp.	Method 2405	3

* This quantity will undergo all of the tests given in Table IV, i.e. 10 units every three years.

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Table V

EED Surveillance Test

NOTE: When surveillance tests are used to verify the service life requirements of 4.5.5, testing shall be conducted one year after lot acceptance testing and each year thereafter to extend service life indefinitely.

TEST	PROCEDURE	QUANTITY
Non-Destructive Tests	Table 1	5
Temperature Cycling	Method 3407	5
Shock	Method 3114	5
Vibration (Use qualification level)	Method 3113	5
X-ray	Method 1103	5
N-ray	Method 1404	5
Bridgewire Resistance	Method 2201	5
Insulation Resistance	Method 2117	5
Leak Test	Method 1111	5
No Fire Verification	Method 2402	5
Firing Test Operating Temp	Fire at specified all fire current per Method 2405	5

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Table VI

Safe and Arm Device Qualification

TEST	PROCEDURE	QUANTITY
Visual Inspection	Method 1101	7
Dimensional check	Method 1102	7
Insulation Resistance	Method 2117	7
Leak Test **	Method 1111	7
Temperature Cycling	Method 3407	7
Shock	Method 3114	7
Vibration (Acceptance)	Method 3113	7
Vibration (Qualification)	Method 3113	7
Insulation Resistance	Method 2117	7
Bench Test	Method 2406	7
Leak Test**	Method 1111	7
Firing Test at Predicted Operating Current		
At Predicted Operating Temp.	Method 2407	2
At High Temp.	Method 2407	2
At Low Temp.	Method 2407	2
Cycle Life*	Paragraph 5.12.1.1	1
Stall*	Paragraph 5.12.3.1h	1
Twenty Foot Drop Test*	Method 3408	1
Visual Inspection*	Inspect for Hazardous Condition(s) Prior to Disposal	1

* The device exposed to these tests shall not be fired.

** For hermetically sealed units only.

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Table VII

Safe and Arm Devices Acceptance

TEST	PROCEDURE	QUANTITY
Visual	Method 1101	100%
Dimensional	Method 1102	100%
Vibration	Method 3113**	100%
Bench Test	Method 2406	100%
Leak Test*	Method 1111	100%

* For hermetically sealed units only

** Do not exceed vibration levels given for acceptance testing in paragraph 3b in Method 3113.

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Table VIII

S&A ROTOR LEAD
ACCEPTANCE TESTING

TEST	PROCEDURE	QUANTITY
Visual Inspection	1101	100% of lot
Dimensional Check	1102	100% of lot
Leak Test	1111	100% of lot
X-ray	1103	100% of lot
N-ray	1404	100% of lot
LOT SAMPLING TEST*		
Temperature Cycling	3407	Entire Sample
Leak Test	1111	Entire Sample
Firing Test	2411	
High Temp		1/2 Sample
Low Temp		1/2 Sample

* The sample consists of 10% of the lot, but not less than 10 units from the same lot. The samples are to be chosen at random..

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GROUP 1000

NON-DESTRUCTIVE TEST METHODS

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METHOD 1101

VISUAL INSPECTION

1. Purpose. To visually inspect the item before and after each manufacturing, handling, storage, and test operation.
2. Procedure. Visually inspect the item before and after each operation or test to insure that good workmanship has been employed and that the item is free of obvious physical defects. The final inspection shall be made under 10x minimum magnification. Cracks, inclusions or voids shall be cause for rejection.

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METHOD 1102

DIMENSIONAL

1. Purpose. To establish the dimensional accuracy of the furnished item to be tested.
2. Procedure. Each item to be tested shall be physically measured to insure that the accuracy of the configuration is within dimensional limits as specified in the device procurement specification.

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METHOD 1103

X-RAY RADIOGRAPHIC

1. Purpose. To nondestructively inspect the device for defects and improper placement in the metallic constituents of the component.
2. Procedure. The test shall be accomplished by the methods outlined in MIL-STD-453. Units shall be X-rayed to quality level 2-2T of MIL-STD-453, unless otherwise specified in the individual specification.

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METHOD 1111

LEAK TEST

1. Purpose. To determine the effectiveness of the seal of a component part which has an internal cavity which is either evacuated or contains air or gas. This test will detect leaks due to the use of inferior sealing materials, or manufacturing processes used to form the seal. The degree of completeness or the seal can be verified by testing in the "as received" condition or after submission to other environmental or physical-characteristic tests, such as thermal shock, physical shock, or vibration.

2. Test Description.

NOTE: (The final (10x magnification) visual inspection performed in Method 1101 will serve to reject defective units which could result in a gross leaker. Method 1101 shall be performed prior to the leak testing per this method).

One of the following procedures shall be performed:

Procedure 1. The completed device(s) shall be placed in a sealed chamber which is evacuated to a pressure of 25 millimeters of mercury (absolute) or less for a minimum of five minutes and then pressurized (bombed) with helium for the time and pressure noted in Table 1111-1 below, based upon the device's internal free volume.

TABLE 1111-1
HELIUM BOMBING

INTERNAL FREE VOLUME (cm ³)	BOMBING PRESSURE (ATM ABSOLUTE)	BOMBING TIME (HOURS)
less than .05	3	.33
.05 to less than .10	3	.50
.10 to less than .20	3	1.00
.20 to less than .30	3	1.50
.30 to less than .40	3	2.00
.40 to less than .50	3	2.50
.50 or greater	3	3.00

The pressure shall then be reduced to one atmosphere which shall be maintained until each specimen is transferred to another chamber or chambers which are connected to the evacuating system and mass-spectrometer-type leak detector. When the chamber(s) is (are) evacuated, any tracer gas which was previously forced into the specimen will thus be drawn out and indicated by the leak detector as a measured leak rate. The number of devices removed from

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pressurization for leak testing shall be limited such that the test of the last device can be completed within 10 minutes. The criterion for passing this test is an indicated measured leak rate less than or equal to 1×10^{-6} standard cc/second of helium when measured at one atmosphere differential pressure, unless otherwise specified by the procuring activity.

NOTE: (The values specified for this procedure are based on MIL-STD-202, Method 112 and will result in the acceptance of units with an actual leak rate of less than or equal to 5×10^{-6} STD cm^3/sec of helium.)

PROCEDURE 2 - The completed device shall be tested per radioactive gas procedures of MIL-STD-202, Method 112, and shall exhibit an actual leak rate less than or equal to 1×10^{-6} STD cm^3/sec . of helium when converted from the measured Krypton-85 leak rate.

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METHOD 1404

NEUTRON RADIOGRAPHIC INSPECTION

1. Purpose. To nondestructively inspect the internal nonmetallic components of the EED and S&A rotor leads.
2. Definitions.
 - 2.1 Conversion Screen. A material placed in contact with radiographic film that absorbs neutrons and emits ionizing radiation, thereby exposing the film.
 - 2.2 Image Quality Indicator. A device or combination of devices whose image or images on a neutron radiograph provide visual or quantitative data or both concerning the radiographic sensitivity of the particular neutron radiograph.
 - 2.3 Sensitivity Level. The level determined by the smallest standard discontinuity in any given sensitivity indicator observable in the radiographic film. Levels are defined by identification of type of indicator, size of defect, and the absorber thickness on which the discontinuity is observed.
 - 2.4 Thermal Neutrons. Neutrons having energies less than 0.4 eV.
3. GENERAL REQUIREMENTS
 - 3.1 Materials
 - 3.1.1 Radiographic Film. Neutron original radiographs shall be made using Kodak type R single coated radiographic film or approved equivalent. Duplicate radiographs shall be made using Kodak X-Omat duplicating film or approved equivalent.
 - 3.1.2 Film Cassettes. Film cassettes used shall provide a positive means of maintaining intimate contact between the conversion screen surface and film emulsion.
 - 3.1.3 Conversion Screen. Conversion screens used shall provide optimum response to neutrons at thermal energies and shall produce radiographs that meet the film quality requirements of this Standard.
 - 3.1.4 Beam Purity Indicators. The beam purity indicator conforming to figure 1 of ASTM E-545 shall be used for all exposures as a minimum.
 - 3.1.5 Sensitivity Indicator. A sensitivity indicator conforming to figure 2 of ASTM E-545 shall be used for all exposures.

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3.2 Personnel. Personnel performing radiographic inspection shall be certified in accordance with the qualification of experience requirements of MIL-STD-410. Certification requirements not addressed in MIL-STD-410 shall be in accordance with Recommended Practice No. SNT-TC-1.

3.3 Exposures. Exposures shall be made using the direct method with the plane of the film as perpendicular as possible to the neutron beam. Reference Standard components shall be included in each exposure, if required.

3.3.1 Configuration. Areas of interest in adjacent parts shall be sufficiently separated to readily permit interpretation of the radiograph and shall be free from extraneous materials that could interfere with film evaluation.

3 Radiographic Image Quality

Radiographs shall have an image quality of at least NC-H-G Category I, as defined in ASTM E-545.

3.5 Workmanship. Radiographs shall be free from blemishes and artifacts that could interfere with their interpretation.

3.6 Facilities and Equipment

3.6.1 Neutron Source. The neutron source and facility shall be capable of producing radiographs that meet all requirements of this test method and shall provide adequate radiation protection for operating personnel.

3.6.2 Film Processing. The film processing equipment and facilities shall be capable of producing radiographs that meet the film quality requirements of this test method. Processing of radiographs shall be within the time and temperature range recommended by the equipment manufacturer.

3.6.3 Film Viewing. The film viewing area shall provide an optimum level of background lighting for viewing radiographs. The film viewing equipment shall provide optimum viewing sizes and intensities for interpreting radiographs in the 2.0 to 3.0 Hurter and Driffield (H&D) density range. A 3X to 7X magnifying glass shall be available.

3.6.4 Densitometer. The densitometer shall be capable of accurately measuring the light level transmitted through a radiograph having a film density up to 3.0 H&D and shall have a density resolution of 0.02 H&D or better. A calibrated reference density strip shall be maintained.

4. DETAIL REQUIREMENTS

4.1 Thermal Neutron Content (NC). Thermal neutron content of the beam shall be determined using densitometer data from the beam purity indicator image as outlined in ASTM E-545. The calculated value shall be 65.0 or greater.

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4.2 Sensitivity Level (H). The image of the 0.25 mm hole through the 1.28 mm gap, at all the absorber thicknesses, shall be visible on all radiographs.

4.3 Film Density. The background density of radiographs shall be between 2.0 and 3.0 H&D, and the background density variation across the film shall not exceed ± 5 percent when measured in accordance with ASTM E-545.

4.4 Film Identification. Radiographs shall be permanently identified with the following information:

- a. Part Number
- b. Serial Number
- c. Date of Exposure
- d. Radiographic Facility
- e. Conversion Screen Used (S/N)

4.5 Radiographic Technique Sheet. Each part number shall have a technique sheet or sheets, approved by the contracting agency, containing the following information as a minimum:

- a. Film identification (see 4.4)
- b. Length of exposure
- c. Number of times exposed
- d. Exposure rate of neutron and gamma radiation
- e. Facility beam resolution (L/D)
- f. Film processing information
- g. Special requirements or tooling
- h. Photographs or Sketches or both of radiographic setup
- i. Signoff (approval) by performing agency quality assurance representative

4.6 Special Safety Provisions. All special precautions pertaining to an item (part) shall be specified by the contracting agency.

4.7 Accept/Reject Criteria. The neutron radiographic evaluation shall be in accordance with accept/reject criteria established by the applicable engineering drawings and specifications.

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GROUP 2000

ELECTRICAL/ORDNANCE DEVICE

TEST METHODS

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METHOD 2117

INSULATION RESISTANCE

1. Purpose. To measure the insulation resistance of electroexplosive subsystem/components. This test is primarily useful in detecting leakage current and other defects degrading safety.
2. Apparatus. Insulation resistance measurements shall be made on an apparatus suitable for the characteristics of the component to be measured such as a megohm bridge, megohm meter, insulation resistance test set, or other suitable apparatus. Unless otherwise specified, the measurement error at that insulation resistance value required shall not exceed 10 percent. Proper guarding techniques shall be used to prevent erroneous readings due to leakage along undesired paths.
3. Procedure. When special preparations or conditions such as special test fixtures, reconnections, grounding, isolation, low atmospheric pressure, humidity, or immersion in water are required, they shall be specified. Insulation resistance measurements shall be made between the mutually insulated points or between insulated points and ground, as specified. The insulation resistance measurements shall be made immediately after a 2-minute period of uninterrupted test voltage application, unless otherwise specified.
4. Test Requirements. Unless otherwise specified by the procuring activity, the applied test voltage shall be a minimum of 500v, DC (all current carrying components and conductors shall be electrically insulated from each other and system ground. The insulation resistance between all insulated parts, at a potential of 500v minimum DC, shall be greater than 2 megohms after exposure to the environment specified herein.) (For the NSI, the potential shall not exceed 250v, DC and only one 250v, DC test shall be permitted. All subsequent NSI testing shall be at 50v, DC.).

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METHOD 2201

BRIDGEWIRE RESISTANCE

1. Purpose. To measure the resistance of the bridgewire.
2. Procedure. Bridgewire resistance shall be measured by applying a maximum current of 10 milliamps or 10 percent of the maximum no-fire current (as determined by Method 2203), whichever is less. An accuracy of at least 2 percent of the true value is required. The open circuit voltage of the test equipment shall not exceed one volt.

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METHOD 2203

DIRECT CURRENT SENSITIVITY

1. Purpose. This test determines pin-to-pin direct current characteristics of electroexplosive devices based on an assumed current log normal density function. The primary use of the determined characteristics is anticipated to be the specification of a pin-to-pin "maximum no-fire level" for the EED that will be used to support dc or low frequency hazard analyses. It is recognized that no small sample, e.g. 40 items, test can accurately determine a small firing probability (less than 10%) with high confidence unless other information about the firing characteristic of the individual EED type is available or assumed. Thus the "maximum no-fire level" determined by this overall test is to be treated as an acceptable level for use in hazard analyses and not as a rigorously determined parameter.

The test described below, uses a 5 minute constant current pulse as a stimulus. Other stimuli can be substituted for special purposes. For instance, the 5 minute stimulus is preferred for a maximum no-fire level determination whereas a 30 millisecond constant current pulse is preferred for all-fire level determinations and 1 millisecond constant current pulse is preferred for one of the tests in Method 2208. Bruceton tests using 5 minute continuous or pulsed RF stimuli can also be run using this procedure.

2. Number of Required Items. Forty-five or more electroexplosive devices are required for this test. Forty items are required for a Bruceton test. In addition, five items are normally used in estimating the mean and Standard deviation of the firing current. However, more items may be required depending on how well the initial estimates of the mean and standard deviation are made. Very bad choices of the mean and standard deviation cause a failure of the Bruceton test and will require another forty items.

3. Environmental Conditions

3.1 Test temperature. The test should be performed under ambient (approximately 25°C) temperature conditions, or operational temperatures if conditions include exposure of the EED to potentially hazardous pin-to-pin stimuli at elevated temperatures. The EED and heat sink (intended to simulate actual installation) shall be allowed to come to thermal equilibrium at the test temperature before the stimulus is applied to the EED.

3.2 Heat sinking. The heat sinking environment of the EED shall approximate the predicted operational thermal environment. If the thermal environments for the EED usage are multiple or unknown, the minimum heat sinking should be used during the test. If hazards related to "hand held" environments are to be evaluated, the EED should be mounted in a fixture that effectively insulates the EED against heat transfer to the environment.

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4. Procedure.

4.1 Test description. A 5 minute constant current pulse applied to the bridgewire of the EED shall be used as the stimulus in a 40 item minimum Bruceton test. Five items, in addition to the 40 test items are provided to allow pretest exposures of the EEDs to the test stimuli. This shall provide an estimate of the mean and variance of the assumed log normal density function. The current pulse amplitudes to be used for the test are to be chosen such that neighboring tests vary by a logarithmic increment approximately equal (0.5 to 1.25) to the Standard deviation. In the event of a no-fire the EED will not be disconnected from the system. A current pulse large enough to ensure firing shall be applied to the EED. If the EED still fails to fire, the no-fire data point will be omitted from the test and the reason for the no-fire determined and reported.

During testing each exposure shall be monitored to provide a permanent record (an oscilloscope picture, digital recording on floppy disk, etc.) of the voltage and current of the bridgewire during the 5 minute pulse. These records shall be retained by the facility performing the test.

4.2 Calculations. Computation of the Bruceton test results shall be made on both fire (X) and no-fire (0) data. Any deviation exceeding 10% between the X determined sigma and the 0 determined sigma will be sufficient to void the test and be cause for rerun of the test. The difference is computed by the ratio of the larger sigma to the smaller sigma, and a ratio greater than 110% will void the test. Tests showing less than 4 or greater than 7 or more levels shall also be considered void and the test must be rerun. Confidence levels shall be calculated using the average of the Standard deviations and the average of the means (log) as determined by the X and 0 data.

The actual computations of the Bruceton results should be performed by a computer program that is capable of demonstrating its accuracy by calculating log normal density function parameters from simulated Bruceton procedure test results. These simulated results must be consistent with an assumed log normal density function. This verification, which consists of simulated test results, the assumed distribution parameters, and the Bruceton calculation, should be included with the test results.

The 0.001 (0.1%) firing level of the EED, in amperes with 95% confidence, shall be computed from the Bruceton test results.

4.3 Test equipment. Test equipment shall be checked for calibration before any data is taken and an estimate made of maximum errors that are possible in pulse amplitudes and durations.

Bruceton Procedure References.

1. "Statistical Analysis for a New Procedure in Sensitivity Experiments," AMP Report No. 101-1R, SRG-P. No. 40, Bruceton Laboratory, Princeton, New Jersey, July 1944. (National Technical Information Center No. ATI-34558)

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2. W. J. Dixon and A. M. Mood, "A Method for Obtaining and Analyzing Sensitivity Data," Journal of the American Statistical Association, Vol. 43, pp 109-122 March 1948.
3. W. J. Dixon and F. J. Massey, "Introduction to Statistical Analysis," McGraw-Hill, N.Y., N.Y., 1957.

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METHOD 2204

RADIO FREQUENCY (RF) IMPEDANCE

1. Purpose. To measure the radio frequency impedance of electroexplosive devices.*

2. Apparatus. The impedance measuring equipment shall function at extremely low radio frequency power levels so that the electroexplosive devices are not subjected to heating effects. Automatic equipment is preferred. It is suggested that no more than 1 milliwatt be applied to the electroexplosive device in any firing mode during the measurements.

The mounting apparatus used to connect the electroexplosive device to the impedance measuring apparatus will be constructed so that the impedance measurements refer to a point as close to the base of the electroexplosive device (exterior surface of the EED header) as is possible.

3. Test environment. All tests will be run at room temperature (approximately 25°C).

4. Number of items required. The minimum number of electroexplosive devices to be used in the impedance measurements is ten. These items may be reused in the Method 2207 or 2208 testing.

5. Firing modes. Impedances shall be measured for each potential firing mode of the electroexplosive device. Specifically, pin-to-pin and pin-to-case impedances will be measured for 2-pin conventional hot wire EEDs. For dual bridge wire EEDs measurements will be performed in the pin-to-pin, pin-to-case and bridge-to-bridge firing modes.

6. Frequencies. Impedance measurements will be performed at 10 frequencies between 1 and 1200 megahertz. The individual measurement frequencies should be selected so that neighboring frequencies differ from each other by an approximately equal logarithmic increment.

* During a worst case analysis of a system's susceptibility (Method 4303) to its electromagnetic environment, a worst-case parameter is used for the impedance (i.e. the DC resistance). If this worst-case resistance parameter causes a rejection of the worst-case analysis results, RF impedance can be used to reduce predicted analytical results.

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METHOD 2205

STATIC DISCHARGE SENSITIVITY

1. Purpose. To verify the insensitivity of an electroexplosive device under electrostatic discharge conditions.
2. Procedure:
 - a. Discharge 25 kv from a 500-pfd capacitor applied (with no series resistor) at the test points for a pin-to-case mode. Pins shall be shorted during this testing. Figure 2205-1 shows the static discharge test circuit.
 - b. Discharge 25 kv from a 500-pfd capacitor applied through a 5 K ohm resistor at the test points for a pin-to-pin mode.
 - c. The method used for a and b above shall preclude external arcing.
 - d. The EED shall not fire, dud, or deteriorate in performance as a result of this test.

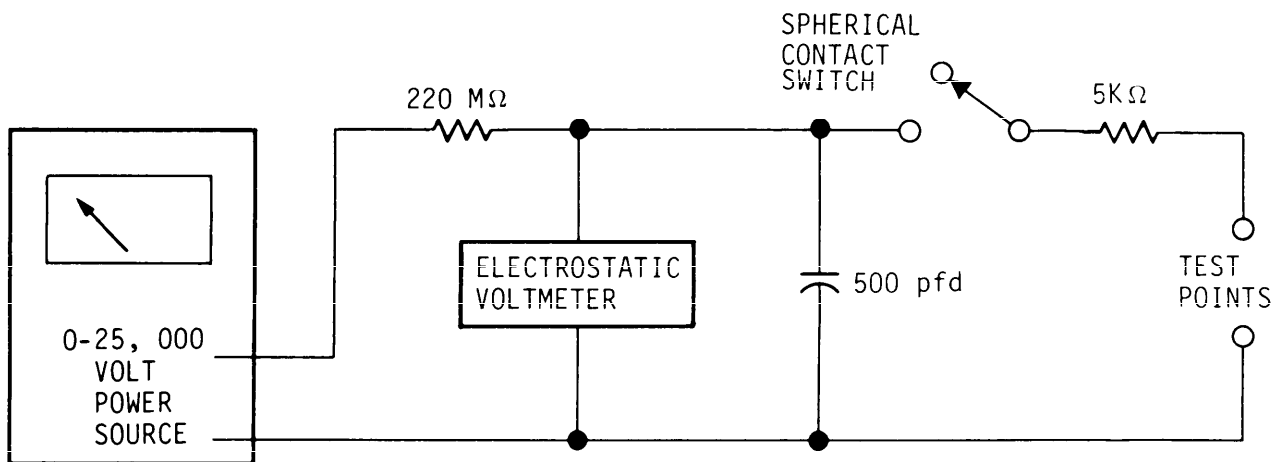


Figure 2205-1 Static Discharge Test Circuit

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METHOD 2207

RADIO FREQUENCY (RF) SENSITIVITY

1. Purpose. To measure the radio frequency sensitivity of electroexplosive devices and provide an RF no-fire level usable for RF hazard analyses.

2. Procedure.

a. Number of electroexplosive devices required:

(1) Single bridgewire type EEDs: 230 minimum

(2) Dual bridgewire type EEDs: 370 minimum

b. Basic radio frequency sensitivity probing tests:

(1) At each radio frequency to be used in the test, the radio frequency power to be applied to the electroexplosive devices is determined from the mean dc firing current measured in Method 2203 and dc bridgewire resistance. This level shall be applied to the devices in each mode (i.e., pin-to-pin, pin-to-case, bridgewire-to-bridgewire).

(2) Equipment used in the tests shall provide a means to account for loss in the power supplying system. Applied powers shall be demonstrated to be those actually delivered to the input of the EED. Mounting hardware for the EED shall be constructed to allow measurement of power as close to the EED (exterior surface of the EED header) base as possible. In addition the environmental conditions of Method 2203, paragraph 3, shall be complied with.

(3) At least 10 frequencies shall be used in the probing tests. These frequencies should be chosen to cover the frequency range from 1 MHz to 32 GHz and should include any frequency corresponding to a known high power density in the EEDs operational environment. Special consideration should be given to frequencies that correspond to transmitters associated with the overall system of which the EED is a part. If there are no specific requirements, the following approximate frequency and modulation stimuli shall be used.

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TABLE 2207-1
Default Test Frequencies and Modulations

Frequency MHz	Modulation *
1.5	CW
27.0	CW
154.0	CW
250.0	CW
900.0	CW
2700.0	P
5400.0	P
8900.0	P
15,000.0	CW
32,000.0	P

- * P = Pulsed modulation with pulse width of 1 microsecond and pulse repetition rate of 1 KHz.
 CW = Continuous Wave.

- (4) At each test frequency, ten electroexplosive devices will be tested for 5 minutes in the pin-to-pin mode and ten in the pin-to-case mode. If the electroexplosive device has dual bridgewires, test 10 more in this mode. Up to five electroexplosive devices that did not fire in the pin-to-pin test can be reused in the pin-to-case test. Thus RF probing tests require, at each frequency, 15 items for a two-pin single bridge device and 25 items for a dual bridge device.
- (5) Count the number of firings at each frequency. At any particular frequency, if two or less fire, it can be stated with very small risk that the electroexplosive devices are less sensitive to the test condition than they are to direct current, and the direct current sensitivity level can be used for subsequent analysis. If from three to seven electroexplosive devices fire, they can be considered to be of the same order of sensitivity to the test condition as to the direct current susceptibility level, and the direct current level can be used in subsequent calculations with a risk of approximately 11 percent. If eight or more fire, there is little doubt that the electroexplosive device is more sensitive to the test conditions than to the direct current level.

c. Statistical radio frequency tests.

- (1) From the data obtained in the probing tests described above, determine the most sensitive frequency/modulation stimulus for each firing mode, in other words, determine the frequency which had the most firings and specify the modulation (pulsed or CW).

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- (2) A 5 minute, 40 item Bruceton test as described in Method 2203, shall be performed at the most sensitive frequency/modulation stimulus for each mode. The equipment used shall be the same equipment as used in the probing tests.
- (3) Forty items are required for each firing mode of the device being tested. Thus 80 items are required for a two-pin single bridge device and 120 items for a dual bridge device.

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METHOD 2208 *

RADIO FREQUENCY (RF) DUDDING EVALUATION

1. Purpose. This test is used to evaluate the possibility of RF Dudding for EEDs. If RF energy applied to an EED in the pin-to-pin (normal) firing mode can desensitize the EED, then mission reliability can be compromised. This test evaluates the RF dudding susceptibility at the 10% firing level (Probability) at the most sensitive frequency. Essentially the method compares dc pulse Bruceton test results (see Method 2203) for virgin items and for EEDs exposed to the 10% pin-to-pin firing level (1.2816 Sigma below the mean) as determined in Method 2207. Since dudding effects can vary with firing pulse time, the method requires comparison of Bruceton data on RF exposed and non-RF exposed groups for two dc pulse times of 5 minutes and 1 millisecond. These are chosen to be long and short, respectively, in relation to the thermal time constant of the EED bridgewire.

2. Number of devices required. A total of 120 devices are required if the results of Method 2203 are available; if not, 165 devices are required.

3. Procedure. The following tests must be performed:

- (a) Method 2203 must have been performed on 40 units using a 5 minute pulse prior to the tests which follow.
- (b) Perform test 2203 on a second group of 40 units using a 1 millisecond dc pulse.
- (c) A third group of 80 virgin EEDs shall be exposed pin-to-pin using the equipment of Method 2207 to the 10% firing level (probability) as calculated from the pin-to-pin RF Bruceton test of Method 2207. This exposure shall be for 5 minutes. It is expected that several items will fire.
- (d) The items remaining from the RF exposure shall be divided into two approximately equal groups. One group shall be used to rerun the 1 millisecond Bruceton described in 3(b) above; the other group shall be used to rerun the 5 minute Bruceton performed in accordance with Method 2203

mal density parameters shall be compared for virgin and exposed items for both the 1 millisecond and 5 minute tests. Any large differences in the mean indicate a propensity for RF dudding, or possibly RF sensitization.

* This test is not recommended if the electroexplosive devices will not be exposed to RF levels greater than the RF no-fire level, as determined by Method 2207. The maximum RF exposure level is that maximum level determined by Method 4303.

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To determine if the RF exposure of the EEDs has altered the DC firing characteristics for either the 5 minutes or 1 millisecond exposure, separately compute:

$$t_t = \frac{|\overline{LX}_C - \overline{LX}_E|}{(N_C S_C^2 + N_E S_E^2)^{1/2}} \times \left[\frac{N_E N_C (N_E + N_C - 2)}{N_C + N_E} \right]^{1/2}$$

where $\overline{LX}_C = \log_{10}$ (mean of the control test (amps))

$\overline{LX}_E = \log_{10}$ (mean of the post-exposure test (amps))

$N_C = 1/2$ the number of items used in the control test,
rounded to the lowest integer

$N_E = 1/2$ number of items used in the post-exposure test,
rounded to the lowest integer

$S_C^2 =$ sigma squared for the control test

$S_E^2 =$ sigma squared of the post-exposure test

and compute

$$DF = N_E + N_C - 2$$

Note: If $N_C = N_E = N$

$$t_t = \frac{|\overline{LX}_C - \overline{LX}_E|}{(S_C^2 + S_E^2)^{1/2}} \times (N - 1)^{1/2}$$

Now consult Table 2208-1 below and determine the value of t associated with DF (degrees of freedom) and a "two tailed" probability of a deviation greater than t of 0.05. Call the value from the table t_c (for critical t).

If t_t is less than or equal to t_c , we can assume, with 95% confidence, that the RF exposure has not altered the DC firing characteristics of the devices. The above test is based on a comparison of the mean firing level of the devices as determined by the two Bruceton tests.

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TABLE 2208-1
TWO TAILED VALUE OF T FOR 5% PROBABILITY*

DEGREES OF FREEDOM	t_c	DEGREES OF FREEDOM	t_c
1	12.7060	26	2.0560
2	4.3030	27	2.0520
3	3.1820	28	2.0480
4	2.1320	29	2.0450
5	2.5760	30	2.0423
6	2.4470	31	2.0402
7	2.3650	32	2.0381
8	2.3060	33	2.0359
9	2.2620	34	2.0338
10	2.2281	35	2.0317
11	2.2010	36	2.0296
12	2.1790	37	2.0275
13	2.1600	38	2.0253
14	2.1450	39	2.0232
15	2.1310	40	2.0211
16	2.1200	41	2.0200
17	2.1100	42	2.0190
18	2.1010	43	2.0179
19	2.0930	44	2.0169
20	2.0860	45	2.0158
21	2.0800	46	2.0148
22	2.0740	47	2.0137
23	2.0690	48	2.0127
24	2.0540	49	2.0116
25	2.0600	50	2.0106

* Values are linear interpolations from commonly published data.

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METHOD 2402

NO FIRE VERIFICATION

1. Purpose. To verify that the EED will not fire or degrade when subjected to the No Fire Current.
2. Procedure. Test EEDs shall be subjected to the specified no fire DC current, +5%/-0% for 5 minutes at laboratory ambient conditions. The EEDs shall not fire as a result of this test. The EEDs shall not degrade, as shown by firing tests of Method 2405. No external heat sinks are to be used in this test.

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METHOD 2405

FIRING TESTS (EED)

1. Purpose. To verify that the EED will fire upon application of a specified current after being subjected to a specified preconditioning and to verify that the output of the electroexplosive device meets the requirements of the component specifications.
2. Procedure. Detailed procedures shall be specified in the EED component specification. However, as a minimum, the following shall be required:
 - a. Gas producing EEDs shall be fired in a closed bomb. The following parameters shall be measured:
 - (1) Time from application of current to bridgewire burn out.
 - (2) Time from application of current to first indication of pressure.
 - (3) Time from first indication of pressure to peak pressure.
 - (4) Peak pressure.
 - b. Detonating EEDs shall be tested using a metal witness plate to record output through a dent depth measurement technique. Specific requirements of this test shall be included in the component specification.

NOTE - Firing test requirements for EEDs to be used in a capacitor discharge firing system shall be specified by the procuring activity.

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METHOD 2406

S & A DEVICE BENCH TESTING

1. Purpose. To verify that the device is capable of cycling within its specified operating time. Insulation resistances are verified in each operating mode. The capability to manually safe the device is verified. Safing pin removal effort and retention capability are also confirmed.

2. Procedure.

- a. Remove safing pin and measure force/torque required for removal (Ref para 5.12.4.g).
 - b. Arm device remotely and measure cycle time (Ref para 5.12.1.3).
 - * c. Measure insulation resistance(s) per Method 2117.
 - d. Safe device remotely.
 - * e. Measure insulation resistance(s) per Method 2117.
 - f. Cycle the device 25 more times and measure each cycle time (safe to arm and arm to safe).
 - g. Return device to safe configuration remotely.
 - * h. Measure insulation resistance per Method 2117.
 - i. Arm device remotely and measure cycle time.
 - * j. Measure insulation resistance per Method 2117.
 - k. Manually safe the device and measure angular displacement of safe rotation as required (Ref para 5.12.3.1.g).
 - l. Verify S&A safing pin can be inserted and removed without binding.
 - m. Install safing pin.
 - n. Measure safe pin retention when unit is in safe position and arming current is applied (Ref para 5.12.4.h).
- * If EEDs or simulator resistors are installed, measure resistance(s) to verify continuity of circuits.

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METHOD 2407

SAFE AND ARM DEVICE FIRING TEST

1. Purpose. To verify that the safe and arm device will fire upon application of a specified current and to verify that the output of the device will initiate a specified explosive train.
2. Procedure.
 - a. The safe and arm devices shall be fired using the predicted operating current. In the event the operating current is unknown, the specified All Fire current shall be used. Half of the devices shall be tested with both detonators receiving current simultaneously. Half of the devices shall be tested with the detonators receiving current sequentially to demonstrate complete redundancy. A minimum of one minute shall be provided between the sequenced detonator firings.
 - b. The output of the safe and arm device shall be demonstrated through initiation of the next explosive component in the train. This explosive component shall be mated with the safe and arm device in the normal manner. A witness target shall be used to verify successful initiation.

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METHOD 2410

BARRIER TEST

1. Purpose. To verify that the S&A barrier will prevent initiation of subsequent explosive charges in the event of an inadvertent firing of the detonator when the device is in the safe condition.
2. Apparatus: A test unit shall be used which duplicates all dimensions; including gaps between explosive components, free volume and diaphragm thickness; of the operational S&A which is to be supplied to the procuring activity. The explosive charge normally mated to the S&A for detonation transfer shall be in place.
3. Procedure:
 - a. For rotating barriers, the test unit rotor shall be positioned 50° or greater from the full safe position.
 - b. For sliding barriers the test unit barrier shall be positioned midway between the safe and the arm position.
 - c. One test unit shall be fired at 71.1°C (+160°F). One test unit shall be fired at ambient (approximately 25°C) temperature. One test unit shall be fired at -53.9°C (-65°F).
 - d. Temperature conditioning of at least 4 hours is required.
 - e. The temperature of the test unit shall be measured and recorded at the time of the test unit firing.
4. Results:
 - a. S&As which use rotor leads shall not have their rotor leads undergo a low or a high order explosion as the result of the test unit firing.
 - b. S&As which couple the detonator directly to an external ordnance train shall not have that external ordnance train undergo a low or a high order explosion as the result of the test unit firing. The external ordnance train and its specified standoff shall be an integral part of the S&As specification. Minimum standoffs shall be used for the test firing.

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METHOD 2411

S&A ROTOR LEAD FIRING TEST

1. Purpose. To verify that the rotor leads will fire when subjected to the detonating output of the specified initiating component and to verify that the output of the rotor leads meet the requirements of the component specification.
2. Procedure:
 - a. Five percent of each lot of rotor leads, but not less than five units, shall be stabilized and tested at 71.1°C (+160°F). These units shall be fired using the specified detonator at a nominal detonator to rotor lead gap.
 - b. Five percent of each rotor lead lot, but not less than five units, shall be stabilized and tested at -53.9°C (-65°F). These units shall be fired using the specified detonator at the maximum specified detonator rotor lead gap plus 20%. Rotor lead output shall be measured as in paragraph 2.a.
 - c. Rotor lead output shall be tested using a metal witness plate to record output through a dent depth measurement technique. Specific requirements of this test shall be included in the component specification.

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GROUP 3000

ENVIRONMENTAL TEST METHODS

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METHOD 3113

RANDOM VIBRATION

1. Purpose. To demonstrate the ability of the component to withstand the predicted random vibration environment which is imposed upon the component in flight, plus a design margin of safety.
2. Test description. The component shall be mounted to a rigid fixture through the normal mounting points of the component. The component shall be tested in each of three mutually perpendicular axes.
3. Test levels.
 - a. The qualification test level (in g rms units) shall be no less than 6 dB greater than the maximum predicted vibration response level. This minimum test level shall not be less than 12 g rms.
 - b. The acceptance test shall be run at the maximum predicted vibration response level, but not less than 6 g rms.
4. Duration. The qualification test duration in each of the three orthogonal axes shall be three times the expected flight exposure time to the maximum predicted environment, but not less than 3 minutes per axis. The acceptance test duration shall be the expected flight exposure duration, but not less than one minute.

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METHOD 3114

SHOCK

1. Purpose. To demonstrate the capability of the component to withstand the predicted transient shock environment imposed upon the component in flight, plus a design margin of safety.
2. Test description. The component shall be mounted to a rigid fixture through the normal mounting points of the component. Transient shocks shall be applied to the component three times in each direction along each of three mutually perpendicular axes. Test methods may include techniques such as shaped pulses, complex decaying sinusoids, or electrodynamic shaker systems to synthesize the waveform. The damage potential of the synthesized waveform and the flight transient are the same when the shock response spectra are equal. The test shock waveform shall be applied and measured at the interface of the component being tested and the test fixture.
3. Test levels. The test shock spectrum shall be 6 dB above the maximum predicted transient shock response spectrum. In absence of more definitive data, the test shock waveform shall approximate a one-half sinusoid measured at the interface of the component being tested and the test fixture. The peak level and duration of the pulse shall be sufficient to cover the severity of the maximum expected flight shock environment plus a 6 dB margin of safety.

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METHOD 3401

HIGH TEMPERATURE EXPOSURE

1. Purpose. To determine the ability of the device to withstand exposure to specified high temperature.
2. Procedure: EEDs shall be placed in an oven preheated to 30°C (54°F) above the maximum predicted temperature during service life, but not less than 71.1°C (+160°F), for a period of 1 hour. The EEDs shall not autoignite nor decompose as a result of this exposure. The lack of decomposition shall be verified by dissecting the item and visually inspecting for any decomposition/degradation.

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METHOD 3403

HIGH TEMPERATURE STORAGE
(ACCELERATED AGING)

1. Purpose. To subject the EED to an extreme storage environment as part of an accelerated aging test. Subsequent testing will determine the existence of an anomalous condition introduced by material variation or assembly procedures which would shorten the service life of an explosive component.
2. Procedure. Store explosive components at +71.1°C (+160°F) and 40 to 60 percent humidity for 30 days.

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METHOD 3407

TEMPERATURE CYCLING

1. Purpose. To determine the ability of an electroexplosive subsystem component to resist cyclic exposure to extremes of high and low temperatures.
2. Apparatus. The test apparatus shall be capable of inducing a temperature transient in the component(s) equal to the worst case predicted thermal transient but not less than 3°C (5.4°F) per minute. The apparatus shall have the capability of maintaining the component at the high and low temperature plateau for no less than two hours.
3. Procedure. The high temperature shall be the maximum predicted under worst case conditions plus an 11°C (20°F) margin, but not less than 71.1°C (160°F). The low temperature shall be the minimum predicted under worst case conditions with a margin of -11°C (-20°F) or -53.9°C (-65°F) whichever is the colder.
 - a. The minimum number of cycles shall be eight. Each cycle shall have a 2 hour or longer dwell at the high and low temperature levels. The transitions between high and low temperatures shall be at the maximum predicted thermal transient for the components, but not less than 3°C (5.4°F) per minute.
 - b. Failures shall be based on measurements and visual inspection made after the specimen has reached thermal stability at room temperature following the last cycle.

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METHOD 3408

TWENTY FOOT DROP TEST

1. Purpose. To demonstrate the capability of the Safe & Arm Device to survive a fall of twenty feet.
2. Apparatus. The Safe & Arm device shall be dropped on to a 1/2" thick steel plate from a height of twenty feet. The device shall not fire as a result of the impact, and shall be safe to handle for subsequent disposal. The device need not be functional following this test.

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METHOD 3409

SIX FOOT DROP TEST

1. Purpose: To demonstrate that the EED will not initiate when dropped from six feet and will perform to specification after impact.
2. Procedure: The EED shall be dropped on to a 1/2" thick steel plate from a height of six feet. Two drops of each initiator shall be conducted. The first drop shall cause the initiator to impact on the output end. The second drop shall cause the initiator to impact on the side. The EED shall not fire, dud, or deteriorate in performance as a result of this test.

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GROUP 4000

ANALYTICAL EVALUATION

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METHOD 4303

WORST CASE ELECTROMAGNETIC HAZARD ANALYSIS

1. Purpose. To provide an analytical method for evaluating potential RF hazards to EEDs.

2. Information Required.

a. Electroexplosive device characteristics:

- (1) The Results of Direct Current Sensitivity Method 2203
- (2) The Results of Radio Frequency Impedance Method 2204
- (3) The Results of Radio Frequency Sensitivity Method 2207

b. Electroexplosive subsystem component characteristics

3. Configurations to be analyzed. All configurations in which premature initiation could result in a hazard shall be analyzed. Most electroexplosive devices used in electroexplosive subsystems are subject to the following configurations of concern:

- a. Installed: electroexplosive device installed in its subsystem and all systems fully assembled.
- b. Check out: electroexplosive device installed in its subsystem and additional non-flight-test equipment attached to the electroexplosive subsystem for checkout.
- c. Partially assembled: electroexplosive device installed in a partially assembled electroexplosive subsystem.
- d. Installation and Hook-up: Installation and electrical connection of the electroexplosive device in the electroexplosive subsystem.
- e. Hand held: the electroexplosive device literally "hand held" prior to installation.

In each of these configurations, and perhaps other configurations, the electroexplosive device may be subject to premature ignition due to coupling of electromagnetic energy from the electromagnetic environment to the electroexplosive device.

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4. Electromagnetic environment. The electromagnetic environment to be assumed incident upon the electroexplosive device or electroexplosive subsystem shall be dictated by the actual environment to be experienced. In lieu of knowledge of the actual environment to be experienced by a particular electroexplosive subsystem, an electromagnetic environment of 2 watts per square meter, from 1 megahertz to 50 megahertz, and 100 watts per square meter from 50 megahertz to 32 gigahertz, shall be assumed.

5. General analytical approach. All analyses shall be carried out in accord with "Monograph on Computation of RF Hazards", Monograph M-C2210-1, prepared by the Applied Physics Laboratory of the Franklin Research Center.

6. Specific analysis performance. The specific analysis shall demonstrate an overall understanding of the handling and sequence of events in the electroexplosive system buildup in electromagnetic environments that may lead to critical or catastrophic hazards. All critical and catastrophic hazard configurations must be analyzed. Although simple calculations of coupling through shielding and aperture penetration may be presented in simple derivative form, all calculations of antenna aperture shall be systematized with a computer program that has been demonstrated to conform with "Monograph on Computation of RF Hazards". (See Appendix for a sample program.) All computations shall be formalized using an aperture parameter so that evaluation of power delivered to the electroexplosive device results from a simple multiplication of the assumed electromagnetic environment and the aperture as a function of frequency. The results of this calculation, the worst case power to the EED, as a function of frequency shall be compared with the RF no-fire level (as determined in Method 2207) for the particular firing mode under consideration. The results of this comparison shall be presented as a dB of safety parameter. This dB of safety parameter is a function of frequency and is defined as

$$dB_S = 10 \log_{10} \frac{P_{NF}}{P_{EED}}$$

where P_{NF} is the no-fire level from Method 2207, and
 P_{EED} is the calculated worst case power delivered to the EED.

The dB of safety parameter shall be plotted on 8-1/2" x 11" paper for a frequency range from 1 megahertz to 32 gigahertz on semilogarithmic graph paper. The impedance results of Method 2204 can be used in the calculation of the pickup for the frequency range from 1 to 1200 megahertz.

The dB values less than 0 are to be considered hazardous and require electroexplosive subsystem redesign.

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APPENDIX

EXAMPLE EED ANALYSIS TOOL

10. GENERAL.

10.1 Scope. This appendix is included as part of this Standard for the purposes of providing an example analysis tool to assess the safety of electroexplosive devices (EEDs) in environments with stray electromagnetic signals. Use of this technique to satisfy the requirements of paragraph 6.10.c and Test Method 4303 is not mandatory as other techniques and mechanizations are available. Consequently, the user of this tool assumes full responsibility for his results.

10.2 Overview and Application. This analysis tool performs a "worst case" analysis of the EED subsystem to determine if the EEDs are safe in the payload's RF environment. If this analysis shows a system is safe, then it is quite safe. On the other hand, an indication of "not safe" from the analysis does not prove that the system is unsafe, but that more specific analysis or testing is required for the system safety to be established.

20. REFERENCE DOCUMENT.

The methods used in the analysis tool are based on analytical models discussed in the following document:

M-C2210-1

Monograph on Computation of RF Hazards,
Monograph M-C2210-1, Franklin Research Center

(Application for copies of this publication should be addressed to the Franklin Research Center, 20th Street and Race, Philadelphia, Pennsylvania 19103)

30. DEFINITIONS. Not applicable.

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40. GENERAL DESCRIPTION

40.1 Host Computer.

40.1.1 Description. This EED Analysis Tool is implemented on an HP-85 Personal Computing System. Peripheral equipment includes a HP82901M Dual Flexible Disk Drive, HP7225A Plotter, and HP2613B Line Printer. The HP-85 must have at least 32K of internal memory and be programmable in BASIC.

40.1.2 Power-up Procedures.

- a. Turn equipment on: First turn on all peripherals to be used (disk drive, printer, plotter). Then turn on the HP-85 unit.
- b. Insert program diskette into Drive 0 and data diskette into Drive 1.
- c. Run Program: the program is run by loading and running a file named MANAGER. Type: CHAIN "MANAGER" and press [End Line]. No further user initialization is required.

40.2 EEDAT Program Protocol.

40.2.1 System Prompts. Whenever the software reaches a point requiring user input, it displays a descriptive phrase followed by "?" as follows:

ENTER POWER DENSITY [W/M*M]
?

40.2.2 User Responses. The user should type the appropriate entry and press [End line].

40.2.3 Data Files. Data files are created at several points in the program. At each of these points the user is given 3 options:

- a. Use the default file
- b. Use an existing file
- c. Create a new file

40.2.3.1 Default Files. Default files exist for four data files and the output file. These are:

DEFAULT FILE:

TEMP
EEDSEN
EEDIMP
SHIELD
OUTPUT

USED FOR:

EM Environment Data
Sensitivity Data
Impedance Data
Shielding Data
Output Data

The default files are appropriate if user is not concerned about losing data files on subsequent runs. Files which are to be re-used should be entered via the "Create" option and given a unique name.

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40.2.3.2 User Defined Files. The user must insure that correct bookkeeping is followed. Two cautions regarding user defined files are appropriate: (a) there is no check to insure that data files are properly used; i.e., no test is made to assure that an impedance file is being used for impedance data and (b) improper naming of files can cause a halt in program execution; e.g., creating a new file with a name already being used to name an existing file or attempting to recall a data file which doesn't exist are fatal errors.

40.2.4 Error Recovery. To recover from a fatal error, the user must type CHAIN "MANAGER" [End line] and start over.

50. DETAILED DESCRIPTION.

50.1 Program Executive. There are three basic functions from which the user may select: environment specification, model selection and output. The top level flow chart which shows relationship between the various functions and files is shown in Figure A-1. The executive which calls the principal subroutines is named MANAGER. MANAGER causes the appropriate function to be executed based on keyboard input by the user. User prompting is provided through the Main Menu of MANAGER as shown below:

EED ANALYSIS PROGRAM

- (1) ELECTROMAGNETIC ENVIRONMENT
- (2) PROCESS DATA FILE FOR OUTPUT
- (3) SELECT + RUN ANALYSIS MODEL
- (4) PROCESS PROGRAM OUTPUT
- (5) END PROGRAM

50.2 Electromagnetic Environment Input. This function is accessed by selecting subroutine (1) of the Main Menu. The user specifies the electromagnetic environment in which the EED is to be analyzed, following the computer prompt:

DATA FILE SELECTION
ELECTROMAGNETIC ENVIRONMENT

- (1) USE DEFAULT FILE
- (2) USE EXISTING FILE
- (3) CREATE NEW FILE
- (4) RETURN TO MAIN MENU

Options (1) through (3) give the user some flexibility in handling the EM environment data. New environment data is input to either a temporary file using option (1), or to a permanent file using option (3). An existing permanent file containing the desired EM environment data can be accessed by exercising option (2).

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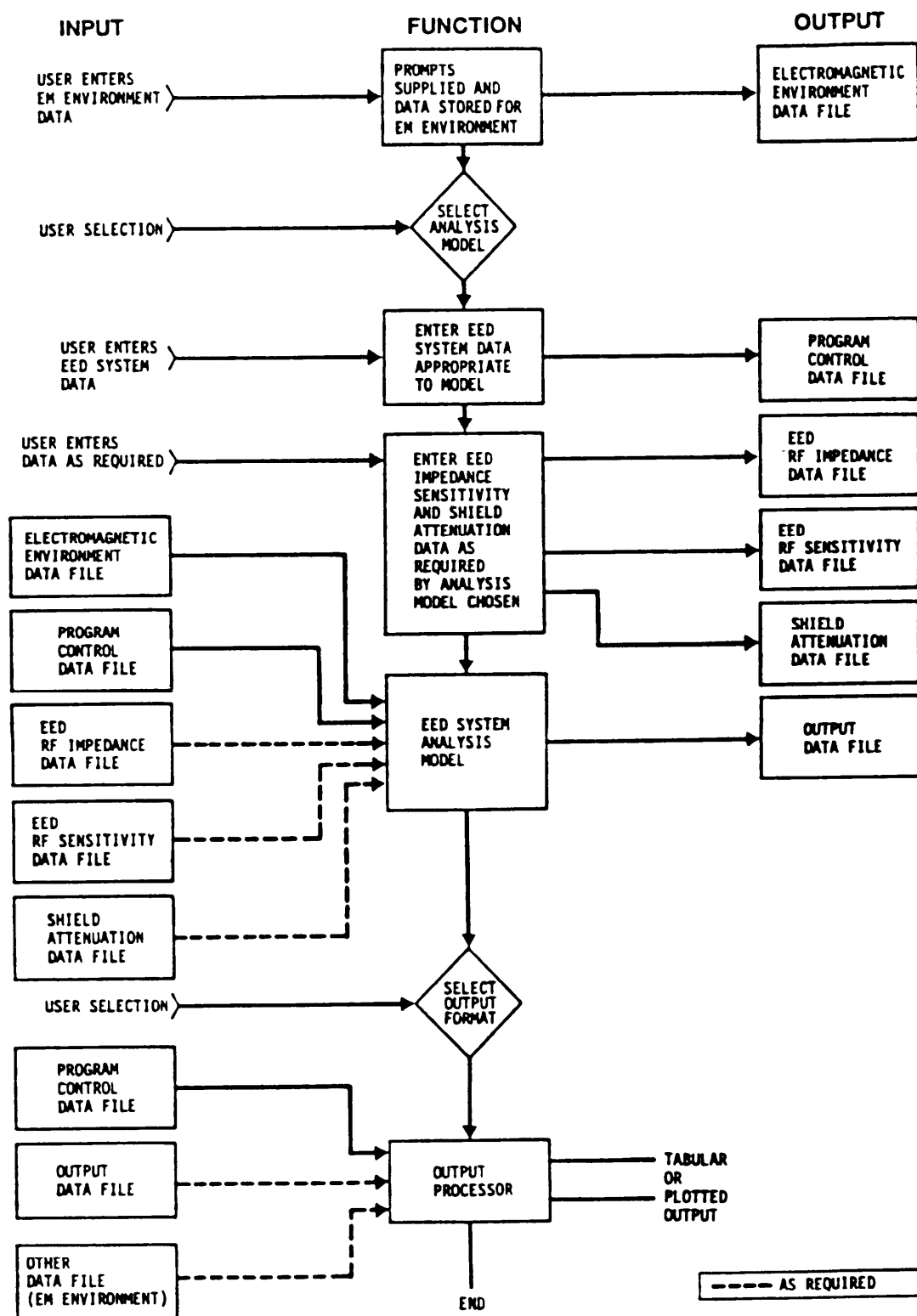


FIGURE A-1 Overall Flow Chart

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If the user selects either option (1) or option (3) he has the further option of entering the data in power density or field strength, and will be prompted as follows:

DO YOU WISH TO INPUT AS FIELD
STRENGTH (V/M) OR POWER DENSITY
(W/M*M)?
ENTER 'V' OR 'W'
?

50.2.1 Option (1): USE DEFAULT FILE. This option enables the user to define EM environment data in the default file TEMP. This option will overwrite any data previously stored in the default file. The following menu appears after option (1) above is selected:

ELECTROMAGNETIC ENVIRONMENT
SPECIFICATION

[Option 1a:] (1) INDIVIDUAL SOURCES
[Option 1b:] (2) SPECTRUM SPECIFICATION
[Option 1c:] (3) MIL-STD-1512 DEFAULT LEVEL
[2 W/M*M 50KHZ-50MHZ]
[100 W/M*M 50MHZ-40GHZ]
[Option 1d:] (4) RETURN TO MAIN MENU

50.2.1.1 Option 1a: INDIVIDUAL SOURCES. Option (1a) permits specification of the environment as a sum of inputs of up to 100 discrete sources, each of which has a name, a frequency, and signal strength in volts-per-meter or watts-per-square-meter. The following is an example of entry for one source:

ENTER INDIVIDUAL RF SOURCE
MAXIMUM OF 12 CHARACTERS

ENTER SOURCE NAME OR ID:
?
[User Response:] FPS-67
ENTER FREQUENCY OF SOURCE [MHZ]:
?
[User Response:] 2900

ENTER FIELD STRENGTH V/M OF
SOURCE AT THE EED:
?
[User Response:] 1

ENTER ANOTHER SOURCE [Y OR N]

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Additional sources may be entered by entering "Y" (for Yes) to the last question. Each source may be entered in any order, not necessarily by ascending frequency. When all sources have been entered, enter "N" (for No). Program execution will then return to the Main Menu.

50.2.1.2 Option 1b: SPECTRUM SPECIFICATION. Option (1b) permits specification of the environment as a continuous spectrum. The lowest frequency and its signal strength, the highest frequency and its signal strength, and exactly eight intermediate points on the spectrum in an ascending frequency order are specified. A partial example of the data entry cycle for this option is presented below:

SPECTRUM SPECIFICATION

SPECTRUM WILL BE SPECIFIED BY
ENTRY OF LOWER AND UPPER
FREQUENCY BOUND AND 8 INTER-
MEDIATE FREQUENCIES EACH WITH
AN ASSOCIATED POWER.
BETWEEN ENTRIES, VALUES WILL
BE LINEARLY INTERPOLATED.

```

ENTER LOW FREQUENCY BOUND [MHZ]:
?
[User Response:] .01
ENTER POWER DENSITY [W/M*M]:
?
[User Response:] .1

ENTER TOP FREQUENCY BOUND [MHZ]:
?
[User Response:] 40000
ENTER POWER DENSITY [W/M*M]:
?
[User Response:] .05

ENTER INTERMEDIATE FREQ 1 [MHZ]:
?
[User Response:] 2800
ENTER POWER DENSITY [W/M*M]:
?
[User Response:] .1

ENTER INTERMEDIATE FREQ 2 [MHZ]:
?
[User Response:] 2801
ENTER POWER DENSITY [W/M*M]:
?
[User Response:] 1

```

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```

ENTER INTERMEDIATE FREQ 3 [MHZ]:
?
[User Response:] 2802
ENTER POWER DENSITY [W/M*M]:
?
[User Response:] 10

ENTER INTERMEDIATE FREQ 4 [MHZ]:
?
[User Response:] 2805
ENTER POWER DENSITY [W/M*M]:
?
[User Response:] 1

ENTER INTERMEDIATE FREQ 5 [MHZ]:
?
[User Response:] 2806
ENTER POWER DENSITY [W/M*M]:
?
[User Response:] .1

```

50.2.1.3 Option 1c: MIL-STD-1512 DEFAULT LEVEL. Option (1c) is the default level identified in MIL-STD-1512, and corresponds to the maximum safe radiation level for personnel. It is a spectrum specification, defined as a level of 2 watts per square meter between 50 KHz and 50 MHz and 100 watts per square meter between 50 MHz and 40 GHz.

50.2.1.4 Option 1d: RETURN TO MAIN MENU. After data entry for each of the three options is completed, control automatically returns to MANAGER and the Main Menu is displayed. Also, RETURN TO MAIN MENU may be commanded at any time it is visible on the monitor screen.

50.2.2 Option (2): USE EXISTING FILE. This system allows the user to use data in a file which was previously created via option (3) (see 50.2.3). After selecting option (2), user is prompted with

ENTER EXACT EXISTING FILE NAME

Now enter the file name of the existing file containing EM environment data. If a matching file is found this file becomes the environments file used in the analysis, program control returns to MANAGER, and the Main Menu is again displayed. If no file name is found to match the name internal, the following message appears:

Error 67 on line 657 : FILE NAME

Program execution ceases and the user must re-initialize by typing CHAIN "MANAGER" [End Line].

50.2.3 Option (3): CREATE NEW FILE. This option requires the user to input a new file name and data.

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The user is prompted with:

ENTER NEW FILE NAME

(If user enters the name of an existing file, the following error message

Error 63 on line 560 : DUP NAME

will appear, program execution ceases and the user must re-initialize by typing CHAIN "MANAGER" [End Line].)

From this point through completion of entry of EM environment, the data entry procedures are identical with those of the Default File, option (1) (see 50.2.1).

50.3 Select & Run Analysis Model. This function is accessed when subroutine (3) of the Main Menu is selected. It contains routines for input of EED data and computes the power coupled into that EED as a function of frequency. The user specifies the physical parameters of the EED subsystem and chooses the type of analysis. The program stores results on output data files.

50.3.1 Data Requirements. A file for storing output data, data which specifies the EED radio frequency (RF) sensitivity, the impedance of the EED, and the physical measurements of the installation are required for all analyses. In addition, other data may be required depending on the type of analysis being accomplished, such as information relating to the shielding of the input leads.

50.3.1.1 Output Data File Selection. The user must first specify the name of the output data file where output of the analysis is stored. The following prompt is displayed:

DATA FILE SELECTION
ANALYSIS OUTPUT DATA FILE

- (1) USE DEFAULT FILE
- (2) USE EXISTING FILE
- (3) CREATE NEW FILE
- (4) RETURN TO MAIN MENU

SELECT FROM ABOVE

The selections listed here are executed similarly to those described in 2.

3.1.2 Analysis Model Selection and Spectrum. Selection of the analysis model is driven by the physical properties of the system to be analyzed. The single bridgewire EED has two basic modes of RF sensitivity: Pin-to-Pin, which is the normal bridgewire heating firing mode, and Pin-to-Case, which involves various other firing mechanisms. Also, a system may be either

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shielded or unshielded. These variations are addressed in the Model Selection Page which is displayed when the user has completed naming the output file, e.g.:

FRANKLIN INSTITUTE WORST CASE
APERTURE MODEL

[Model 1:] (1) UNSHIELDED PIN-TO-PIN
[Model 2:] (2) SHIELDED PIN-TO-PIN
[Model 3:] (3) PIN-TO-CASE
(4) RETURN TO MAIN MENU

SELECT FROM (1-4)

50.3.1.3 EED RF Sensitivity Data File. Once a model has been selected, the user must identify the name of an RF Sensitivity Data File and will be prompted with the following display:

DATA FILE SELECTION

PIN-TO-PIN
EED RF SENSITIVITY DATA FILE

[Option 2a:] (1) USE DEFAULT FILE
[Option 2b:] (2) USE EXISTING FILE
[Option 2c:] (3) CREATE NEW FILE

SELECT FROM ABOVE

(If model 3, the pin-to-case model, is being used, "PIN-TO-CASE" appears in place of "PIN-TO-PIN").

50.3.1.3.1 Default or New EED Sensitivity Data. If user selected options 2a or 2c then he will now enter EED RF sensitivity data as follows:

ELECTROEXPLOSIVE DEVICE
RF SENSITIVITY SPECIFICATION

[Option 3a:] (1) CONSTANT SENSITIVITY
[Option 3b:] (2) SENSITIVITY SPECTRUM SPECIFICATION
[Option 3c:] (3) NSI-1'S RF SENSITIVITY

50.3.1.3.1.1 Option 3a: CONSTANT SENSITIVITY. Option (3a) CONSTANT SENSITIVITY can be chosen if more detailed data is unavailable. User would then be requested to specify a value for the sensitivity:

ENTER CONSTANT RF SENSITIVITY
[WATTS]

50.3.1.3.1.2 Option 3b: SENSITIVITY SPECTRUM SPECIFICATION. Option (3b) SENSITIVITY SPECTRUM SPECIFICATION enables user to specify a sensitivity at ten frequencies, in a manner similar to that described previously for the spectrum EM environment (see 50.2.1).

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50.3.1.3.1.3 Option 3c: NSI-1's RF SENSITIVITY. Option (3c) NSI-1's RF SENSITIVITY may be selected if the NASA Standard Initiator-1 (NSI-1) is the EED being analyzed.

50.3.1.3.2 Previously Entered EED Sensitivity Data. If instead of choosing the Default File or creating a new file, the user elected to use an existing file, he would be prompted to name an existing file, and the program would continue directly to the next portion of the program.

50.3 .4 Shielding Data File. If user has chosen a model requiring shielding data, the user will be prompted with the choices:

SHIELD ATTENUATION DATA FILE

[Option 4a:] (1) USE DEFAULT FILE
[Option 4b:] (2) USE EXISTING FILE
[Option 4c:] (3) CREATE NEW FILE

SELECT FROM ABOVE

50.3.1.4.1 Previously Entered Shield Data. Option 4b USE EXISTING FILE will employ the results of a previously created and named file.

50.3.1.4.2 Default or New Shield Data. Option 4a and 4c will be followed by the prompt

SHIELD ATTENUATION SPECIFICATION

[Option 5a:] (1) CONSTANT ATTENUATION
[Option 5b:] (2) ATTENUATION VS. FREQUENCY
[Option 5c:] (3) "FIGURE 2" SHIELD DATA
[Option 5d:] (4) DEFAULT (20dB CONSTANT)

SELECT FROM ABOVE

Options (5a) and (5b) are exercised similarly to the spectrum and sensitivity specification options (see 50.2.1 or 50.3.1.3). Option (5c) "FIGURE 2" SHIELD DATA is composite data created for a specific program. It is provided for illustrative purposes only and should not be used indiscriminately. Option (5d) uses a constant 20 dB attenuation.

50.3.1.5 Impedance Data File. A data file is now identified and values entered. First the prompt for file choice appears:

EED RF IMPEDANCE DATA FILE

[Option 6a:] (1) USE DEFAULT FILE
[Option 6b:] (2) USE EXISTING FILE
[Option 6c:] (3) CREATE NEW FILE

SELECT FROM ABOVE

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Option (6b) USE EXISTING FILE will employ the results of a previously created and named file. Options (6a) and (6c) are followed by a prompt to specify frequency as a constant across the frequency band, or as a spectrum specification, as follows:

ELECTROEXPLOSIVE DEVICE
RF IMPEDANCE SPECIFICATION

- (1) CONSTANT IMPEDANCE
- (2) SPECTRUM SPECIFICATION

SELECT FROM ABOVE

Data input is similar to that previously described in paragraph 50.2.1 or 50.3.1.3.

50.3.1.6 Geometry of Connecting Leads. A critical point in the physics of energy coupling is the physical size and arrangement of the leads connected to the EED. The data describing the arrangement of the leads may be input in two ways: (a) as length and width of a presumed rectangular aperture, or (b) as the area and perimeter of an aperture. The equations for power coupling use area or perimeters, so the user should use length and width with care. An example of the data input sequence is shown below:

```

ENTER AREA OF LOOP [CMSQ]
ENTER '0' IF NOT KNOWN.
?
[User Response:] 9.5
ENTER PERIMETER OF LOOP [CM].
ENTER '0' IF NOT KNOWN.
?
[User Response:] 38.4
ENTER WIDTH OF LOOP [CM].
ENTER '0' IF NOT KNOWN.
?
[User Response:] 0
ENTER LENGTH OF LOOP [CM].
ENTER '0' IF NOT KNOWN.
?
[User Response:] 0

```

50.3.2 Model Execution. Following entry of the geometry data, the program computes power coupled into the EED, stores the results on the data diskette and returns control to the main menu. The equations used in the computations are described in paragraph 60.

50.4 Output Format Processor. Any of the data files created during program execution may be output to the plotter, line printer or both devices upon user command. Data files for electromagnetic environment, EED sensitivity or impedance are accessed through selection of subroutine (2) in the Main Menu.

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The analysis output file containing the results of the power calculations is processed for output through selection of subroutine (4) in the Main Menu.

The following choices are available for the user:

- a. Title of plot or listing
- b. Scale range (plotter only)
- c. Axes labels (plotter only)
- d. Linear or logarithmic axes (plotter only)

Needed user actions are clearly indicated in the instructions displayed for each entry. The program requests specific choices and responds appropriately to user commands during the course of the execution.

60. POWER EQUATIONS.

Equations used in this program were developed by Franklin Research Institute and adapted for this program as follows:

60.1 Case 1: Pin-to-Pin, Continuous Incident Spectrum. For an aperture of small size with respect to wavelength ($\lambda/2$ greater than P) the power coupled to the EED as a function of frequency may be expressed as

$$W(f) = \frac{4.67 * 10^4 * A^2 * P_i(f)}{\pi * (\lambda)^2 R_T}$$

where:

- $W(f)$ = power spectral density coupled to the EED (Watts/Hz)
- A = Area of aperture formed by input leads to EED (meters squared)
- $P_i(f)$ = power spectral density incident on EED leads (Watts/meter squared/Hz)
- λ = wavelength at frequency f ($\lambda = \frac{3 \times 10^8 \text{ meters}}{f}$)
- R_T = termination resistance of EED (ohms)
- P = perimeter of aperture (meters)
- f = frequency (Hz)

For an aperture of large size (P greater than $\lambda/2$)

$$W(f) = \frac{D(\lambda)^2}{4 \pi} P_i(f)$$

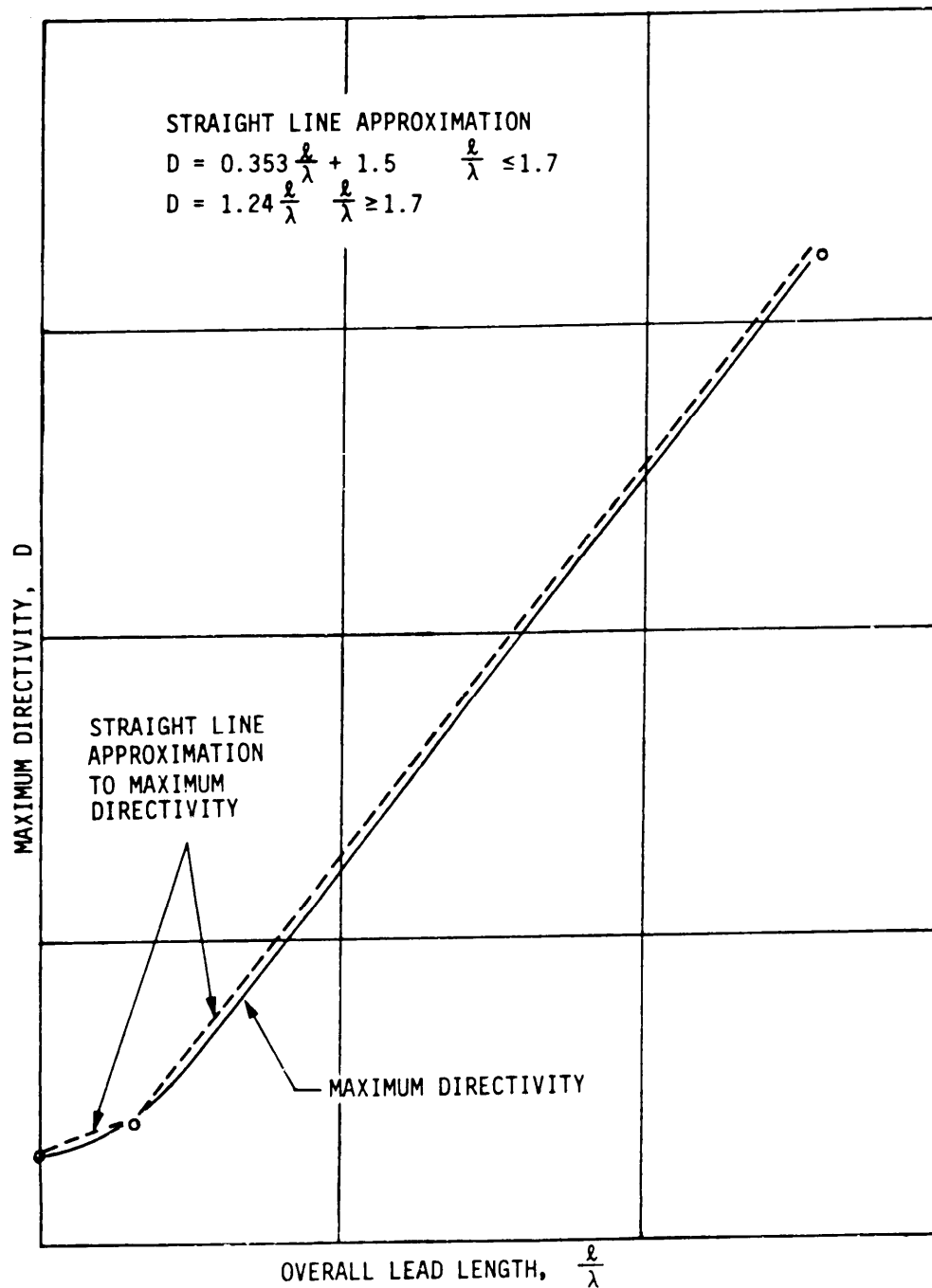
where:

- D = directivity of loop.

For worst case calculations, a composite directivity of 3 antennas is used. The composite as given in the reference document is shown here as Figure A-2.

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MAXIMUM DIRECTIVITY OF THREE KNOWN ANTENNA CONFIGURATIONS
the unterminated rhombic, the long wire, and the circular loop.

FIGURE A-2 Antenna Directivity

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60.2 Case 2: Pin-to-Pin, Discrete Incident Spectrum. The same equations apply except that $W(f)$ and $P_i(f)$ have units of watts and watts per meter squared, respectively.

60.3 Case 3: Pin-to-Case. For high frequencies,

$$W(f) = P_i(f) \frac{1.64(\lambda)^2}{4 \pi^2}$$

The directivity of the loop is assumed to be that of a half dipole (1.64).

For low frequencies,

$$W(f) = P_i(f) l^2 \frac{Z_0}{\text{Re}[Z_{pc}(f)]}$$

where:

l = lead length in meters

$W(f)$ = power coupled to the EED (watts)

$P_i(f)$ = power incident on EED leads (watts/meter squared)

Z_0 = impedance of free space (ohms)

$\text{Re}[Z_{pc}(f)]$ = real part of the pin-to-case impedance at a particular frequency (ohms).

70. PROGRAM LISTINGS.

The following pages contain listings for the four programs used to support the EED Analysis Tool. All programs have been written in BASIC for the HP-85 Computer.

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70.1 Program Listing For EED ANALYSIS PROGRAM

```
10 REM LED ANALYSIS PROGRAM
20 REM
30 REM
40 REM
50 REM
60 REM
70 REM THIS IS THE MANAGER FOR THE EED ANALYSIS PROGRAM
80 ASSIGN# 2 TO "PFLAGS:D701"
90 ASSIGN# 5 TO "TEMP:D701"
100 REM
110 CLEAR
120 BEEP @ WAIT 200 @ BEEP @ WAIT 200 @ BEEP
130 DISP "      EED ANALYSIS PROGRAM"
140 DISP
150 DISP "(1) ELECTROMAGNETIC ENVIRONMENT"
160 DISP
170 DISP "(2) PROCESS DATA FILE FOR OUTPUT"
180 DISP
190 DISP "(3) SELECT + RUN ANALYSIS MODEL"
200 DISP
210 DISP "(4) PROCESS PROGRAM OUTPUT"
220 DISP
230 DISP "(5) END PROGRAM"
240 DISP
250 DISP "      SELECT FROM (1-5)"
260 INPUT S1
270 REM BRANCH BASED ON CHOICE
280 IF S1=1 THEN GOSUB 340
290 IF S1=2 THEN GOSUB 720 @ CHAIN "LPLOT5"
300 IF S1=3 THEN GOSUB 340 @ GOSUB 1050 @ CHAIN "FRANK2"
310 IF S1=4 THEN GOSUB 340 @ CHAIN "LPLOT5"
320 IF S1=5 THEN END
330 BEEP @ GOTO 110
340 REM      FILE SELECTION
350 CLEAR
360 DISP "      DATA FILE SELECTION"
370 DISP
380 IF S1=1 THEN DISP "  ELECTROMAGNETIC ENVIRONMENT"
390 IF S1=3 THEN DISP "  ANALYSIS OUTPUT DATA FILE"
400 IF S1=4 THEN DISP "OUTPUT DATA FILE TO BE PROCESSED"
410 DISP
420 DISP "(1) USE DEFAULT FILE"
430 DISP "(2) USE EXISTING FILE"
440 IF S1#4 THEN DISP "(3) CREATE NEW FILE"
450 DISP "(4) RETURN TO MAIN MENU"
460 DISP
470 DISP "      SELECT FROM ABOVE"
480 INPUT S2
490 REM
```

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70.1 (Continued)

```

500 IF S2=1 AND S1=1 THEN U1$="FDATA"
510 IF S2=1 AND S1=3 THEN U1$="OUTPUT"
520 IF S2=1 AND S1=4 THEN U1$="OUTPUT"
530 IF S2=2 THEN DISP "ENTER EXACT EXISTING FILE NAME" @ INPUT U1$
540 IF S2=3 AND S1#4 THEN DISP "ENTER NEW FILE NAME" @ INPUT U1$
550 REM CREATE FILE
560 IF S2=3 AND S1=1 THEN CREATE U1$&":D701",102,40
570 IF S2=3 AND S1=3 THEN CREATE U1$&":D701",1000,32
580 IF S2=4 THEN 110
590 REM STORE FILES IN PFLAGS
600 IF S1=1 THEN PRINT# 2,20 ; U1$
610 IF S1=3 THEN PRINT# 2,24 ; U1$
620 IF S1=4 THEN PRINT# 2,24 ; U1$
630 !
640 IF S1=1 AND S2#2 THEN CHAIN "FENTER"
650 !
660 ! TEST EXISTING FILE NAME
670 ! TO BE SURE IT EXISTS
680 !
690 IF S2=2 THEN ASSIGN# 1 TO U1$&":D701"
700 RETURN
710 !
720 ! PROCESS FILE
730 !
740 CLEAR
750 DISP " PROCESS FILE FOR OUTPUT"
760 DISP
770 DISP "SELECT DATA FILE TO BE PROCESSED" @ DISP
780 DISP " (1) DEFAULT SENSITIVITY DATA"
790 DISP " (2) DEFAULT SHIELD DATA"
800 DISP " (3) DEFAULT IMPEDANCE DATA"
810 DISP " (4) SOME OTHER DATA FILE"
820 DISP " (5) RETURN TO MAIN MENU"
830 INPUT S3
840 IF S3=5 THEN 110
850 IF S3=1 THEN U1$="EEDSEN" & GOTO 910
860 IF S3=2 THEN U1$="SHIELD" & GOTO 910
870 IF S3=3 THEN U1$="EEDIMP" & GOTO 910
880 IF S3#4 THEN GOTO 720
890 DISP @ DISP "ENTER EXACT FILE NAME"
900 INPUT U1$
910 ASSIGN# 9 TO U1$&":D701"
920 REM STORE TEMP AS OUTPUT FILE IN PFLAGS
930 PRINT# 2,24 ; "TEMP"
940 PRINT# 2,3 ; 10
950 REM PROCESS FILE
960 READ# 2,2 ; D@ READ# 2,3 ; Q
970 FOR G=1 TO Q ! I HOPE
980 IF D=1 THEN READ# 9,G ; S$,F,P& GOTO 1000
990 READ# 9,G ; F,P

```

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70.1 (Continued)

```
1000 IF P=0 THEN D0=0 ELSE D0=LGT(1000xP) ! dB mW
1010 PRINT# 5,G ; F,P,P,D0
1020 NEXT G
1030 RETURN
1040 !
1050 !      SELECT MODEL
1060 !
1070 CLEAR
1080 DISP " FRANKLIN INSTITUTE WORST CASE"
1090 DISP "      APERTURE MODEL"
1100 DISP
1110 DISP
1120 DISP "(1) UNSHIELDED PIN-TO-PIN"
1130 DISP
1140 DISP "(2) SHIELDED PIN-TO-PIN"
1150 DISP
1160 DISP "(3) PIN-TO-CASE"
1170 DISP
1180 DISP "(4) RETURN TO MAIN MENU"
1190 DISP
1200 DISP
1210 DISP "      SELECT FROM (1-4)";
1220 DISP
1230 INPUT S1
1240 IF S1=4 THEN 110
1250 IF S1<1 OR S1>3 THEN 1200
1260 PRINT# 2,1 ; S1
1270 REM MODEL CHOICE STORED
1280 DISP USING 1290 ; S1
1290 IMAGE 9X,"MODEL",K,"CHOSEN"
1300 RETURN
1310 ASSIGN# 2 TO *
1320 ASSIGN# 5 TO *
1330 ASSIGN# 9 TO *
1340 END
```

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70.2 Program Listing For FENTER

```

10 REM FENTER--EM ENVIRONMENT DATA ENTRY
20 PRINTER IS 2
30 !
40 ASSIGN# 2 TO "PFLAGS:D701"
50 !
60 READ# 2,20 ; H1$
70 ASSIGN# 8 TO H1$&":D701"
80 !
90 DIM F1(9),P1(9),S$(12)
100 CLEAR
110 BEEP @ WAIT 200 @ BEEP @ WAIT 200 @ BEEP
120 DISP "      ELECTROMAGNETIC ENVIRONMENT"
130 DISP "      SPECIFICATION"
140 DISP
150 DISP "(1)  INDIVIDUAL SOURCES"
160 DISP
170 DISP "(2)  SPECTRUM SPECIFICATION"
180 DISP
190 DISP "(3)  MIL-STD-1512 DEFAULT LEVEL"
200 DISP "      [ 2 W/MxM 50KHZ-50MHZ]"
210 DISP "      [100 W/MxM 50MHZ-40GHZ]"
220 DISP
230 DISP "(4)  RETURN TO MAIN MENU"
240 DISP
250 DISP "      SELECT FROM (1-4) ABOVE"
260 REM
270 INPUT A
280 IF A=1 THEN PRINT# 2,2 ; 1 @ GOTO 330
290 IF A=2 THEN PRINT# 2,2 ; 0 @ PRINT# 2,3 ; 10 @ GOTO 640
300 IF A=3 THEN PRINT# 2,2 ; 0 @ PRINT# 2,3 ; 10 @ GOTO 1110
310 IF A=4 THEN CHAIN "MANAGER"
320 GOTO 250 @ REM INVALID
330 REM  INDIVIDUAL SOURCES
340 N=1
350 PRINT# 2,3 ; N
360 CLEAR
370 DISP " DO YOU WISH TO INPUT AS FIELD STRENGTH (V/M) OR POWER
DENSITY (W/MxM)?"
380 DISP "ENTER 'V' OR 'W'." @ INPUT L$ @ IF L$="V" AND L$="W" THEN GOTO
360
390 DISP "  ENTER INDIVIDUAL RF SOURCE"
400 DISP "  (MAXIMUM OF 12 CHARACTERS)"
410 DISP
420 DISP "ENTER SOURCE NAME OR ID:"
430 INPUT S$
440 DISP
450 DISP "ENTER FREQUENCY OF SOURCE [MHZ]:"
460 INPUT F
470 IF L$="W" THEN DISP @ DISP "ENTER POWER DENSITY W/MxM OF"
480 IF L$="V" THEN GOTO 500
490 GOTO 510

```


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70.2 (Continued)

```

500 DISP @ DISP "ENTER FIELD STRENGTH V/M OF"
510 DISP "      SOURCE AT THE EED:"
520 INPUT P
530 IF L$="V" THEN P=P^2/377
540 PRINT# 8,N ; S$,F,P
550 DISP
560 DISP
570 DISP "ENTER ANOTHER SOURCE [Y OR N]"
580 INPUT A$
590 IF A$="Y" THEN N=N+1 @ GOTO 390
600 IF A$#"N" THEN 550
610 PRINT# 2,3 ; N
620 REM      RETURN TO MAIN
630 GOTO 1210
640 REM      SPECTRUM
650 CLEAR
660 DISP " DO YOU WISH TO INPUT AS FIELD STRENGTH (V/M) OR POWER DENSITY
(W/M*M)?"
670 DISP "ENTER 'V' OR 'W'." @ INPUT L$
680 IF L$#"V" AND L$#"W" THEN GOTO 650
690 DISP "      SPECTRUM SPECIFICATION"
700 DISP
710 DISP " SPECTRUM WILL BE SPECIFIED BY"
720 DISP "ENTRY OF LOWER AND UPPER"
730 DISP "FREQUENCY BOUND AND 8 INTER-"
740 DISP "MEDIATE FREQUENCIES EACH WITH"
750 DISP "AN ASSOCIATED POWER."
760 DISP " BETWEEN ENTRIES, VALUES WILL"
770 DISP "BE LINEARLY INTERPOLATED."
780 N=0
790 DISP
800 DISP "ENTER LOW FREQUENCY BOUND [MHZ]:"
810 INPUT F1(N)
820 IF L$="V" THEN DISP "ENTER FIELD STRENGTH [V/M]:" @ GOTO 840
830 DISP "ENTER POWER DENSITY [W/M*M]:"
840 INPUT P1(N)
850 IF L$="V" THEN P1(N)=P1(N)^2/377
860 PRINT# 8,1 ; F1(N),P1(N)
870 DISP
880 DISP "ENTER TOP FREQUENCY BOUND [MHZ]:"
890 INPUT F1(9)
900 IF F1(9)<F1(N) THEN BEEP @ DISP "UPPER BOUND< LOWER, REENTER" @ GOTO
870
910 IF L$="V" THEN DISP "ENTER FIELD STRENGTH [V/M]:" @ GOTO 930
920 DISP "ENTER POWER DENSITY [W/M*M]:"
930 INPUT P1(9)
940 IF L$="V" THEN P1(9)=P1(9)^2/377
950 PRINT# 8,10 ; F1(9),P1(9)

```

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70.2 (Continued)

```

960 REM      INTERMEDIATE FREQ.
970 N=N+1
980 DISP
990 DISP USING 1000 ; N
1000 IMAGE "ENTER INTERMEDIATE FREQ",K,"[MHZ]:"
1010 INPUT F1(N)
1020 IF F1(N)<F1(N-1) OR F1(N)>F1(9) THEN BEEP @ DISP "ENTRY OUT OF
BOUNDS REENTER" @ GOTO 980
1030 IF L$="V" THEN DISP "ENTER FIELD STRENGTH [V/M]:" @ GOTO 1050
1040 DISP "ENTER POWER DENSITY [W/M*M]:"
1050 INPUT P1(N)
1060 IF L$="V" THEN P1(N)=P1(N)^2/377
1070 PRINT# 8,N+1 ; F1(N),P1(N)
1080 IF N<B THEN 960
1090 GOTO 1220
1100 !
1110 !      MIL-STD-1512
1120 !      2W/M*M 50KHZ-50MHZ
1130 !      100W/M*M 50 MHZ-40GHZ
1140 !
1150 FOR I=1 TO 10
1160 READ F,P
1170 PRINT# 8,I ; F,P
1180 NEXT I
1190 DATA .05,2,49.999999,2,50,100,5000,100,9000,100,14000,100,19000,100,
26000,100,33000,100
1200 DATA 40000,100
1210 !
1220 !      TEMPORARY DIAGNOSTIC
1230 !
1240 READ# 2,2 ; D
1250 READ# 2,3 ; N1
1260 PRINT "      EM ENVIRONMENT DATA"
1270 IF D=0 THEN PRINT "      FREQUENCY          POWER"
1280 IF D=0 THEN PRINT "      (MHZ)          (W/M*M)"
1290 IF D=1 THEN PRINT "      SOURCE          FREQUENCY    POWER"
1300 IF D=1 THEN PRINT "      ID          (MHZ)    (W/M*M)"
1310 FOR N=1 TO N1
1320 IF D=0 THEN DISP ." CONTINUOUS SPECTRUM MODE" @ READ# 8,N ; F,P@
PRINT USING 1340 ; F,P
1330 IF D=1 THEN DISP " DISCRETE SOURCES MODE " @ READ# 8,N ; S$,F,P@
PRINT USING 1350 ; S$,F,P
1340 IMAGE 5X,6D,3D,7X,4D,2D
1350 IMAGE 12A,2X,5D,3D,2X,4D,2D
1360 NEXT N
1370 REM RETURN TO MAIN MENU
1380 ASSIGN# 2 TO *
1390 ASSIGN# 8 TO *
1400 CHAIN "MANAGER"
1410 END

```

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70.3 Program Listing For FRANK2

```

10 !           FRANK2
20 !   FRANKLIN WORST CASE
30 !   MODEL EED ANALYSIS PROGRAM
40 !
50 !   PROGRAM FUNCTION FLAGS ETC.
60 !
70 ASSIGN# 2 TO "PFLAGS:D701"
80 D=16 @ B9=8
90 DIM F1(9),P1(9),S$(12)
100 REM FREQUENCY DATA FILE
110 READ# 2,20 ; H1$
120 ASSIGN# 8 TO H1$&"D701"
130 REM ASSIGN OUTPUT FILE
140 BEEP @ WAIT 200 @ BEEP @ WAIT 200 @ BEEP @ OFF ERROR
150 Z1=1
160 G9=0
170 GOSUB 2120
180 !
190 READ# 2,24 ; H2$
200 ASSIGN# 1 TO H2$&"D701" & OFF ERROR
210 !
220 !
230 READ# 2,1 ; G9 ! ANAL MODEL
240 READ# 2,2 ; D1 ! (1)-DISCRETE      (0)-CONTINUOUS SPECTRUM
250 READ# 2,3 ; N ! # DIS FREQS
260 IF N > 10 AND D1=0 THEN N=10
270 Q=N
280 !
290 !           ENTER DATA FILE INFO AS IS APPROPRIATE TO MODEL
300 !
310 !   EED RF SENSITIVITY DATA FILE [ALL MODELS]
320 !
330 Z1=2 @ GOSUB 2120
340 IF J0=-1 THEN GOTO 360
350 J0=1 @ GOSUB 2570
360 !
370 ! EED RF IMPEDANCE DATA FILE [ALL MODELS]
380 !
390 Z1=3 @ GOSUB 2120
400 IF J0=-1 THEN GOTO 420
410 J0=0 @ GOSUB 2570
420 !
430 ! EED RF SHIELDING DATA [MODELS #2 AND #3]
440 !
450 IF G9 > 1 THEN Z1=4 @ GOSUB 2120
460 IF J0=-1 THEN GOTO 480
470 IF G9 > 1 THEN J0=2 @ GPSIB 2570
480 !
490 !   ENTER LEAD DIMENSIONS

```

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70.3 (Continued)

```

500 !
510 GOSUB 1270
520 !
530 REM    DISCRETE FREQUENCIES
540 IF D1=0 THEN 750
550 !
560 !    DISCRETE FREQUENCY [MAIN LOOP]
570 !
580 PRINT# 2,3 ; Q
590 FOR I=1 TO Q
600 READ# 8,I ; S$,F0,P9
610 !  CALL FRANKLIN CALC
620 F4=F0 @ A1=1
630 IF G9=1 THEN GOSUB 1590 @ GOTO 690
640 !
650 IF G9=2 THEN F1=0 @ B9=7 @ GOSUB 4330 @ GOSUB 1590
660 !
670 IF G9=3 THEN F1=0 @ B9=7 @ GOSUB 4330
680 !
690 !
700 PRINT# 1,I ; F4,P9,P8,D0
710 NEXT I
720 !
730 GOTO 1060 ! END
740 !
750 !    CONTINUOUS SPECTRUM [MAIN LOOP]
760 !
770 Q=1
780 FOR I=1 TO N-1
790 READ# 8,I ; F0,P9
800 READ# 8,I+1 ; F3,P3
810 REM CHECK FOR CLOSE DATA
820 IF F0+10 > F3 THEN H0=1 @ S=F3-F0 @ GOTO 850
830 S=(F3-F0)/10
840 H0=10
850 F4=F0 @ F1=0
860 FOR J=1 TO H0
870 !  INTERPOLATE POWER AT F0
880 B9=8 @ F1=0
890 GOSUB 4330
900 P9=A1 !  INTERPOLATED POWER
910 !
920 F1=0 @ A1=1
930 IF G9=1 THEN GOSUB 1590
940 !
950 IF G9=2 THEN F1=0 @ B9=7 @ GOSUB 4330 @ GOSUB 1590
960 !
970 IF G9=3 THEN F1=0 @ B9=7 @ GOSUB 4330
980 !
990 !

```

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70.3 (Continued)

```

1000 PRINT# 1,Q ; F4,P9,P8,D0
1010 Q=Q+1
1020 F4=F4+S
1030 NEXT J
1040 NEXT I
1050 Q=Q-1 @ PRINT# 2,3 ; Q
1060 REM TOTAL POWER
1070 ! T7=0
1080 ! IF D1=0 THEN GOSUB 1910
1090 ! IF D1=1 THEN GOSUB 2070
1100 ! PRINT USING 1080 ; T7
1110 ! IMAGE "TOTAL POWER AT EED = ",K
1120 ! PRINT# 2,10 ; T7 ! STORE
1130 !
1140 ! END OF ANALYSIS
1150 ! CLOSE ALL DATA FILES
1160 !
1170 ASSIGN# 1 TO *
1180 ASSIGN# 2 TO *
1190 ASSIGN# 6 TO *
1200 IF G9 > 1 THEN ASSIGN# 7 TO *
1210 ASSIGN# 8 TO *
1220 DISP @ DISP " RETURNING TO MAIN MENU" @ CHAIN "MANAGER"
1230 END
1240 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
1250 ! ! SUBROUTINES !
1260 ! !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
1270 REM EED SYSTEM DATA INPUT
1280 CLEAR
1290 REM
1300 IF G9=1 THEN DISP " UNSHIELDED PIN TO PIN"
1310 IF G9=2 THEN DISP " SHIELDED PIN TO PIN"
1320 IF G9=3 THEN DISP " PIN TO CASE"
1330 CLEAR @ DISP " SYSTEM DATA ENTRY "
1340 REM
1350 REM
1360 DISP @ DISP
1370 IF G9=3 THEN A8=1 @ A9=1 @ W=1 @ GOTO 1430
1380 DISP "ENTER AREA OF LOOP [CM]." @ DISP "ENTER '0' IF NOT KNOWN." @
INPUT A8 @ A8=A8/10000
1390 DISP "ENTER PERIMETER OF LOOP [CM]." @ DISP "ENTER '0' IF NOT
KNOWN." @ INPUT A9 @ A9=A9/100
1400 IF A8<0 OR A9 < 0 THEN GOTO 1330
1410 DISP "ENTER WIDTH OF LOOP [CM]." @ DISP "ENTER '0' IF NOT KNOWN." @
INPUT W
1420 DISP "ENTER LENGTH OF LOOP [CM]." @ DISP "ENTER '0' IF NOT KNOWN."
@ INPUT L @ GOTO 1440
1430 DISP "ENTER LEAD LENGTH [CM]." @ INPUT L

```

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70.3 (Continued)

```

1440 IF (A9=0 OR A8=0) AND (L=0 OR W=0) THEN 1460
1450 GOTO 1480
1460 BEEP @ CLEAR @ DISP "MORE DATA IS NEEDED TO CONTINUE." @ DISP "
PLEASE REENTER"
1470 WAIT 3000 @ GOTO 1330
1480 L=L/100 @ W=W/100
1490 IF A8=0 THEN A8=L*W
1500 IF A9=0 THEN A9=2*L+2*W
1510 IF G9=3 THEN A8=0 @ A9=0 @ W=0
1520 !
1530 REM STORE PARAMS IN PFLAGS
1540 PRINT# 2,6 ; L*100,W*100
1550 PRINT# 2,7 ; A8*10000,A9*100
1560 L9=2*L+2*W @ IF A9#0 THEN L9=A9
1570 RETURN
1580 REM
1590 REM FRANKLIN CALCULATIONS
1600 REM CONVERT F TO WAVELENGTH
1610 REM
1620 F0=F4
1630 L1=3000000000/(F0*1000000)
1640 DISP
1650 REM HIGH OR LOW FREQUENCY
1660 REM APERTURE. HIGH IF
1670 REM L1 > 2*PERIMETER
1680 P=L9
1690 IF L1 < 2*P THEN 1750
1700 REM LOW FREQUENCY APERTURE
1710 DISP " LOW FREQUENCY APERTURE"
1720 GOSUB 4540
1730 A=46700*AB ^ 2/(3.14159*L1 ^ 2*I1)
1740 GOTO 1830
1750 REM HIGH FREQ. APERTURE
1760 DISP " HIGH FREQUENCY APERTURE"
1770 REM CALC DIRECTIVITY
1780 IF L9/L1<=1.7 THEN D=.353*(L9/L1)+1.5
1790 IF L9/L1 > 1.7 THEN D=1.24*(L9/L1)
1800 DISP USING 1810 ; D
1810 IMAGE "D =",X,3D,5D
1820 A=D*L1 ^ 2/(4*3.14159)
1830 REM WORST CASE POWER
1840 P8=A*P9*A1
1850 D0=-99.99 @ IF P8 > 0 THEN D0=10*LGT(P8)
1860 RETURN
1870 REM
1880 REM INTEGRATE POWER OVER
1890 REM SPECTRUM TRAPEZOIDAL

```

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70.3 (Continued)

```

1900 REM
1910 FOR I=1 TO Q-1
1920 READ# 1,I ; F0,P,P0,D
1930 READ# 1,I+1 ; F1,P,P1,D
1940 REM  TRAPEZOID PARAMETERS
1950 IF P0 > P1 THEN L0=P1 @ L1=P0
1960 IF P0=P1 THEN L0=P0 @ L1=P0
1970 IF P0<P1 THEN L0=P0 @ L1=P1
1980 T1=(F1-F0)*L0+.5*(F1-F0)*(L1-L0)
1990 REM T1=AREA UNDER TRAPEZOID FROM F0 TO F1
2000 T7=T7+T1 ! RUNNING TOTAL
2010 NEXT I
2020 RETURN
2030 REM
2040 REM DISCRETE SUMMATION
2050 REM
2060 FOR I=1 TO Q
2070 READ# 1,I ; F0,P,P8,D
2080 T7=T7+P8
2090 NEXT I
2100 RETURN
2110 REM
2120 REM  DATA FILE SELECTION SUBROUTINE
2130 REM
2140 REM          Z4=WHICH FILE TYPE
2150 REM
2160 CLEAR
2170 DISP "          DATA FILE SELECTION"
2180 DISP
2190 IF Z1=1 THEN DISP "          OUTPUT DATA FILE"
2200 IF Z1=2 AND G9<3 THEN DISP "          PIN TO PIN"
2210 IF Z1=2 AND G9=3 THEN DISP "          PIN TO CASE"
2220 IF Z1=2 THEN DISP "  EED RF SENSITIVITY DATA FILE"
2230 IF Z1=3 THEN DISP "  EED RF IMPEDANCE DATA FILE"
2240 IF Z1=4 THEN DISP "  SHIELD ATTENUATION DATA FILE"
2250 DISP
2260 DISP "(1) USE DEFAULT FILE"
2270 DISP "(2) USE EXISTING FILE"
2280 DISP "(3) CREATE NEW FILE"
2290 DISP
2300 DISP "          SELECT FROM ABOVE"
2310 INPUT Z2
2320 REM
2330 IF Z1=1 AND Z2=1 THEN U5$="OUTPUT"
2340 IF Z1=2 AND Z2=1 THEN U5$="EEDSEN"
2350 IF Z1=3 AND Z2=1 THEN U5$="EEDIMP"
2360 IF Z1=4 AND Z2=1 THEN U5$="SHIELD"
2370 REM
2380 IF Z2=2 THEN DISP "ENTER EXACT EXISTING FILE NAME" @ INPUT U5$
2390 IF Z2=3 THEN DISP "ENTER NEW FILE NAME" @ INPUT U5$

```

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70.3 (Continued)

```

2400 IF Z2=3 AND Z1=1 THEN CREATE U5$&":D701",1000,32
2410 IF Z2=3 AND Z1#1 THEN CREATE U5$&":D701",102,40
2420 REM
2430 REM NOW STORE FILE NAME INTO PFLAGS
2440 REM
2450 IF Z1=1 THEN PRINT# 2,24 ; U5$
2460 IF Z1=2 THEN PRINT# 2,22 ; U5$
2470 IF Z1=3 THEN PRINT# 2,21 ; U5$
2480 IF Z1=4 THEN PRINT# 2,23 ; U5$
2490 IF Z2=2 THEN GOTO 2520
2500 J0=0
2510 RETURN
2520 J0=-1
2530 IF Z1=2 THEN ASSIGN# 6 TO U5$&":D701" @ S5=6
2540 IF Z1=3 THEN ASSIGN# 5 TO U5$&":D701" @ S5=5
2550 IF Z1=4 THEN ASSIGN# 7 TO U5$&":D701" @ S5=7
2560 RETURN
2570 !
2580 ! EED/SHIELD SPECIFICATION
2590 !
2600 IF J0=0 THEN READ# 2,21 ; J9$@ ASSIGN# 5 TO J9$&":D701" @ S5=5
2610 IF J0=1 THEN READ# 2,22 ; J9$@ ASSIGN# 6 TO J9$&":D701" @ S5=6
2620 IF J0=2 THEN READ# 2,23 ; J9$@ ASSIGN# 7 TO J9$&":D701" @ S5=7
2630 !
2640 CLEAR
2650 BEEP @ WAIT 200 @ BEEP @ WAIT 200 @ BEEP
2660 IF J0<2 THEN DISP " ELECTROEXPLOSIVE DEVICE"
2670 IF J0=0 THEN DISP " RF IMPEDANCE SPECIFICATION"
2680 IF J0=1 THEN DISP " RF SENSITIVITY SPECIFICATION"
2690 IF J0=2 THEN DISP "SHIELD ATTENUATION SPECIFICATION"
2700 DISP
2710 IF J0=0 THEN DISP "(1) CONSTANT IMPEDANCE"
2720 IF J0=1 THEN DISP "(1) CONSTANT SENSITIVITY"
2730 IF J0=2 THEN DISP "(1) CONSTANT ATTENUATION"
2740 DISP
2750 IF J0 < 2 THEN DISP " (2) SPECTRUM SPECIFICATION"
2760 IF J0=2 THEN DISP " (2) ATTENUATION VS. FREQUENCY"
2770 DISP
2780 IF J0=2 THEN DISP "(3) 'FIGURE 2' SHIELD DATA" @ DISP
2790 IF J0=2 THEN DISP "(4) DEFAULT (20dB CONSTANT)"
2800 DISP @ DISP " SELECT FROM ABOVE"
2810 !
2820 INPUT S1
2830 IF S1 > 4 THEN GOTO 2640
2840 IF J0=0 THEN PRINT " IMPEDANCE DATA " @ PRINT "
FREQ(MHZ) IMP(OHMS)"
2850 IF J0=1 THEN PRINT " SENSITIVITY DATA" @ PRINT "
FREQ(MHZ) SENS(WATTS)"
2860 IF J0=2 THEN PRINT " SHIELDING DATA" @ PRINT "
FREQ(MHZ) SHIELD(dB)"

```


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70.3 (Continued)

```

2870 IF S1=1 THEN 2970
2880 IF S1=2 AND J0=0 THEN 3760
2890 IF S1=2 AND J0 > 0 THEN 3240
2900 IF S1=3 AND J0 < 2 THEN 2640
2910 IF S1=3 AND J0=2 THEN 4160
2920 IF S1=4 AND J0=2 THEN S2=20 @ GOTO 3080
2930 GOTO 2640
2940 !
2950 !      CONSTANT VALUES
2960 !
2970 IF J0=0 THEN DISP "ENTER CONSTANT IMPEDANCE [OHMS]"
2980 IF J0=1 THEN DISP "ENTER CONSTANT RF SENSITIVITY [WATTS]"
2990 IF J0=2 THEN DISP "ENTER CONSTANT ATTENUATION [dB]"
3000 !
3010 INPUT S2
3020 IF J0=0 AND S2 <=0 THEN DISP "THE IMPEDANCE MAY NOT BE <= 0" @
DISP "PLEASE REENTER . . . ."
3030 IF J0=0 AND S2 <=0 THEN BEEP @ WAIT 100 @ GOTO 2950
3040 IF S2 < 0 THEN DISP "ENTRY MUST NOT BE < 0" @ BEEP @ GOTO 2750
3050 !
3060 !   STORE CONSTANT SPECTRUM
3070 !
3080 S3=0
3090 IF J0=0 THEN S5=5 @ B=2 @ T=11
3100 IF J0=1 THEN S5=6 @ B=1 @ T=10
3110 IF J0=2 THEN S5=7 @ B=1 @ T=10
3120 !
3130 S4=S2
3140 IF J0=2 THEN S4=1/10 ^ (S2/10)
3150 FOR I=B TO T
3160 PRINT USING 3170 ; S3,S2
3170 IMAGE 4X,D.DE,6X,3D.3D
3180 PRINT# S5,I ; S3,S4
3190 S3=S3+10000000000
3200 NEXT I
3210 IF J0=0 THEN PRINT# S5,1 ; 10
3220 RETURN
3230 !
3240 !      SPECTRUM
3250 !
3260 CLEAR
3270 IF J0=1 THEN DISP "FEED RF SENSITIVITY SPECIFICATION"
3280 IF J0=2 THEN DISP "SHIELD ATTENUATION SPECIFICATION"
3290 DISP
3300 DISP " SPECTRUM WILL BE SPECIFIED BY"
3310 DISP "ENTRY OF A LOWER AND UPPER"
3320 DISP "FREQUENCY BOUND AND 8 INTER-"
3330 DISP "MEDIATE FREQUENCIES EACH WITH"
3340 IF J0=2 THEN DISP "AN ASSOCIATED ATTENUATION (MUST BE >=0)." @
GOTO 3360

```

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70.3 (Continued)

```

3350 DISP "AN ASSOCIATED POWER (MUST BE >=0) ."
3360 DISP "  VALUES BETWEEN ENTRIES WILL BE"
3370 DISP "ESTIMATED BY THE PROGRAM VIA  LINEAR INTERPOLATION."
3380 I=0
3390 DISP
3400 DISP "ENTER LOWER FREQ. BOUND [MHZ]"
3410 INPUT F1(I)
3420 IF J0=1 THEN DISP "ENTER EED RF SENSITIVITY [WATTS]"
3430 IF J0=2 THEN DISP "ENTER SHIELDING ATTENUATION [dB]"
3440 INPUT P1(I)@ IF P1(I) < 0 THEN DISP "VALUE MAY NOT BE <
0--REENTER" @ GOTO 3420
3450 PRINT USING 3460 ; F1(I),P1(I)
3460 IMAGE 4X,5D,2D,6X,3D.3D
3470 IF J0=2 THEN P1(I)=1/10 ^ (P1(I)/10)
3480 PRINT# S5,1 ; F1(I),P1(I)
3490 DISP
3500 DISP "ENTER UPPER FREQ. BOUND [MHZ]"
3510 INPUT F1(9)
3520 IF F1(9)<F1(I) THEN BEEP @ DISP "UPPER BOUND < LOWER,REENTER" @
GOTO 3490
3530 IF J0=1 THEN DISP "ENTER EED RF SENSITIVITY [WATTS]"
3540 IF J0=2 THEN DISP "ENTER SHIELDING ATTENUATION [dB]"
3550 INPUT P1(9)@ IF P1(9)<0 THEN DISP "VALUE MAY NOT BE < 0 --
REENTER" @ GOTO 3530
3560 IF J0=2 THEN P1(9)=1/10 ^ (P1(9)/10)
3570 PRINT# S5,10 ; F1(9),P1(9)
3580 !  INTERMEDIATE ENTRIES
3590 I=I+1
3600 DISP
3610 DISP USING 3620 ; I
3620 IMAGE "ENTER INTERMEDIATE FREQ ",K," [MHZ]"
3630 INPUT F1(I)
3640 IF F1(I)<F1(I-1) OR F1(I) > F1(9) THEN BEEP @ DISP "ENTRY OUT OF
BOUNDS REENTER" @ GOTO 3600
3650 IF J0=1 THEN DISP "ENTER EED RF SENSITIVITY [WATTS]"
3660 IF J0=2 THEN DISP "ENTER SHIELDING ATTENUATION [dB]"
3670 INPUT P1(I)@ IF P1(I) < 0 THEN DISP "VALUE MAY NOT BE <
0--REENTER" @ GOTO 3650
3680 PRINT USING 3460 ; F1(I),P1(I)
3690 IF J0=2 THEN P1(I)=1/10 ^ (P1(I)/10)
3700 PRINT# S5,N+1 ; F1(I),P1(I)
3710 IF I < 8 THEN 3590
3720 IF J0 < 2 THEN PRINT USING 3460 ; F1(9),P1(9) @ GOTO 3740
3730 PRINT USING 3460 ; F1(9),-(10*LGT(P1(9)))
3740 RETURN
3750 REM
3760 REM IMPEDANCE VS FREQUENCY
3770 REM      DATA INPUT
3780 REM
3790 DISP "  EED IMPEDANCE VS FREQUENCY"

```

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70.3 (Continued)

```

3800 DISP
3810 DISP "    SPECTRUM WILL BE SPECIFIED BY"
3820 DISP "THE ENTRY OF UP TO 10 PAIRS OF"
3830 DISP "IMPEDANCES AND THEIR ASSOCIATED"
3840 DISP "FREQUENCIES, ANY # of PAIRS MAY"
3850 DISP "BE ENTERED; THE ONLY CAVEAT IS"
3860 DISP "THAT ANY ONE FREQUENCY BE > ="
3870 DISP "THE PREVIOUS FREQUENCY, WHEN"
3880 DISP "FINISHED, ENTER '-1' TO QUIT."
3890 DISP "    VALUES BETWEEN ENTRIES WILL"
3900 DISP "BE DETERMINED VIA LINEAR INTER-"
3910 DISP "POLATION."
3920 I=1 @ F0=0
3930 DISP "ENTER FREQUENCY #";I;"[MHZ]"
3940 INPUT F1@ IF F1 < 0 THEN 4070
3950 IF F1 > =F0 THEN GOTO 3990
3960 BEEP @ DISP " FREQUENCY <  PREVIOUS FREQUENCY"
3970 DISP "    PLEASE REENTER"
3980 WAIT 200 @ GOTO 3930
3990 DISP "ENTER IMPEDANCE OF EED [OHMS]"
4000 INPUT P
4010 IF P < =0 THEN DISP "THE IMPEDANCE MAY NOT BE  < =0"
4020 IF P < =0 THEN DISP "    PLEASE REENTER" @ GOTO 3990
4030 PRINT# S5,I+1 ; F1,P
4040 PRINT# S5,1 ; I
4050 I=I+1 @ IF I  >  10 THEN GOTO 4070 ELSE GOTO 3930
4060 ! OUTPUT IMPEDANCE DATA
4070 READ# S5,1 ; J
4080 FOR I=2 TO J+1
4090 READ# S5,I ; F,P
4100 PRINT USING 4110 ; F,P
4110 IMAGE 4X,5D.2D,6X,3D.3D
4120 NEXT I
4130 RETURN
4140 !
4150 REM
4160 REM "FIGURE 2" SHIELD DATA
4170 REM (USED FOR DEFAULT PURPOSES)
4180 REM FROM MIL-STD-1512 HANDBOOK
4190 REM
4200 FOR I=1 TO 10
4210 READ F,P
4220 P=1/10^(P/10)
4230 PRINT# S5,I ; F,P
4240 NEXT I
4250 DATA .1,30,.55,44,1,49,2.1,53,5.5,58,17,59,100,43,200,35,800,30,
20000,18

```

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70.3 (Continued)

```

4260 RESTORE
4270 FOR I=1 TO 10
4200 READ F,P
4290 PRINT USING 4300 ; F,P
4300 IMAGE 4X,5D.2D,6X,3D.3D
4310 NEXT I
4320 RETURN
4330 REM
4340 REM LINEAR INTERPOLATION ROUTINE
4350 REM INPUTS:  F4=FREQUENCY
4360 REM          B9=BUFFER #
4370 REM RETURNS A1=INTERPOLATED VALUE
4380 REM
4390 FOR K=1 TO 10
4400 READ# B9,K ; F2,X2
4410 IF K=1 THEN X1=X2
4420 IF F2 >=F4 THEN GOTO 4460
4430 F1=F2 @ X1=X2
4440 NEXT K
4450 IF K=11 THEN A1=X1 @ GOTO 4470
4460 A1=X1+(F4-F1)*((X2-X1)/(F2-F1))
4470 IF G9#3 THEN RETURN
4480 REM PIN-TO CASE POWER CALCULATIONS
4490 L1=3000000000/(F4*1000000)
4500 IF L*2<L1/2 THEN GOSUB 4540 @ P8=P9*A1*L^2*(377/I1) @ GOTO 4520
4510 P8=P9*A1*1.64*L1^2/(4*PI)
4520 IF P8=0 THEN D0=-99.99 ELSE D0=10*LGT(P8)
4530 RETURN
4540 REM
4550 REM LINEAR INTERPOLATION ROUTINE
4560 REM          PIN TO-CASE IMPEDANCE
4570 REM INPUTS:  F4=FREQUENCY
4580 REM          5=BUF #=EEDIMP
4590 REM RETURNS:  I1=INTERPOLATED VALUE
4600 REM
4610 F7=0
4620 READ# 5,1 ; N1 ! # OF VALUES
4630 FOR X=2 TO N1+1
4640 READ# 5,X ; F3,X3
4650 IF X=2 THEN X0=X3
4660 IF F3 >=F4 THEN GOTO 4700
4670 F7=F3 @ X0=X3
4680 NEXT X
4690 IF X=N1+2 THEN I1=X0 @ RETURN
4700 I1=X0+(F4-F7)*((X3-X0)/(F3-F7))
4710 RETURN

```

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70.4 Program Listing for LPL0T5

```

10 !           LPL0T5
20 !
30 !           GENERAL PURPOSE
40 !           GRAPHING FOR EED ANALY
50 !
60 DIM L$[80],L1$[32],L2$[32]
70 DIM F$[80],P$[80]
80 F$="FREQ(MHZ):      " @ P$="Re(Zpc)[OHMS]:  "
90 CLEAR @ GCLEAR
100 !
110 ASSIGN# 2 TO "PFLAGS:D701"
120 READ# 2,24 ; X1$
130 ON ERROR GOTO 4080
140 X$=X1$
150 ASSIGN #1 TO X1$&" :D701"
160 READ #2,20 ; X2$
170 X$=X2$
180 ASSIGN #8 TO X2$&" :D701"
190 READ #2,21 ; X3$
200 X$=X3$
210 ASSIGN #5 TO X3$&" :D701"
220 OFF ERROR
230 READ# 2,1 ; M9 ! MODEL FLAG
240 READ# 2,2 ; D ! DIS/CONT FLAG
250 READ# 2,3 ; Q ! # OF PLOT POINTS
260 ! OUTPUT DEVICE SELECT
270 BEEP @ WAIT 200 @ BEEP @ WAIT 200 @ BEEP
280 DISP "           OUTPUT SPECIFICATION"
290 DISP
300 DISP
310 DISP "(1)  TABULAR OUTPUT ONLY"
320 DISP "(2)  PLOTTED OUTPUT ONLY"
330 DISP "(3)  BOTH TABULAR AND PLOTTED"
340 DISP "(4)  RETURN TO MAIN MENU"
350 DISP
360 DISP "           SELECT FROM (1-4) ABOVE"
370 INPUT B
380 IF B=4 THEN CHAIN "MANAGER"
390 IF B < 1 OR B > 3 THEN BEEP @ GOTO 350
400 DISP
410 DISP
420 DISP "ENTER TITLE OF PLOT [80 CHARS]"
430 INPUT L$
440 !
450 IF B=2 THEN 610
460 !
470 CLEAR
480 DISP "TABULAR OUTPUT TO WHICH DEVICE"
490 DISP

```

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70.4 (Continued)

```

500 DISP "(1) CRT SCREEN"
510 DISP "(2) THERMAL PRINTER"
520 DISP "(3) LINE PRINTER"
530 DISP
540 DISP "      SELECT FROM (1-3) ABOVE"
550 INPUT B1
560 IF B1 < 1 OR B1 > 3 THEN BEEP @ GOTO 530
570 IF B1=1 THEN PRINTER IS 1
580 IF B1=2 THEN PRINTER IS 2
590 IF B1=3 THEN PRINTER IS 701,80
600 !
610 ! CALL APPROP. ROUTINES
620 !
630 IF B=1 THEN GOSUB 2720
640 IF B=2 THEN GOSUB 770
650 IF B=3 THEN GOSUB 770 @ GOSUB 2720
660 ! CLOSE DATA FILES
670 ASSIGN# 1 TO *
680 ASSIGN# 2 TO *
690 ASSIGN# 8 TO *
700 PRINTER IS 2
710 !
720 CHAIN "MANAGER"
730 END
740 !
750 ! PLOTTING SUBROUTINE
760 !
770 CLEAR
780 DEG
790 GOSUB 3620 ! HIGH/LOW SORT
800 !
810 ! F0,P0,D0 IS MIN OF FILE
820 ! F1,P1,D1 IS MAX
830 !
840 X2=F1 @ X1=F0 @ Y2=P1 @ Y1=P0
850 DISP USING 910 ; "MINIMUM FREQUENCY:",F0
860 DISP USING 910 ; "MAXIMUM FREQUENCY:",F1
870 DISP USING 910 ; "MINIMUM POWER (W):",P0
880 DISP USING 910 ; "MAXIMUM POWER (W):",P1
890 DISP USING 910 ; "MINIMUM POWER (dBW):",D0
900 DISP USING 910 ; "MAXIMUM POWER (dBW):",D1
910 IMAGE 20A,2X,5D.3D
920 DISP
930 DISP "      FORMAT OUTPUT"
940 DISP
950 DISP
960 DISP "OUTPUT TO PLOTTER (Y/N)"
970 INPUT A$
980 PLOTTER IS 1 ! DEFAULT TO CRT
990 IF A$="Y" THEN PLOTTER IS 705 @ GOTO 1020

```

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70.4 (Continued)

```

1000 IF A$#"N" THEN BEEP @ GOTO 950
1010 IF A$="N" THEN X$="N"
1020 SCALE -20,236,-20,172
1030 !
1040 DISP
1050 DISP "                X-AXIS"
1060 DISP
1070 DISP "ENTER X-AXIS LABEL"
1080 INPUT L1$
1090 DISP
1100 T4=0
1110 DISP "LOG PLOT FOR X-AXIS (Y/N)"
1120 INPUT A$
1130 IF A$="N" THEN T4=1 @ GOTO 1160
1140 IF A$#"Y" THEN BEEP @ GOTO 1090
1150 !
1160 DISP
1170 DISP "                Y AXIS"
1180 DISP
1190 DISP "ENTER Y-AXIS LABEL"
1200 INPUT L2$
1210 T5=0
1220 T6=0
1230 DISP
1240 DISP "PLOT IN WATTS [W] OR dBW [D]"
1250 INPUT A$
1260 IF A$="D" THEN T6=1 @ T5=1 @ Y2=D1 @ Y1=D0 @ GOTO 1360
1270 IF A$# "W" THEN BEEP @ GOTO 1230
1280 DISP
1290 DISP "LOG PLOT FOR Y-AXIS (Y/N)"
1300 INPUT A$
1310 IF A$="N" THEN T5=1 @ GOTO 1330
1320 IF A$#"Y" THEN BEEP @ GOTO 1200
1330 !
1340 IF Y1=0 THEN U2=0 ELSE U2=FLOOR(LGT(Y1))
1350 T2=CEIL(LGT(Y2))
1360 IF X1=0 THEN U1=0 ELSE U1=FLOOR(LGT(X1))
1370 T1=CEIL(LGT(X2))
1380 !
1390 ! CALL BOUNDING SUBROUTINE
1400 !
1410 IF T4=0 THEN Z1=U1 @ Z2=T1 @ L5$="X" @ GOSUB 3780 @ U1=Z1 @ T1=Z2 @
S1=230/(T1-U1)
1420 IF T4=1 THEN Z1=X1 @ Z2=X2 @ L5$="X" @ GOSUB 3930 @ X1=Z1 @ X2=Z2 @
S1=230/(X2-X1)
1430 IF T5=0 THEN Z1=U2 @ Z2=T2 @ L5$="Y" @ GOSUB 3780 @ U2=Z1 @ T2=Z2 @
S8=170/(T2-U2)
1440 IF T5=1 AND T6=0 THEN Z1=Y1 @ Z2=Y2 @ L5$="Y" @ GOSUB 3940 @ Y1=Z1
@ Y2=Z2 @ S8=170/(Y2-Y1)
1450 IF T6=1 THEN Z1=D0 @ Z2=D1 @ L5$="Y" @ GOSUB 3940 @ Y1=Z1 @ YZ=Z2 @
S8=170/(Y2-Y1)

```

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70.4 (Continued)

```

1460 !
1470 !  SKIP AXIS PLOT
1480 !
1490 DISP
1500 DISP "PLOT AXES (Y/N)
1510 INPUT A$
1520 IF A$="N" THEN 2440
1530 IF A$# "Y" THEN 1490
1540 !  LOG OR NOT
1550 IF T4=1 THEN 1770
1560 !  X AXIS LOG PLOT
1570 MOVE 0,-6 @ LABEL U1
1580 MOVE -2,-10 @ LABEL "10"
1590 MOVE 0,0
1600 X=0 @ Y=0
1610 S1=230/(T1-U1)
1620 DISP U1,T1,S1
1630 FOR J=U1 TO T1-1
1640 !
1650 D=2 @ V=0
1660 FOR I=2 TO 10
1670 L=LGT(I)*S1
1680 DRAW X+L,Y
1690 IF I=10 AND D=0 THEN O=3 AND V=160
1700 DRAW X+L,Y O @ DRAW X+L,Y+V
1710 MOVE X+L,Y
1720 IF I=10 THEN X=X+L @ MOVE X,Y-6 @ LABEL J+1 @ MOVE X-2,Y-10 @ LABEL
"10"
1730 NEXT I
1740 MOVE X,Y
1750 NEXT J
1760 GOTO 1910
1770 !  LINEAR X-AXIS
1780 S1=230/(X2-X1)
1790 T1=CEIL((X2-X1)/10)
1800 T3=X1 @ X=0 @ Y=0
1810 MOVE X,Y
1820 FOR I=1 TO 10
1830 DRAW X,Y
1840 DRAW X,Y-3
1850 MOVE X-8,Y 10
1860 LABEL T3
1870 MOVE X,Y
1880 T3=T3+T1
1890 X=X+23
1900 NEXT I
1910 !
1920 IF T5=1 THEN 2130
1930 !  Y AXIS PLOT
1940 MOVE -8,0 @ LABEL U2

```


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70.4 (Continued)

```

1950 MOVE -12, 2 @ LABEL "10"
1960 MOVE 0,0
1970 X=0 @ Y=0
1980 S8=170/(T2-U2)
1990 FOR J=U2 TO T2-1
2000 !
2010 O=2
2020 FOR I=2 TO 10
2030 L=LGT(I)*S8
2040 DRAW X,Y+L
2050 IF I=10 THEN O=3
2060 DRAW X-O,Y+L
2070 MOVE X,Y:L
2080 IF I=10 THEN Y=Y+L @ MOVE X-8,Y @ LABEL J+1 @ MOVE X-12,Y-2 @ LABEL
"10"
2090 NEXT I
2100 MOVE X,Y
2110 NEXT J
2120 GOTO 2280
2130 ! LINEAR Y-AXIS
2140 S8=170/(Y2-Y1)
2150 T8=(Y2-Y1)/10
2160 T3=Y1 @ X=0 @ Y=0
2170 MOVE X,Y
2180 FOR I=1 TO 11
2190 DRAW X,Y
2200 DRAW X-3,Y
2210 MOVE X-15,Y-1
2220 LABEL USING 2230 ; T3
2230 IMAGE 4D.D
2240 MOVE X,Y
2250 T3=T3+T8
2260 Y=Y+17
2270 NEXT I
2280 ! LABEL AXES
2290 LDIR 0
2300 MOVE 5,167
2310 LABEL L$
2320 MOVE -15,70
2330 LDIR 90
2340 LABEL L2$
2350 LDIR 0
2360 MOVE 90,-20
2370 LABEL L1$
2380 REM PAUSE TO INSERT NEW PEN
2390 IF X$="N" THEN GOTO 2440
2400 CLEAR @ DISP " IF YOU WISH TO PAUSE TO INSERT A DIFFERENT COLOR PEN,
NOW'S THE TIME."
2410 DISP " CHOOSE THE COLOR PEN YOU WANT AND PLACE IT IN THE PLOTTER
ARM."

```

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70.4 (Continued)

```

2420 DISP " PRESS 'C' TO CONTINUE."
2430 INPUT X$@ IF X$#"C" THEN 2430
2440 ! BEGIN DATA PLOT
2450 READ# 1,1 ; L,M0,M,0
2460 MOVE 0,0
2470 P4=0
2480 FOR I=1 TO Q
2490 READ# 1,I ; L,M0,M,0
2500 ! #####TEMP#####
2510 IF T4=0 AND L=0 THEN X=-U1 @ GOTO 2530
2520 IF T4=0 THEN X=LGT(L) U1
2530 IF T4=1 THEN X=L-X1
2540 IF T5=0 AND M=0 THEN Y= U2 @ GOTO 2560
2550 IF T5=0 THEN Y=LGT(M)-U2
2560 IF T5=1 THEN Y=M-Y1
2570 IF T6=1 THEN Y=O-Y1
2580 ! CHECK FOR IN BOUNDS
2590 IF X*S1<0 OR X*S1>230 THEN P4=0 @ GOTO 2680 ! OUT OF BOUND
2600 IF Y*S8<0 OR Y*S8>170 THEN P4=0 @ GOTO 2680 ! OUT OF BOUND
2610 ! DISCRETE OR CONTINUOUS
2620 IF P4=0 THEN MOVE X*S1,Y*S8
2630 IF D=0 THEN DRAW X*S1,Y*S8
2640 IF D=1 THEN MOVE X*S1,0 @ DRAW X*S1,Y*S8
2650 !
2660 P4=1
2670 !
2680 NEXT I
2690 PENUP
2700 RETURN
2710 !
2720 ! TABULAR OUTPUT ROUTINE
2730 !
2740 READ# 2,6 ; J2,J3
2750 READ# 2,7 ; Q1,Q2 ! AREA, PERIMETER
2760 READ# 2,10 ; J5 ! TOT POWER
2770 !
2780 PRINT L$
2790 PRINT
2800 IF M9=1 THEN PRINT "UNSHIELDED PIN-TO-PIN"
2810 IF M9=2 THEN PRINT "SHIELDED PIN-TO-PIN"
2820 IF M9=3 THEN PRINT "PIN-TO-CASE"
2830 PRINT
2840 PRINT " IMPEDANCE DATA"
2850 REM LEFT JUSTIFY IMPEDANCE VALUES FOR OUTPUT
2860 READ# 5,1 ; J ! # OF IMPEDANCE POINTS
2870 FOR I=2 TO J:1
2880 READ# 5,I ; F,P
2890 IF F=(I-2)*1000000000 THEN F$=F$&VAL$(I-2)&"E+10 " @ GOTO 2960

```

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70.4 (Continued)

```

2900 F1$=VAL$(F) @ L=LEN(F1$)
2910 IF L=1 THEN F1$=" "&F1$
2920 IF L=2 THEN F1$=" "&F1$
2930 IF L=3 THEN F1$=" "&F1$
2940 IF L=4 THEN F1$=" "&F1$
2950 F$=F$&F1$&" "
2960 P1$=VAL$(P) @ L=LEN(P1$)
2970 IF L=1 THEN P1$=" "&P1$
2980 IF L=2 THEN P1$=" "&P1$
2990 IF L=3 THEN P1$=" "&P1$
3000 IF L=4 THEN P1$=" "&P1$
3010 P$=P$&P1$&" "
3020 NEXT I
3030 PRINT F$ @ PRINT P$
3040 IF M9=3 THEN PRINT USING 3050 ; J2 @ GOTO 3120
3050 IMAGE "LENGTH OF LEAD; ",K," CM"
3060 IF J2#0 AND J3#0 THEN PRINT USING 3070 ; J2,J3
3070 IMAGE "LOOP DIMENSIONS: ",K," X ",K," CM"
3080 IF Q1#0 THEN PRINT USING 3090 ; Q1
3090 IMAGE "AREA OF LOOP: ",K," SQR CM"
3100 IF Q2#0 THEN PRINT USING 3110 ; Q2
3110 IMAGE "PERIMETER OF LOOP: ",K," CM"
3120 PRINT
3130 ! LINE PRINTER IF B1=3
3140 IF B1=3 THEN 3370
3150 ! CRT OR THERMAL
3160 FOR I=1 TO Q
3170 PRINT USING 3180 ; I
3180 IMAGE "SOURCE # ",K
3190 IF D=1 THEN READ# 8,I ; S$,L,M@ PRINT USING 3200 ; S$
3200 IMAGE "I.D.:",K
3210 READ# 1,I ; L,M0,M,O
3220 PRINT USING 3230 ; L
3230 IMAGE "FREQ:",K," MHZ"
3240 PRINT USING 3250 ; M0
3250 IMAGE "POWER;",K," W/M*M"
3260 PRINT
3270 PRINT "POWER CALCULATED AT EED IN:"
3280 PRINT USING 3290 ; M
3290 IMAGE "WATTS = ",K
3300 PRINT USING 3310 ; O
3310 IMAGE "dBW = ",K
3320 PRINT
3330 PRINT
3340 NEXT I
3350 RETURN
3360 :
3370 ! LINE PRINTER FORMAT
3380 :
3390 ! TABLE FOR PRINTER

```

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70.4 (Continued)

```

3400 IF D=0 THEN PRINT "      SOURCE  FREQUENCY  POWER      CALCULATED
POWER AT EED"
3410 IF D=1 THEN PRINT "SOURCE      ID      FREQUENCY  POWER
CALCULATED POWER AT EED"
3420 IF D=0 THEN PRINT "      #      MHZ      W/M*M      WATTS
      dBW"
3430 IF D=1 THEN PRINT "  #      MHZ      W/M*M
WATTS      DBW"
3440 FOR I=1 TO Q
3450 IF D=1 THEN READ# 8,I ; S$
3460 READ# 1,I ; L,M0,M,O
3470 !
3480 IF D=0 THEN PRINT "-----
-----"
3490 IF D=1 THEN PRINT "-----
-----"
3500 !
3510 !
3520 !
3530 !
3540 IF D=0 THEN PRINT USING 3560 ; I,L,M0,M,O
3550 IF D=1 THEN PRINT USING 3570 ; I,S$,L,M0,M,O
3560 IMAGE 5X,3D,4X,6D.3D,4X,3D.2D,6X,4D.5D,2X,S4D.2D
3570 IMAGE 3D,5X,12A,1X,5D.3D,4X,3D.2D,6X,4D.5D,2X,S4D.2D
3580 !
3590 NEXT I
3600 RETURN
3610 !
3620 !  HIGH/LOW SORT ROUTINE
3630 !
3640 READ# 1,1 ; L,M0,M,O
3650 F0=L @ F1=L @ P0=M @ P1=M
3660 D0=0 @ D1=0
3670 FOR I=2 TO Q
3680 READ# 1,I ; L,M0,M,O
3690 IF F0 > L THEN F0=L
3700 IF F1 < L THEN F1=L
3710 IF P0 > M THEN P0=M
3720 IF P1 < M THEN P1=M
3730 IF D0 > 0 THEN D0=0
3740 IF D1 < 0 THEN D1=0
3750 NEXT I
3760 RETURN
3770 !
3780 !  LOG PLOT BOUND INPUT
3790 !
3800 CLEAR
3810 DISP USING 3820 ; L5$,Z1,Z2
3820 IMAGE "LOG ",K,"-AXIS TO BE PLOTTED FROM      10E",K," TO 10E",K
3830 DISP
3840 DISP "      CHANGE (Y) CONTINUE (C)"

```

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70.4 (Continued)

```
3850 INPUT A$
3860 IF A$="C" THEN RETURN
3870 IF A$#"Y" THEN BEEP @ GOTO 3830
3880 DISP "ENTER EXPONENT:LOWER,UPPER BOUND"
3890 INPUT Z1,Z2
3900 Z1=FLOOR(Z1) @ Z2=CEIL(Z2)
3910 IF Z2<=Z1 THEN BEEP @ DISP " UPPER BOUND MUST BE  >  LOWER" @ GOTO
3880
3920 GOTO 3810
3930 !  LINEAR PLOT BOUND
3940 CLEAR
3950 DISP USING 3960 ; L5$,Z1,Z2+1
3960 IMAGE "LINEAR ",K,"AXIS TO BE",/,"PLOTTED FROM:",K," TO:",K
3970 DISP
3980 DISP "      CHANGE (Y) CONTINUE (C)"
3990 INPUT A$
4000 IF A$="C" THEN RETURN
4010 IF A$#"Y" THEN BEEP @ GOTO 3990
4020 DISP "ENTER : LOWER,UPPER BOUND"
4030 INPUT Z1,Z2
4040 IF Z1 > =Z2 THEN BEEP @ DISP "UPPER BOUND MUST BE  >  LOWER" @ GOTO
4020
4050 !
4060 GOTO 3950
4070 !
4080 DISP " THE FILE YOU REQUESTED, ";X$;", CANNOT BE FOUND ON THIS
DISK."
4090 DISP
4100 DISP "  PLEASE RECHECK YOUR FILE NAME AND BE SURE THE CORRECT DISK
IS IN THE DRIVE."
4110 DISP @ DISP @ DISP @ DISP "ERROR NUMBER GENERATED = ";ERRN
4120 DISP "ERROR OCCURRED ON LINE # ";ERRL
4130 WAIT 5000 @ GOTO 720
```

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80. EXAMPLES OF OUTPUT.

80.1 Case 1: Pin-to-Pin Mode. See Figure A-3 and Table A-1.

Environment: 1 watt/sq meter from 1.5 MHz to 1300 MHz
EED Impedance: Variable
Shielding: none
Lead dimensions: Area = 9.5 cm²
Perimeter = 38.4 cm

80.2 Case 2: Pin-to-Pin Mode. See Figure A-4 and Table A-2.

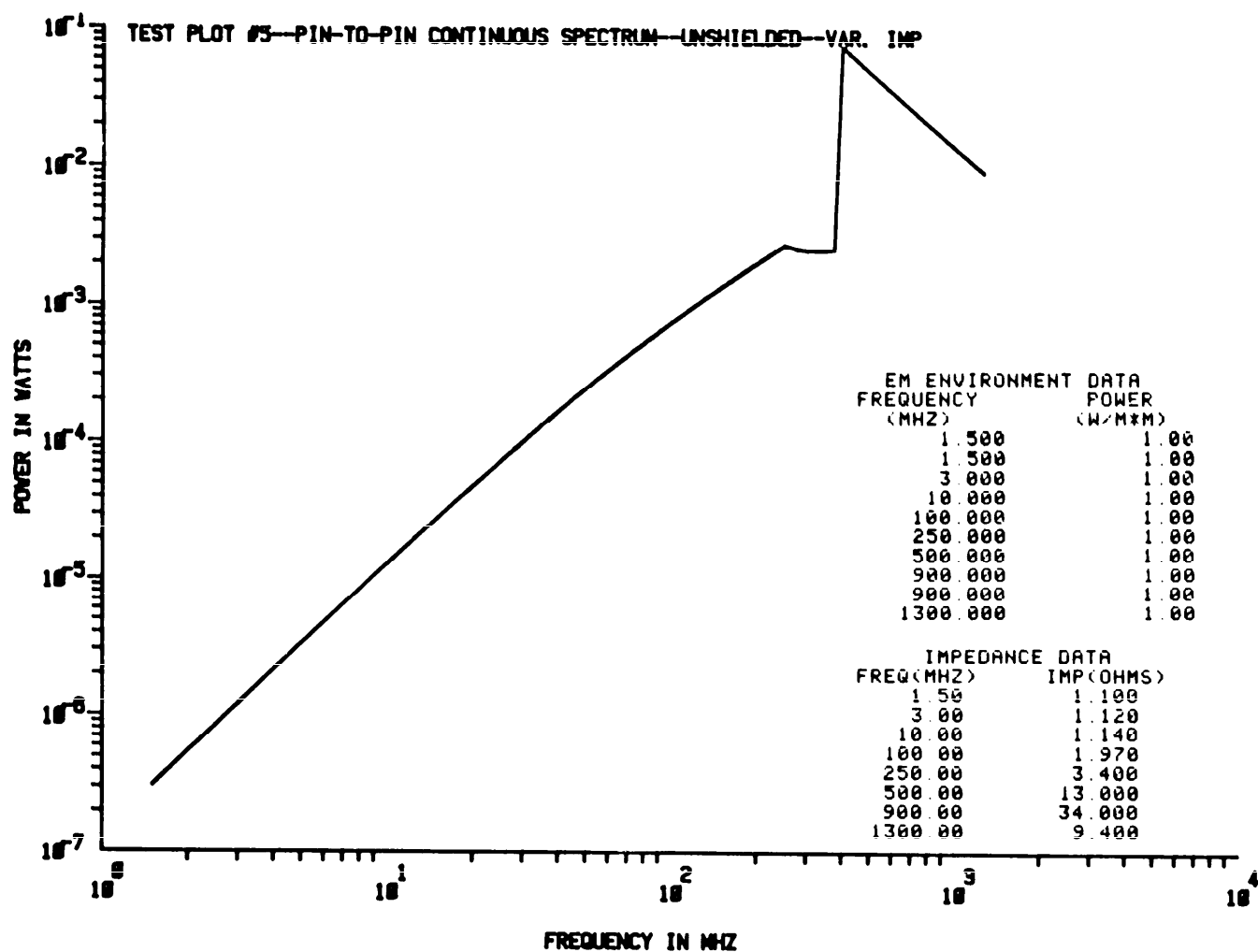
Environment: Discrete spectrum
Impedance: Constant 1.4 ohms
Lead dimensions: Area = 9.5 cm²
Perimeter = 38.4 cm
Shielding: None

80.3 Case 3: Pin-to-Case Mode. See Figure A-5 and Table A-3.

Environment: 1 watt/sq. meter from 1.5 MHz to 1300 MHz
EED Impedance: Variable
Shielding: 24 dB, constant over spectrum
Lead Dimensions: Length = 100 cm

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FIGURE A-3 Sample Output - Pin-To-Pin Mode

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TABLE A-1

SAMPLE OUTPUT - PIN-TO-PIN MODE

TEST PLOT #5 -- PIN-TO-PIN CONTINUOUS SPECTRUM UNSHIELDED VAR. IMP. UNSHIELDED PIN-TO-PIN								
				IMPEDANCE DATA				
FREQ (MHZ):	1.5	3	10	100	250	500	900	1300
Re (Zpc) (OHMS):	1.1	1.12	1.14	1.77	3.4	13	34	7.4
AREA OF LOOP: 9.5 SQR CM								
PERIMETER OF LOOP: 38.4 CM								
SOURCE #	FREQUENCY MHZ	POWER W/M*M	CALCULATED POWER AT EED					
			WATTS	dBW				
1	1.500	1.00	.00000	-65.16				
2	1.500	1.00	.00000	-65.16				
3	3.000	1.00	.00000	-59.22				
4	10.000	1.00	.00001	-48.84				
5	19.000	1.00	.00004	-43.57				
6	28.000	1.00	.00009	-40.48				
7	37.000	1.00	.00015	-30.33				
8	46.000	1.00	.00021	-36.69				
9	55.000	1.00	.00029	-35.38				
10	64.000	1.00	.00037	-34.29				
11	73.000	1.00	.00046	-33.36				
12	82.000	1.00	.00056	-32.55				
13	91.000	1.00	.00065	-31.84				
14	100.000	1.00	.00076	-31.21				
15	115.000	1.00	.00093	-30.30				
16	130.000	1.00	.00112	-29.52				
17	145.000	1.00	.00131	-28.84				

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TABLE A-1 (Continued)

18	160.000	1.00	.00150	-28.24
19	175.000	1.00	.00170	-27.69
20	190.000	1.00	.00190	-27.21
21	205.000	1.00	.00211	-26.76
22	220.000	1.00	.00232	-26.35
23	235.000	1.00	.00253	-25.77
24	250.000	1.00	.00274	-25.62
25	275.000	1.00	.00062	-32.09
26	300.000	1.00	.00052	-32.84
27	325.000	1.00	.00044	-33.54
28	350.000	1.00	.00038	-34.18
29	375.000	1.00	.00033	-34.78
30	400.000	1.00	.00029	-35.34
31	425.000	1.00	.00026	-35.87
32	450.000	1.00	.00023	-36.37
33	475.000	1.00	.00021	-36.84
34	500.000	1.00	.00019	-37.28
35	540.000	1.00	.00016	-37.95
36	580.000	1.00	.00014	-38.57
37	620.000	1.00	.00012	-39.15
38	660.000	1.00	.00011	-39.69
39	700.000	1.00	.00010	-40.20
40	740.000	1.00	.00009	-40.69
41	780.000	1.00	.00008	-41.14
42	820.000	1.00	.00007	-41.58

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TABLE A-1 (Continued)

43	860.000	1.00	.00006	-41.99
44	900.000	1.00	.00006	-42.39
45	900.000	1.00	.00006	-42.39
46	940.000	1.00	.00005	-42.76
47	980.000	1.00	.00005	-43.13
48	1020.000	1.00	.00004	-43.47
49	1060.000	1.00	.00004	-43.81
50	1180.000	1.00	.00004	-44.13
51	1140.000	1.00	.00004	-44.44
52	1180 .000	1.00	.00003	-44.74
53	1220.000	1.00	.00003	-45.03
54	1260.000	1.00	.00003	-45.31

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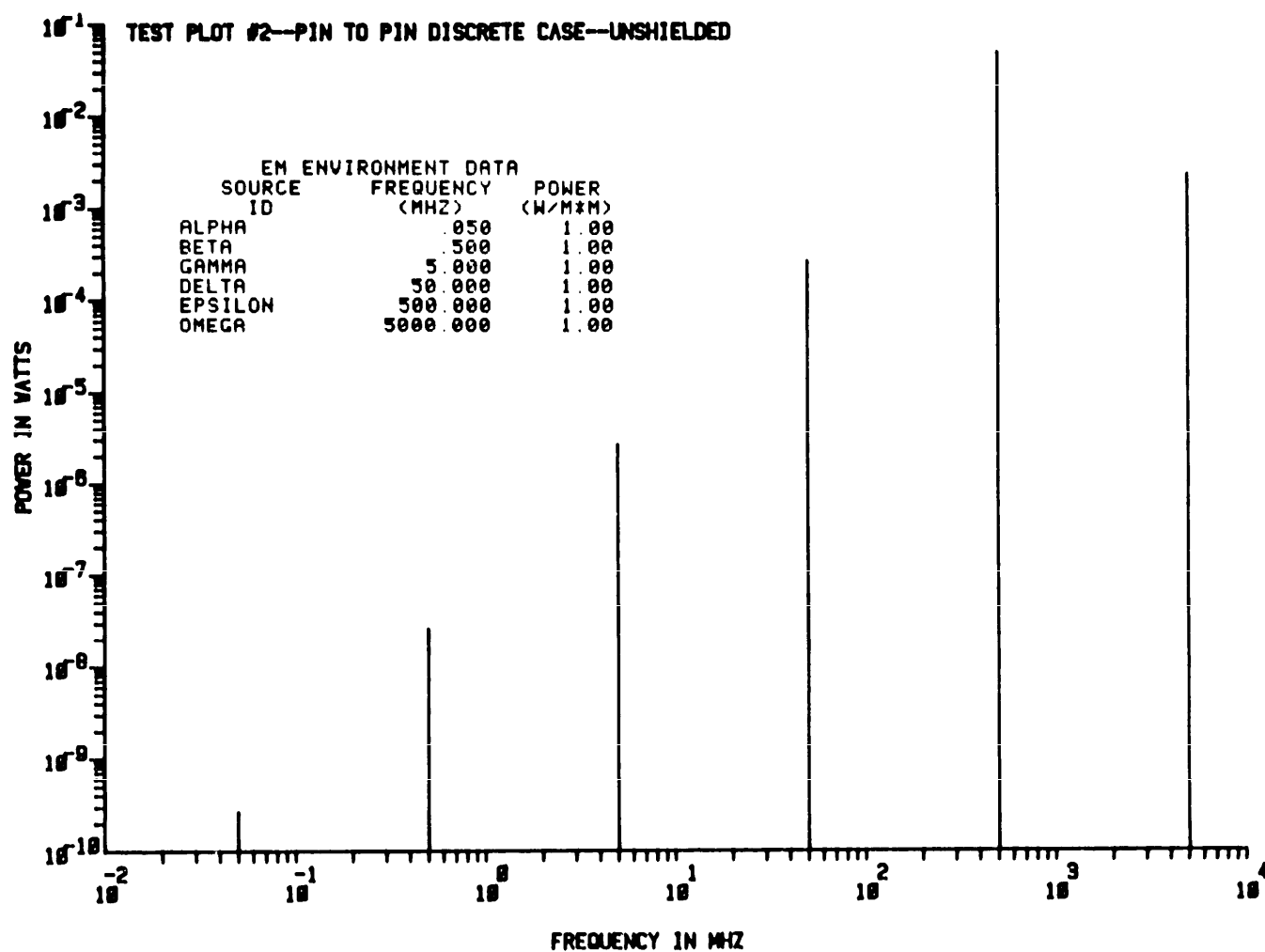


FIGURE A-4 Sample Output - Pin-To-Pin Discrete Spectrum

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TABLE A-2

SAMPLE OUTPUT - PIN-TO-PIN DISCRETE SPECTRUM

TEST PLOT #2 -- PIN-TO-PIN DISCRETE CASE -- UNSHIELDED
UNSHIELDED PIN-TO-PIN

IMPEDANCE DATA

FREQ(MHZ): 0E+10 1E+10 2E+10 3E+10 4E+10 5E+10 6E+10 7E+10 8E+10 9E+10

Re (Zpc) (OHMS): 1.4 1.4 1.4 1.4 1.4 1.4 1.4 1.4 1.4 1.4

AREA OF LOOP: 9.5 SQR CM

PERIMETER OF LOOP: 38.4 CM

SOURCE #	ID	FREQUENCY MHZ	POWER W/M*M	CALCULATED POWER AT EED WATTS	POWER AT EED dBW
1	ALPHA	.050	1.00	.00000	-95.75
2	BETA	.500	1.00	.00000	-75.75
3	GAMMA	5.000	1.00	.00000	-55.75
4	DELTA	50.000	1.00	.00027	-35.75
5	EPSILON	500.000	1.00	.04944	-13.06
6	OMEGA	5000.000	1.00	.00227	-26.43

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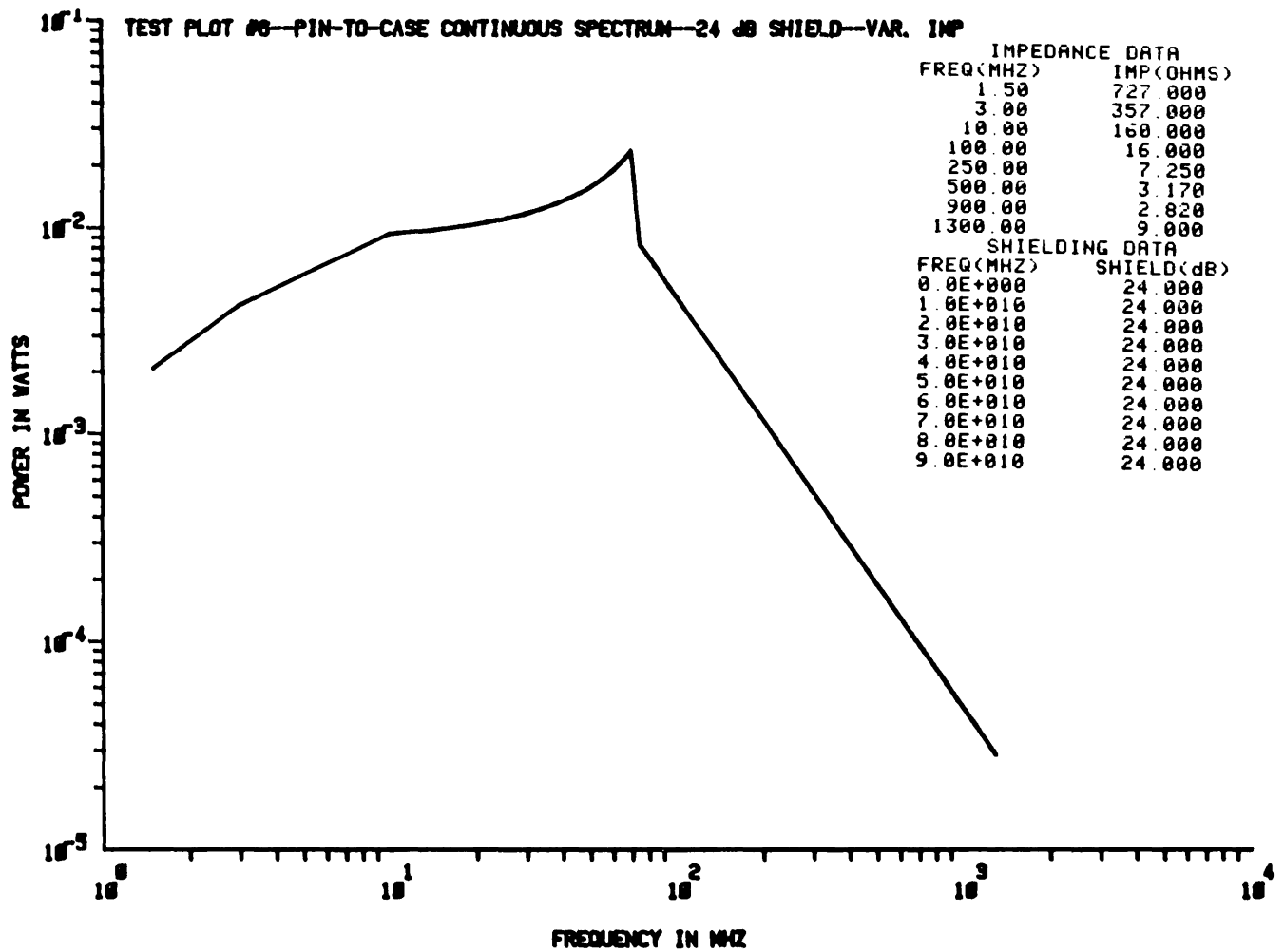


FIGURE A-5 Sample Output - Pin-To-Case Mode

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TABLE A-3

SAMPLE OUTPUT - PIN-TO-CASE MODE

TEST PLOT #6 -- PIN-TO-CASE CONTINUOUS SPECTRUM -24dB SHIELD -VAR. IMP. PIN-TO-CASE								
			IMPEDANCE DATA					
FREQ (MHZ):	1.5	3	10	100	250	500	900	1300
Re (Z _{pc}) (OHMS):	727	357	160	16	7.25	3.17	2.82	9
LENGTH OF LEAD: 100 CM								
SOURCE #	FREQUENCY MHZ	POWER W/M*M	CALCULATED POWER AT EED					
			WATTS		dBW			
1	1.500	1.00	.00206		-26.85			
2	1.500	1.00	.00206		-26.85			
3	3.000	1.00	.00420		-23.76			
4	10.000	1.00	.00938		-20.28			
5	19.000	1.00	.01031		-19.87			
6	28.000	1.00	.01144		-19.42			
7	37.000	1.00	.01285		-18.91			
8	46.000	1.00	.01466		-18.34			
9	55.000	1.00	.01706		-17.68			
10	64.000	1.00	.02039		-16.91			
11	73.000	1.00	.02535		-15.96			
12	82.000	1.00	.00695		-21.58			
13	91.000	1.00	.00565		-22.48			
14	100.000	1.00	.00468		-23.30			
15	115.000	1.00	.00354		-24.52			
16	130.000	1.00	.00277		-25.58			
17	145.000	1.00	.00222		-26.53			
18	160.000	1.00	.00183		-27.38			

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TABLE A-3 (Continued)

19	175.000	1.00	.00153	-28.16
20	190.000	1.00	.00130	-28.88
21	205.000	1.00	.00111	-29.54
22	220.000	1.00	.00097	-30.15
23	235.000	1.00	.00085	-30.72
24	250.000	1.00	.00075	-31.26
25	275.000	1.00	.00259	-25.87
26	300.000	1.00	.00252	-25.98
27	325.000	1.00	.00251	-26.01
28	350.000	1.00	.00252	-25.98
29	375.000	1.00	.00256	-25.92
30	400.000	1.00	.07523	-11.24
31	425.000	1.00	.06709	-11.73
32	450.000	1.00	.06024	-12.20
33	475.000	1.00	.05443	-12.64
34	500.000	1.00	.04944	-13.06
35	540.000	1.00	.04283	-13.68
36	580.000	1.00	.03751	-14.26
37	620.000	1.00	.03317	-14.79
38	660.000	1.00	.02957	-15.29
39	700.000	1.00	.02655	-15.76
40	740.000	1.00	.02399	-16.20
41	780.000	1.00	.02181	-16.61
42	820.000	1.00	.01992	-17.01
43	860.000	1.00	.01829	-17.38

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TABLE A-3 (Continued)

44	900.000	1.00	.01686	-17.73
45	900.000	1.00	.01686	-17.73
46	940.000	1.00	.01560	-18.07
47	980.000	1.00	.01449	-18.39
48	1020.000	1.00	.01350	-18.70
49	1060.000	1.00	.01261	-18.99
50	1100.000	1.00	.01182	-19.27
51	1140.000	1.00	.01111	-19.54
52	1180.000	1.00	.01046	-19.81
53	1220.000	1.00	.00987	-20.06
54	1260.000	1.00	.00934	-20.30

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