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Model Specification
Power Unit; Aircraft Auxiliary
Gas Turbine, Type I, Navy Model No. P-7

This specification has been approved by the Naval Air Systems Command, Department of the Navy.

1. Scope. This specification covers the requirements of a gas turbine auxiliary power unit to provide mechanical power for aircraft main engine starting and secondary electrical power.

1.1 Format. The paragraphs listed herein are numbered to correspond to those in Specification MIL-P-8686 and either include specific information as required by Specification MIL-P-8686 or indicate revised requirements differing from those of Specification MIL-P-8686. Omission of reference in this specification to a particular requirement of Specification MIL-P-8686 shall be interpreted as compliance therewith.

1.2 Classification. The gas turbine auxiliary power unit (APU) as defined herein is an airborne Type I APU for a source of mechanical power for main engine starting and for secondary electrical power. The APU consists of two major sections, namely, the gas turbine unit and the accessory gearbox. The gas turbine unit consists of a single stage centrifugal compressor, an annular combustor and a single stage inflow turbine. The compressor and the turbine are mounted back-to-back on a single shaft. The accessory gearbox provides the necessary gearing to provide a speed reduction gear ratios of 7.09 to 1.0 and 6.88 to 1.0 between the turbine shaft and the axial and transverse AND 20002, Type XII-A, power take-off drives respectively. The accessory gearbox also provides support for the lubricating oil sump and drives for other engine driven accessories. The unit incorporates a complete lubricating system including a pressure pump, an oil pressure relief valve, an oil filter and an oil sump permitting at least 30 hours of operation without refilling; a fuel system including a unit driven fuel pump, fuel filter, fuel control for controlling speed and overspeed, and six vaporizing fuel nozzles. A starting fuel nozzle is also provided which is cut-out at 90% unit speed. The electrical system components include an ignition exciter (powered from the airframe installation), a single spark ignitor, tachometer generator, exhaust gas temperature thermocouple, thermal switch, start counter, overspeed switch and speed switch.

2. Applicable Documents.

2.1 Applicability. The following specifications, standards, drawings, and publications, of the issue specified below, shall form a part of this specification only to the extent specified herein or in the referenced paragraphs of Specification MIL-P-8686:

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Specifications

Federal

TT-S-735	Standard Test Fluids; Hydrocarbon.

Military

MIL-C-3702	Cable, Power, Electrical; Ignition, High-Tension.
MIL-E-5007	Engines, Aircraft, Turbojet; General Specification for.
MIL-J-5161	Jet Fuel, Referee.
MIL-E-5607	Engine, Gas Turbine, Preparation for Storage and Shipment, Process for.
MIL-J-5624	Jet Fuel, Grades JP-4 and JP-5.
MIL-I-6181	Interference Control Requirements, Aircraft Equipment.
MIL-F-7024	Fluid; Calibrating, for Aircraft Fuel System Components.
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for.
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base.
MIL-P-8686	Power Units; Aircraft Auxiliary, Gas Turbine Type, General Specification for.
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for.
MIL-C-9282	Container, Shipping, Metal, Reusable 5 Cubic Feet - 50 Cubic Feet Volume.
MIL-E-15090	Enamel Equipment, Light Grey (Formula 111).
MIL-L-23699	Lubricating Oil, Aircraft Turboprop and Turbo-shaft Engines, Synthetic Base.
MIL-G-26611	Generator, Tachometer GEU-7/A, Miniature.
MIL-D-1000	Drawings; Engineering and Associated Lists.

Industry Specifications

AMS2640	Magnetic Particle Inspection.
AMS2645	Fluorescent Penetrant Inspection.
AS478	Identification Marking Methods.

Military Standards

MIL-STD-130	Identification Marking of US Military Property.
MIL-STD-210	Climatic Extremes for Military Equipment.
MIL-STD-453	Inspection, Radiographic.
MS33540	Safety Wiring, General Practices for.
MS33586	Metals, Definition of Dissimilar.

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MS33666	Packing, Preformed - Aeronautical, Elastomeric, Range of Sizes.
MS33668	Packing, Preformed - Pipe Fitting, Elastomeric, Range of Sizes.
AN10050	Bosses, Standard Dimensions for Gasket Seal Straight Thread.
AND20002	Drive-Type XII-A Engine Accessory.
AND20005	Drive-Type XV-B Engine Accessory.

Air Force-Navy Aeronautical Bulletins

ANA182	Material Changes and Substitutions; Aircraft Engine Parts.
ANA343	Specifications and Standards Applicable to Aircraft Engines and Propellers.
ANA423	Engines; Aircraft, Vendor Substantiation Tests for.
ANA438	Age Controls of Age-sensitive Elastomeric Items.
ANA445	Enginering Changes to Weapons, Systems, Equipments and Facilities.

Drawings

Solar Aircraft Company

26764	Control Assembly Fuel System Schematic.
27507	Air Flow Diagram.
27525	Oil-Air Mist Lubrication System.
27615	Schematic, Ignition System.
28677-0	Unit Basic Assembly.
29406	Outline and Installation.
30238	Schematic, Electrical System.

Other Documents

U. S. Standard Atmosphere - 1962.
National Bureau of Standards Cicular No. 561 (Reference Tables for Thermocouples).
ASME PTC Power Test Codes 19.5; 4-1949.

2.2 Supersedence. If any of the documents forming a part of this specification are superseded by a later document, revision, or amendment, it shall be permissible to apply such later documents or superseding issues, insofar as such superseding requirements are equivalent to or exceed the requirements of this specification or of the documents forming a part hereof as may be approved by the Government.

3.0 Requirements.

3.1.1 Critical Materials. Not applicable.

3.1.2 Dissimilar Metals. The use of dissimilar metals in contact as defined in MS33586 shall be avoided wherever practicable.

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3.1.3.1 Marking. "O" ring seals shall not be marked with any identification.

3.1.3.3 "O" Ring Seals and Packing. All nonmetallic "O" ring seals and gaskets used in the design of the unit shall conform to the applicable dimensions and tolerances shown on MS33666 and MS33668.

3.1.3.4 Age Controls. Age controls for synthetic rubber parts shall comply with the requirements of ANA Bulletin No. 438.

3.1.4 Material, Processes and Products. Materials, processes and products used in the manufacture of auxiliary power units shall be of high and consistent quality, shall be suitable for the purpose, and shall conform to the applicable specifications selected in accordance with ANA Bulletin No. 343. Where contractor's specifications are used for materials and processes, such specifications shall be submitted to the Government for review prior to preproduction test, and unless specifically disapproved will be considered released upon satisfactory completion and approval of the unit preproduction tests. Approval of non-Government specifications shall not constitute waiver of Government inspection.

3.1.4.1 Standard Parts. AN or MS standard parts shall be used unless they are positively determined to be unsuitable for the purpose, and shall be identified by their standard part numbers. In particular, standard parts released by AN Bulletin No. 343 are preferred and will be considered for use prior to consideration of any other standard. Where general purpose standards, as identified by envelope dimensions or Qualified Products Lists (QPL's), are used in critical or high strength applications, they shall be identified by the vendor or contractor's part number. Parts derived from general purpose standards solely on an inspection or selection basis, shall be identified by the contractor's part numbers (not necessarily on the part), and all previous identification marks shall be removed.

3.2.1 Standardization. Standardization principles shall be applied at all phases of initial design and to all design changes. Since these principles have, as final objectives, the reduction of varieties of unit components (e.g., materials, sizes, design elements, need for special tools, etc.,) both within a particular model, and between various models supplied to the military services, maximum use of military and recognized industry standard parts (restricted to the minimum number of varieties within that series) will assure that such standardization is accomplished. When standard parts are determined to be unsuitable for use in a specific application, the variety of special parts used shall be restricted to the most practicable limit. Under conditions wherein economics of production conflict with standardization objectives, the latter group will govern or the using service shall be requested to select the component desired for use.

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3.3 Model Specification. This specification conforms to the model specification requirements specified in MIL-P-8686. Unless otherwise positively identified, all performance data contained in this specification are guaranteed values.

3.4 Qualification and Acceptance. The final acceptance of any unit shall be predicated upon (1) the satisfactory completion and approval of a preproduction test conducted on a prototype unit in accordance with Appendix I of this specification and (2) the satisfactory completion and approval of acceptance tests conducted on each production unit in accordance with Appendix II of this specification. The parts list of each production unit shall be as established by the approved preproduction test except as specifically approved by the Government through the medium of engineering changes.

3.5 Performance Characteristics. The performance characteristics shall be as specified herein. These performance characteristics shall be determined using fuel in accordance with Specification MIL-J-5161, Grade II, and oil in accordance with Specification MIL-L-7808 or MIL-L-23699. These performance characteristics shall be determined under the sole control of the automatic control system furnished on the unit.

3.5.1 Fuel Types. The unit shall function satisfactorily throughout its operating range with fuel conforming to Specification MIL-J-5624, grades JP-4 and JP-5. External control adjustments will be allowed to meet this requirement only for changing from one fuel type to another. In particular, the operating limits specified herein will not be exceeded when fuels having any of the variations in characteristics permitted by Specification MIL-J-5624, grades JP-4 and JP-5, are used. The unit internal fuel system shall incorporate controls necessary for operation of the unit at the altitude limits and ambient operating temperatures specified in 3.5.7. Fuel pressure supplied at the unit fuel connection shall be from a minimum of 5 psi above the true vapor pressure of the fuel up to a maximum of 40 psi gage.

Fuel Types	Fuel Inlet Temperatures for Starting and Operating	
	Minimum	Maximum
JP-4	-65°F	135°F
JP-5	-40°F*	135°F

*Provided the fuel viscosity is not more than 12 centistokes.

3.5.2 Fuel Contamination. The unit shall function satisfactorily when using fuel contaminated to the extent specified in Specification MIL-E-5007 except the concentration of cotton linters shall be 0.1 gm/1000 gal.

A fuel filter shall be provided and shall be capable of 10 hours of continuous operation at the maximum rating shown in Table I, with the type of contaminant specified above added to the fuel. For operation with normal fuel, the interval between filter cleanings shall be a minimum of 200 hours.

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3.5.3 Lubricant. The unit shall be capable of satisfactory operation, with MIL-L-7808 or MIL-L-23699 used as the lubricant, throughout the ambient altitude and temperature ranges specified herein for operating conditions. (See 3.5.7).

3.5.4 Ratings. The performance ratings of the unit are as listed in Table I when using fuel conforming to Specification MIL-J-5161, grades I and II, and oil conforming to Specification MIL-L-7808 or MIL-L-23699. These data are based on no restriction at the unit air inlet or exhaust, and no loading of the accessory drives.

Table I

Performance Ratings

(U.S. Standard Sea Level Pressure and Temperature and with no air inlet or exhaust losses)

	*Total BHP Output	Fuel Consumption (lb/hr)	Axial Shaft Speed (RPM) **	Side Shaft Speed (RPM) **	Rated Measured EGT (°F)
	Min	Nominal	Nominal	Nominal	Nominal
Maximum	75	92	7790	7585	990
Normal	65	87	7840	7635	910
75% Normal	48.7	76	7920	7712	800
50% Normal	32.5	66	8000	7790	710
0	0	47	8160	7945	580

*The combined maximum output from both pad drives is limited to 75 BHP. However, 75 BHP can be delivered from the axial drive pad alone. Due to gear design, the side drive pad is limited to a total of 65 BHP.

**See 3.19 for steady state speed variation with load.

NOTE: The above performance ratings are based on the fuel lower heating value of 18,400 BTU/lb.

3.5.5 Estimates. The estimated performance curves are shown in Figures 1 through 3 inclusive, and shall constitute a part of this specification. These curves indicate the changes of the ratings of Table I with changes in ambient temperatures and pressures, and are based on other operating conditions as specified in 3.5.4.

3.5.5.1 Estimated Performance Curves.

Figure 1. Shaft horsepower vs compressor total inlet temperature.

Figure 2. Fuel flow vs compressor total inlet temperature.

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Figure 3. Operating speed tolerance.

3.5.5.2 Correction Data.

Figure 4. Altitude correction factor vs ambient temperature.

Figure 5. Data for correction of performance for duct losses.

3.5.6 Oil Consumption. The oil consumption shall not exceed 0.1 pound per hour under any operating condition as specified herein.

3.5.7 Altitude - Temperature Limits for Starting and Operating.

(1) Altitude Limits - The unit shall be capable of starting and operating satisfactorily from sea level up to a pressure altitude of 6,000 feet when operating within the flight attitude conditions specified in 3.5.8.

(2) Temperature Limits - The maximum allowable ambient starting and operating temperatures for ground operation shall be 130°F when supplied with fuel at a maximum temperature of 135°F, inlet air at a maximum temperature of 130°F and using the lubricants specified in 3.5. The maximum allowable ambient starting and operating temperature for inflight operation of the unit shall be within the hot atmosphere limits of MIL-STD-210. The minimum allowable ambient starting and operating temperature for either ground or inflight operation shall be minus 65°F when using MIL-L-7808 oil and JP-4 fuel and minus 40°F when using MIL-L-23699 oil and JP-5 fuel.

3.5.8 Attitude Conditions.

3.5.8.1 Ground Operating Attitude. The unit may be installed and will operate satisfactorily under any of the following conditions:

(1) Plus or minus 10 degrees displacement of the fore and aft axis.

(2) Plus or minus 10 degrees inclination to either side.

(3) Any combination of (1) and (2) above.

3.5.8.2 Flight Operating Attitude. The unit shall be capable of operating satisfactorily with the gravity vector tilted 25 degrees in any direction from the vertical axis passing through the center of gravity of the installed unit and shall be capable of operating satisfactorily without premature shutdown or any other adverse effect on the unit under conditions of either negative or zero "g" for up to 10 seconds at a time.

3.5.9 Ambient Temperature Conditions. The complete unit will perform satisfactorily from sea level to 6,000 feet altitude at outputs from no load to maximum output.

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3.5.9.1 Ambient Soaking Temperature Conditions. The unit shall suffer no detrimental effects after being subjected to the following:

(1) A soaking period of 8 hours at an ambient temperature of 160°F, and shall start and operate in this ambient when supplied with fuel at 135°F, inlet air at 130°F, and utilizing the appropriate lubricant specified in 3.5.3.

(2) A soaking period of 72 hours at an ambient temperature of minus 65°F, when utilizing MIL-L-7808 oil as a lubricant, and shall start and operate in this ambient condition when supplied with air at minus 65°F and with JP-4 fuel at minus 65°F.

(3) A soaking period of 72 hours at an ambient temperature of minus 40°F when MIL-L-23699 oil is utilized as a lubricant, and shall start and operate in this ambient condition when supplied with air at minus 40°F and with JP-5 fuel at minus 40°F (except as specified in 3.5.1).

3.5.10 Reduced Speed, Idle Operation. Not Applicable.

3.5.12 Exhaust Gas Temperature Limits. During continuous load operation, the measured exhaust gas temperature shall not exceed 1070°F. During starting or transient load operation, the measured exhaust gas temperature shall not exceed 1200°F and shall not exceed 1070°F for more than 10 seconds.

3.5.12.1 Measurement. A Chromel-Alumel thermocouple shall be provided for the measurement of the turbine exhaust gas temperature. Details of the thermocouple wiring connections are shown on Drawing Number 29406. Thermocouple as furnished on the unit shall meet the requirements of NBS Circular Number 561.

3.5.13 Starting. The unit shall make consistent, successful starts when used in accordance with 3.5.7 and when the recommended starting torque as shown on Figure 6 is supplied through either one of the two accessory drive pads. A successful start shall be defined as a complete start and acceleration, with no loading other than inertial on the two accessory pad drives, from initiation of starter torque to stabilized governed speed within 6 to 20 seconds.

3.5.13.1 Starter. The unit shall not be equipped with a starter. Unit starting may be accomplished by utilizing one of the two accessory pad drives as a starter drive.

3.5.13.2 Starting Power. The starting power torque-speed requirements for a successful start are shown on Figure 6. The estimated electrical power required for all ignition and control components which are operated only during the starting cycle shall not exceed the values specified in Table II at any ambient temperature from -65°F to 130°F.

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Table II

Estimated Electrical Power Requirements During Starting Cycle

Condition	Volts DC	Amp	Approx. Rotor Speed RPM
Current Inrush (Momentary)	28	4.0	0
Commence Firing	28	4.0	1,775
Starting Cut-out	28	4.0	42,550

3.5.13.3 Automatic Starting. The control components required for automatic starting are shown in Drawing Number 30238. The components furnished with the unit are indicated in Drawing Number 30238.

3.5.13.4 Special Starting Fuel. Not Applicable.

3.5.13.5 Restart Time. In the event of a false start, the unit shall be maintained inoperative for a 10 second period to allow the combustion chamber to be drained of residual fuel before another start sequence is initiated.

3.5.14 Maximum Rotor Speed. The maximum allowable rotor speed at the point of actuation of the overspeed switch shall not exceed 62,365 rpm. The normal governed unit rotor speed is 56,695 rpm. The ratio of rotor speed to the axial output drive shaft speed is 7.09 to 1.

3.5.15 Section Protection. Not Applicable.

3.6 Drawings and Data. The following Solar Aircraft Company drawings form a part of this specification:

28677-0	Unit Basic Assembly
29406	Outline and Installation
26764	Control Assembly Fuel System Schematic
27507	Air-Flow Diagram
27525	Oil - Air Mist Lubrication System
27615	Schematic, Ignition System
30238	Schematic, Electrical System.

3.6.1 Detail Drawings. Not Applicable.

3.6.2 Microfilm Drawings. Not Applicable.

3.7.2 Changes in Design. No changes shall be made in the design or materials of parts listed in an approved APU parts list except where such changes are approved in accordance with the provisions of ANA Bulletin Number 445.

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3.7.3 Service Bulletin. Not Applicable.

3.8 Interchangeability. All parts having the same contractor's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Matched sets or selective fits will be permitted only to the extent absolutely required for satisfactory operation of the APU in service. Changes in contractor's part numbers shall be governed by the drawing requirements of Specification MIL-D-1000.

3.13.4 Electrical Power. Electrical power required by the unit shall not exceed four (4) amperes at 14 to 30 volts dc at any ambient temperature from -65°F to 130°F.

3.14 Dry Weight. The maximum dry weight of the unit as shown in Drawing Number 29406, including power section, reduction gear, mounting points, fuel system, oil system, plumbing, ignition system, overspeed switch, oil pressure switch, tachometer generator, exhaust gas thermocouple, and thermal switch shall not exceed 70 pounds.

3.15 Over-all Dimensions. Over-all dimensions of the complete unit shall not exceed those shown in Drawing Number 29406.

3.16 Mounting Provisions. The number, type, and location of the mounting provisions shall be as shown in Drawing Number 29406.

3.16.1 Handling Supports. The provisions for hoisting the unit and for resting on the ground shall be as shown in Drawing Number 29406.

3.17.6 Vibration. The unit shall be designed to withstand, while non-operating, the vibration requirement of procedure XII of Specification MIL-E-5272, and in addition, the following aircraft vibration environment:

	Simple Amplitude Displacement		
Frequency	Vertical	Lateral	Longitudinal
13 cps	± 0.04 in.	± 0.06 in.	± 0.04 in.

3.18 Polar Moment of Inertia of Compressor - Turbine System. The Polar moment of inertia of the rotating parts referred to the nominal axial output pad shaft speed (8000 rpm) shall not exceed 3.4 pound-feet^2.

3.19 Output Drives. Two (2) AND 20002, Type XII-A, engine accessory drives shall be furnished as the main output drives of the unit. The output drives shall be capable of carrying an accessory having the maximum weight and overhung moment specified on the AND drawing under the loads specified in 3.17. The speed of the axial drive shaft under steady state load conditions at standard sea level pressure, over the temperature range of -65°F to +130°F, shall not vary in excess of ± 80 rpm (± 1%) from the nominal speed which varies

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linearly with load from 8160 rpm at no load to 7840 rpm at normal rated power. The speed of the right angle drive shaft shall be 37/38 of that of the axial drive shaft (7789 rpm at 8000 rpm axial drive shaft speed). The load applied to the output drives during shutdown shall be limited to decelerating the unit from full speed to rest in not less than 12 seconds.

3.19.1 Adapter Gearbox. Not Applicable.

3.19.2 Generator Cooling Air. Not Applicable.

3.19.2.1 Generator Cooling Air Connection. Not Applicable.

3.20 Compressed Air Products. Not Applicable.

3.20.1 Compressed Air Bleed. Not Applicable.

3.20.2 Mixed Bleed. Not Applicable.

3.20.3 Bleed Air Connection. Not Applicable.

3.21.2 Fire Detecting and Extinguishing Systems. Not Applicable.

3.22.2 Duct Attachment. Provisions for air intake duct attachment are shown on Drawing Number 29406. The following loads on the intake flange shall not be exceeded: Shear, 10 pounds; axial, 25 pounds; and the overhung moment, 80 pound-inches.

3.22.3 Inlet Air Pressure Drop. The maximum allowable inlet air pressure drop to the unit shall be 4.8 inches of water with zero exhaust pressure drop. For maximum allowable combined losses, see Figure 7.

3.23 Exhaust System.

3.23.1 Turbine Exhaust. Attachment provisions for the turbine exhaust duct are shown on Drawing Number 29406. The following loads on the exhaust duct attachment shall not be exceeded: Shear, 25 pounds; axial, 25 pounds; overhung moment, 200 pound-inches.

3.23.1.1 Turbine Exhaust Pressure Drop. The maximum allowable exhaust pressure drop external to the unit shall be 6.5 inches of water with zero inlet pressure drop. For allowable combined losses, see Figure 7.

3.23.2 Cooling Air Discharge. Not Applicable.

3.23.2.1 Cooling Air Discharge Pressure Drop. Not Applicable.

3.24 Lubrication System. The oil pressure and temperature indicator ranges required for remote indicators are 0 to 60 psi and -65°F to +300°F, respectively.

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3.24.4 Oil Filter. An AN oil filter shall be provided as a component part of the unit. The filter element shall be of sufficient capacity to permit operation without change for a period of 200 hours or 1000 starts, whichever first occurs.

3.24.5 Scavenging System. A separate oil scavenging system is not provided.

3.24.6.1 Oil Pressure Pump. The operating oil pressure at normal governed speed at any operating condition specified herein, when using the lubricant specified herein, shall be 15 to 30 psig.

3.24.6.2 Oil Pressure Measurement. The provisions for the measurement of unit oil pressure shall be as shown on Drawing Number 29406.

3.24.7 Oil Drain. An oil drain with a magnetic plug shall be provided at the bottom of the oil tank. The details of the oil drain are shown on Drawing Number 29406.

3.24.8 Oil Tank. The oil tank shall be a part of the accessory gearbox. Satisfactory functioning of the unit shall be provided under any of the attitude conditions specified in 3.5.8 when the oil in the tank is a minimum of 20 percent of the usable capacity as defined in 3.24.8.2.

3.24.8.2 Oil Tank Capacity. The oil tank shall have a capacity of 0.75 gallon.

3.24.8.3 Oil Tank Filler Cap. Applicable except as follows: The cap shall be fastened to the adapter by a chain. The outside of the cap shall be painted with a fuel and oil resistant paint and shall be marked in yellow with the following information: "Oil Fill - Dip Stick - Cap. 6 U.S Pts."

3.24.9 Oil Cooler. A separate oil cooler is not required.

3.24.10 Oil Breather. An overboard MS 33656-4 oil vent fitting is provided. Its location is shown on Drawing Number 29406.

3.25 Fuel System.

3.25.1 Performance. During APU operation, the unit's fuel system shall perform satisfactorily using the fuels specified in 3.5.1 and shall be capable of supplying the required amount of fuel at the required pressure under all conditions specified herein, with fuel temperatures ranging from zero to 80°F above the ambient temperature, but not in excess of 135°F, when the fuel pressure at the unit fuel inlet connection is from a minimum of 5 psi above the true vapor pressure of the fuel to a maximum of 40 psig. However, the unit fuel pump is not self-priming. Therefore, solid fuel must be provided at the fuel inlet connection during starting and operation.

3.25.4 Fuel Pressure Connection. A fuel pressure measuring connection conforming to AND-10050-4 shall be provided. The location of this connection is shown on Drawing Number 29406.

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3.25.6 Fuel Drains. The time required to drain the unit of fuel sufficiently to safely attempt another start following one normal ground-starting attempt shall not exceed 10 seconds. The fuel drain connection shall conform to MS 33656-4 and shall be located as shown on Drawing Number 29406.

3.26 Ignition System. The unit ignition system shall be a high energy, low tension capacitor discharge system powered by an external source of 14 to 30 volts DC power. A single surface-discharge type ignitor shall provide an intermittent spark for initial ignition of the fuel-air mixture. The ignition system is no longer required after the unit reaches 90% of normal rated speed.

3.26.1 High Tension Ignition Cable. The high tension ignition cable shall conform to Specification MIL-C-3702.

3.27 Control Systems.

3.27.1 Primary Controls. The unit shall incorporate an automatic control system which shall provide fuel shut-off valves, an auxiliary fuel injection system for starting, acceleration fuel scheduling, and speed governing at rated output shaft speed as specified in 3.19.

3.27.2 Emergency Controls. The unit shall incorporate emergency controls which shall shut the unit down in the event of low oil pressure (6 psig or less), overspeed, or when the exhaust gas temperatures limits as specified in 3.5.12 are exceeded. During a main engine start, automatic shutdown due to low oil pressure and overtemperature conditions shall be locked-out but shall be activated in the event of overspeed. The emergency controls shall function only when suitable control circuitry is provided by the airframe manufacturer as shown in Drawing Number 30238.

3.27.2.1 Warning Light System. Only a ready light as indicated on Drawing Number 30238 is used in the airframe.

3.27.3.1 Bleed Air Controls. Not Applicable.

3.28 Accessory Drives. A three-phrase two pole tachometer generator, USAF type GEU-7-A, Specification MIL-G-26611 shall be furnished with the unit.

3.29 Counting Devices. A counter for indicating the total number of starts shall be incorporated in the unit.

3.31.1 Screw Threads. All screw threads will conform with Specifications MIL-S-7742 or MIL-S-8879. The latter type of thread is preferred and shall be used for new designs wherever possible.

3.31.3 Coating Threaded Parts. When threaded parts are treated at the time of assembly with antiseize compound, the compound shall conform to a suitable commercial or military requirement.

3.32 Identification of Product.

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3.32.1 Gas Turbine Power Unit Data Plate. A gas turbine power unit data plate shall be attached to the unit and shall include the following information:

Power Unit, Gas Turbine; Type I

Model Number P-7

Manufacturers Serial Number

Contract or Order Number

Manufacturer's Name or Trade Mark

U.S.

3.33.2.1 Primer Coat. The primer coat applied under painted surfaces shall be compatible with the Epoxy-type diester oil resistant finish coat. W. P. Fuller 162Y19 mixed 1:1 with 75C371 catalyst shall be applied within two (2) hours after prior surface treatments or coatings. The primer coat shall be thoroughly dried prior to application of the finish coat(s) in order to prevent any consolidation of primer and finish coats. When the primer coat is soiled or damaged by intervening operations, it shall be thoroughly cleaned and another light primer coat applied before the finish coat may be applied.

3.33.2.2 Finish Coat. The finish paint coat for the unit shall be an Epoxy-type, diester oil and heat resistant enamel, W. P. Fuller 171H12 enamel mixed 4:1 with 75C376 catalyst, color to match Formula Number 111 in accordance with Specification MIL-E-15090.

3.35 General Additional Information.

3.35.1 Service Operating Conditions. The unit shall operate in accordance with this specification under any or all variables of any or all of the following environmental conditions.

3.35.1.1 High Temperature. Ambient temperature of 130°F.

3.35.1.2 Low Temperature. Ambient temperature of -65°F or the lowest temperature at which the fuel viscosity is 12 centistokes and the lubricating oil is 13,000 centistokes.

3.35.1.3 Humidity. Exposure to all conditions of humidity.

3.35.1.4 Fungi. Exposure to the action of fungi (Design requirement, not to be tested).

3.35.1.5 Salt Atmosphere. Continued exposure to the atmosphere over or adjacent to sea water.

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3.35.1.6 Sand and Dust. Exposure to airborne sand and dust.

3.35.2 Inspection Seals. Slug inspection seals, when used, shall be of non-corrosive and light material such as aluminum or plastic. The use of lead or similar material shall not be permissible.

3.35.3 Safety Locking. Loosening of screw, threaded parts and other mechanical connections shall be prevented by safety wiring, staking or other locking devices (see 3.1.4.1) to comply with the requirements of Specification MS 33540.

3.35.4 Corrosion Resistance. Metals shall be chosen or treated to resist corrosion during service life. Emphasis shall be placed on the selection or treatment of metals to minimize corrosion resulting from electrolytic action.

3.35.5 Non-Metallic Materials. Non-metallic materials shall be resistant to moisture, fuel, and lubricating oils as specified herein as well as all other fluids as may be encountered in Naval Aircraft and shall be so treated as to resist fungus growth.

3.35.6 System Diagrams. The unit shall function satisfactorily with the systems shown on the drawings listed in 3.6 of this specification.

3.35.7 Service Life. The design objective shall be for a service life of 10,000 starts and an overhaul period of 3000 starts or 1000 hours of running under load.

3.36 Rotor Design. The design of the unit shall be such that the following provision is provided when the unit is operated within the limitations of this specification at any combination of speed up to the maximum speed specified in 3.5.14 and temperature up to the maximum allowable operating turbine temperature.

3.36.1 Rotor Integrity. Integrity of the high-energy rotors will be provided to the extent that each rotor will be capable of withstanding the stabilized speed required to produce 1.50 times the kinetic energy of the rotor as determined at the maximum speed likely to occur under transient conditions and at maximum operating temperature.

4.0 Quality Assurance Provisions.

4.1.1 Preproduction and Acceptance Tests.

4.1.1.1 Preproduction Tests. Refer to Appendix I of this specification.

4.1.1.2 Acceptance Tests. An acceptance test shall be conducted in accordance with Appendix II of this specification on each unit prior to delivery of the unit for final acceptance by the Government.

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4.2 General. Auxiliary power units, components, and all material entering into the construction thereof shall be subject to inspection during the course of manufacture and during all testing specified herein by authorized Government Inspectors who shall be given reasonable facilities to determine compliance with this specification.

4.3.3.1 Hydrostatic Testing. Not Applicable.

4.3.4 Excepted Parts.

4.3.4.1 Commercial or Military Standard Parts. Low-stressed commercial or military standard parts, such as cotter pins and washers, are not required to be inspected by magnetic or fluorescent penetrant methods.

4.3.4.2 Antifriction Bearings. Non-separable or permanently sealed grease filled ball or roller bearings shall not be inspected by magnetic or fluorescent penetrant methods. However, all antifriction bearings containing magnetic materials shall be demagnetized prior to assembly in any production units. In addition, all handling of antifriction bearings shall be performed with nylon gloves or with an approved hand cream to prevent any acid etching of any bearing surface.

4.3.5 Radiographic or Ultrasonic Inspection. The first sentence of this paragraph is revised to read: "The following parts shall be subject to radiographic or ultrasonic inspection for defects:"

4.3.5.1 Radiographic Inspection. Radiographic inspection shall be conducted in accordance with MIL-STD-453 in lieu of Specifications MIL-I-6865 and MIL-X-6141.

4.3.6 Control Tests. All production acceptance bench testing of components of the fuel system shall be accomplished with calibrating fluid meeting the requirements of Specification MIL-F-7024, Type II.

5. Preparation for Delivery.

5.2 Preservation, Packaging and Packing.

5.2.1 Preservation. The auxiliary power unit, components, and accessories shall be packaged and preserved in accordance with Specification MIL-E-5607. The requirements of 3.4.1.2 of MIL-E-5607 and the use of MIL-C-8188 corrosion-preventive oil shall not be required. The unit inlet shall not be sprayed with oil of any kind.

5.2.2 Shipping Container. The auxiliary power unit, components and accessories shall be packaged and packed in reusable metal shipping containers in accordance with Specification MIL-C-9282. The contract or purchase order shall stipulate whether the metal shipping containers will be contractor or government furnished.

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5.3 Marking of Shipments. Identification marking shall conform to the requirements of Specification MIL-E-5607. Interior packages and exterior shipping containers shall be marked in accordance with MIL-STD-130. The identification shall consist of the following information listed in the order shown:

Stock number or other identification number as specified in the purchase document.

Power Unit, P-7; Aircraft Auxiliary, Gas Turbine, Type I

Specification (Insert Number and Date)

Manufacturer's Serial Number

Contract or Order Number

Manufacturer's Name or Trade Mark.

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APPENDIX I

10. Quality Assurance Provisions - Unless specifically waived by the procuring activity, a preproduction test is required for every new type or model auxiliary power unit or for an existing type or model manufactured by a new manufacturing source. When required, preproduction tests shall be conducted in accordance with Appendix I of Specification MIL-P-8686 with the following exceptions:

10.1 General - Auxiliary power units, components, and test appratus shall be subject to inspection by authorized Government Inspectors who shall be given reasonable facilities to determine conformance with this appendix. All preproduction tests conducted at the contractor's plant shall be subject to official witnessing by an authorized representative of the procuring activity. When preproduction tests are conducted at the contractor's plant, a complete test report shall be prepared in accordance with figure I of Appendix I of Specification MIL-P-8686 and when submitted for approval, the report shall be accompanied with a copy of all original test log sheets and a complete set of engineering drawings applicable to the Unit. When preproduction tests are conducted at a government laboratory, the test units shall be accompanied by one complete set of manufacturer's drawings, a parts list, a spare parts kit containing all spare parts which the manufacturer considers necessary for the support of the test units for the furation of the preproduction testing and a tool kit containing all special tools required for complete disassembly of the test units.

10.1.1 Sampling Instructions - For preproduction tests involving a new type or model of an auxiliary power unit for which design approval is desired, a test sample shall consist of two identical power units designated as units "A" and "B". For preproduction tests involving an existing type or model made by a new manufacturing source, the test sample shall consist of a single unit which will be used for all of the tests specified herein.

10.2.2.1 Test Units - Applicable except for units of the existing design made by a new manufacturing source where unit "A" will be used for all of the tests specified herein.

10.2.2.4.2 Starts - Applicable except the two hour shutdown period is changed to one hour.

10.2.2.6 Miscellaneous Tests - Applicable except when the preproduction tests are intended to prove a new manufacturing source for the existing design, the tests specified in 10.2.2.6.1.1, 10.2.2.6.1.2 and 10.2.2.6.3 are not required.

10.2.2.6.2 Test of Overspeed Control - Applicable except unit "A" will be used for this test when a single unit is used for preproduction tests.

10.2.2.7 Test Operating Condition -

10.2.2.7.1 This paragraph is revised to read: The preproduction tests shall be run at the prevailing ambient laboratory temperatures and pressures. Fuel conforming to Specification MIL-J-5161, Grade II and lubricating oil conforming

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to Specification MIL-L-23699 are the primary fuel and oil to be used during all tests specified herein except for the alternate fuel test (10.2.2.6.3). For the latter test, fuel conforming to Specification MIL-J-5161, Grade I and lubricating oil conforming to Specification MIL-L-7808 shall be used. The conditions of loadings and the rated loads applied during preproduction tests shall be as specified in 3.5.4.

10.2.2.7.8.1 Correction - This paragraph is revised to read: "Readings of airflow fuel flow, gas pressures, and gas temperatures shall be corrected to standard sea level atmospheric conditions as defined in U. S. Standard Atmosphere 1962.

10.3 Component Tests - Applicable, except the component tests specified hereunder are not required when components of the unit are obtained from a previously approved manufacturing source. However, when components are obtained from a new manufacturing source(s), the applicable component test applies. Such component tests shall be subject to separate approval by the Procuring Activity.

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APPENDIX II

Appendix II of Specification MIL-P-8686 is applicable except as follows:

20.2.1.4 Temperature and Pressure Measurements - Applicable except the measured exhaust gas temperatures shall be obtained from the exhaust gas temperature measurement system supplied with the unit.

20.2.2 Fuel and Oil - The fuel and oil used for all acceptance testing, including preliminary runs, shall be as follows:

a. Fuel - MIL-J-5624, Grade JP-5.

b. Oil - MIL-L-23699.

20.4.1.1 Initial Run - This paragraph is revised to read: The unit shall be subjected to a one (1) hour initial run in accordance with the following schedule:

a. With the normal speed governing rendered inoperative and under conditions of no load, start and accelerate the unit to overspeed actuation for three consecutive times.

b. Perform three consecutive, fully automatic starts and acceleration to no load governed speed. Each start is to be followed by a 5 minute period with the unit at rest.

c. After the last start under (b) above, the unit shall be operated for four (4) cycles of alternate periods of 3 minutes at maximum load and 3 minutes at no-load.

d. Operate the unit for four (4) cycles of alternate periods of 3 minutes at maximum load and 3 minutes at normal rated load.

e. Operate the unit at normal load for 12 minutes.

20.4.1.1.1 Initial Run Test Data - Applicable except as noted:

c. Bleed Airflow - Not Applicable.

d. Bleed Air Total Pressure - Not Applicable.

e. Bleed Air Total Temperature - Not Applicable.

f. Bleed Airpower - Not Applicable.

i. Duration of turbine exhaust temperature in excess of maximum permissable value specified in seconds.

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20.4.1.2 Additional Runs - Not Applicable.

20.4.1.6 Final Run - This paragraph is revised to read: "The final run shall be a complete repetition of the initial run".

20.4.2 Overspeed Test - This test as a separate test is not applicable.

20.4.3 Radio Interference Level - Not Applicable.

20.4.4 Automatic Start Test - This test is not applicable as a separate test.

20.5 Schedule "B" - Schedule "B" shall consist of the requirements specified in 20.4.1.1 followed by an inspection consisting of an examination of the unit for evidence of fuel, oil or air leaks, cracks, or foreign object damage to the rotating components by viewing the compressor and turbine from the air inlet and exhaust discharge duct. Should the foregoing inspection reveal any leaks or foreign object damage beyond limits established for service use, appropriate corrective action shall be taken. In the event that any disassembly or parts replacement is necessary, the unit shall be subjected to penalty runs as required.

20.7.1 This paragraph is revised to read: "The performance data taken during the final test under schedule "A" or during the initial test under schedule "B" when corrected to standard sea level conditions shall meet the maximum or minimum performance data (output, specific fuel consumption, unit speed and measured exhaust gas temperature) as specified in Table I of 3.5.4. In addition, the overspeed and automatic start test data shall not exceed the limits specified in 3.5.14 and 3.5.13, respectively.

20.7.2 Overspeed Test - Not Applicable.

20.7.3 Radio Interference Tests - Not Applicable.

20.7.4 Automatic Start Tests - A successful start shall be defined as a continuous acceleration from actuation of the start switch to rated speed within the limits specified in 3.5.13.

20.7.5 Measured Exhaust Gas Temperature - The measured exhaust gas temperature when corrected to standard sea level conditions by a method approved by the procuring activity, shall not exceed the rated measured exhaust gas temperatures specified in Table I of 3.5.4 by more than 15°F.

20.8 Not Applicable.

20.9.2 Not Applicable.

20.9.3 Maximum Hours of Running - If any unit, other than an experimental unit requires more than 6 hours for schedule "A" or 4 hours for schedule "B" of running under its own power, or more than 25 starts in connection with its test

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under this specification, including preliminary runs or running-in when performed, the unit shall stand rejected unless otherwise determined acceptable by procuring activity. Rejected units, as defined above, will be accepted after replacement of worn or defective parts or components which cannot be reconditioned to enable them to pass the detailed inspection for similar parts or components from acceptable units and after completing of a test run of suitable duration and characteristics as established by mutual agreement of the Government Representative and the contractor. Parts and components from rejected units shall not be re-submitted for inspection without full particulars being given the Government Inspector concerning previous rejection of the unit."

20.10 Acceptance Test Log - An acceptance test log shall be prepared for each accepted unit. Each test log shall be validated by the Government Representative at the contractor's plant. An official copy of the acceptance test log shall be kept on file at the contractor's plant for a period of two (2) years after acceptance of the unit.

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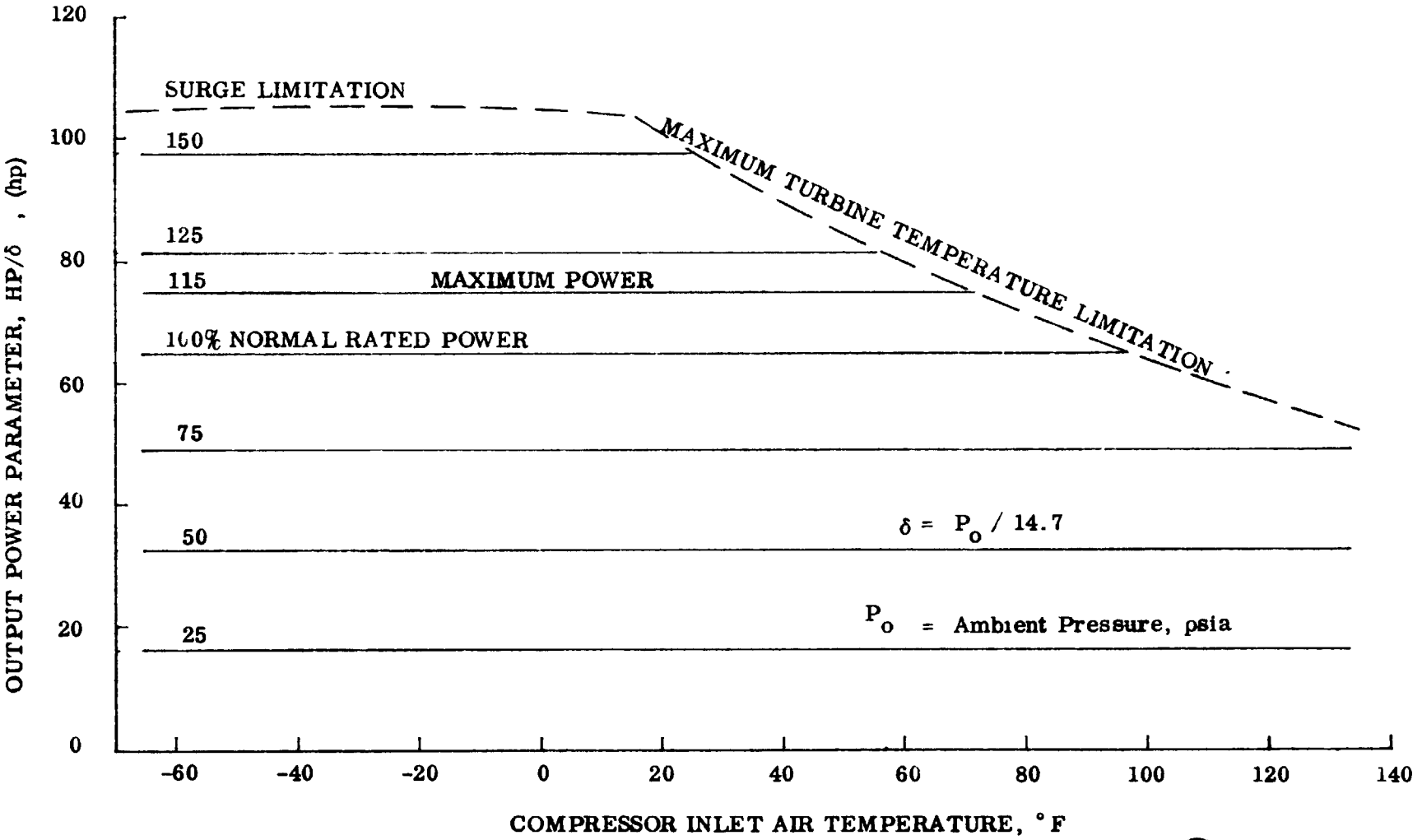

D

FIGURE 1. APP OUTPUT POWER RATINGS

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SOLAR GAS TURBINE APP

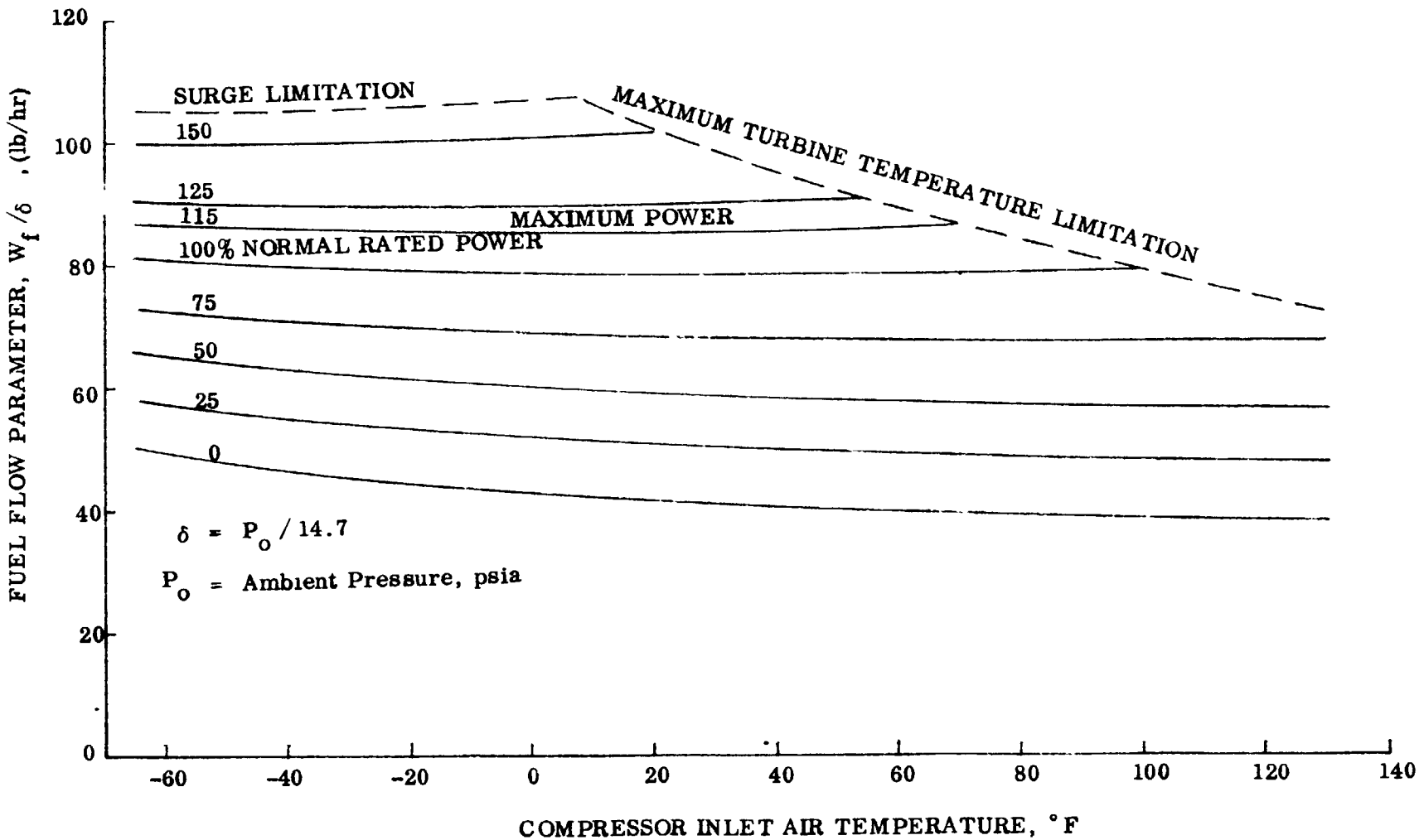

FIGURE 2. APP FUEL CONSUMPTION

D

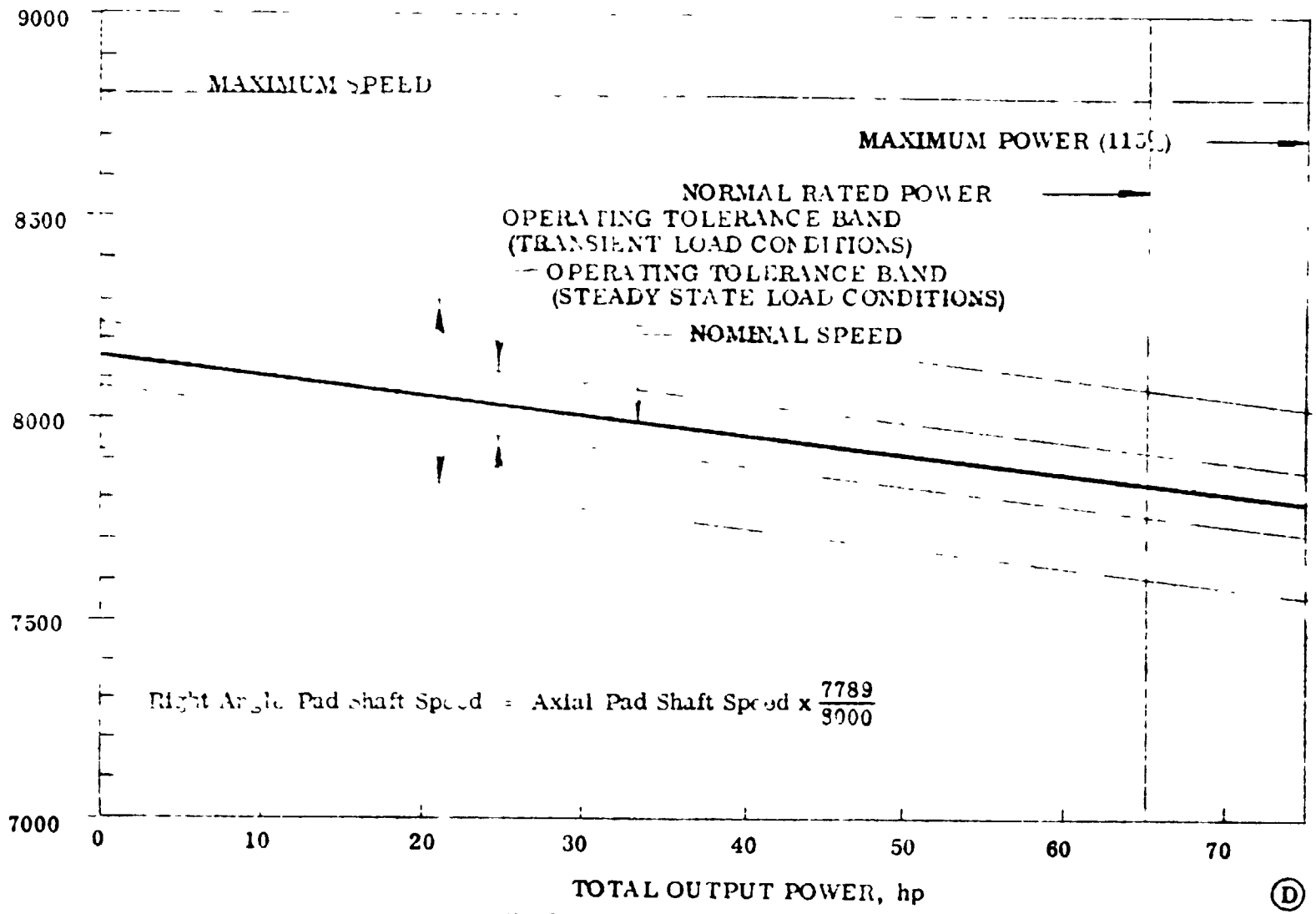

FIGURE 3. OPERATING SPEED TOLERANCE

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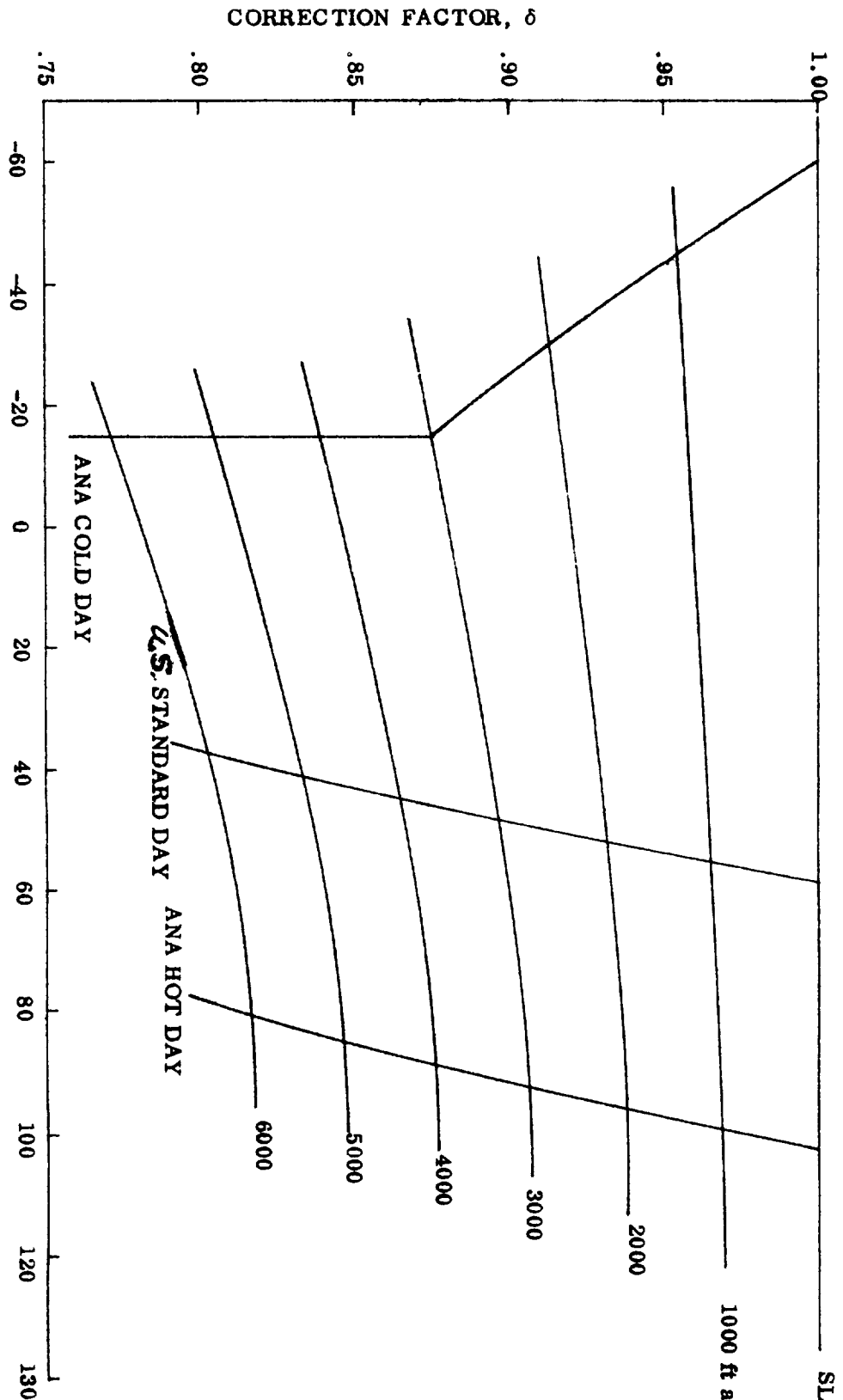

FIGURE 4. ALTITUDE CORRECTION FACTOR

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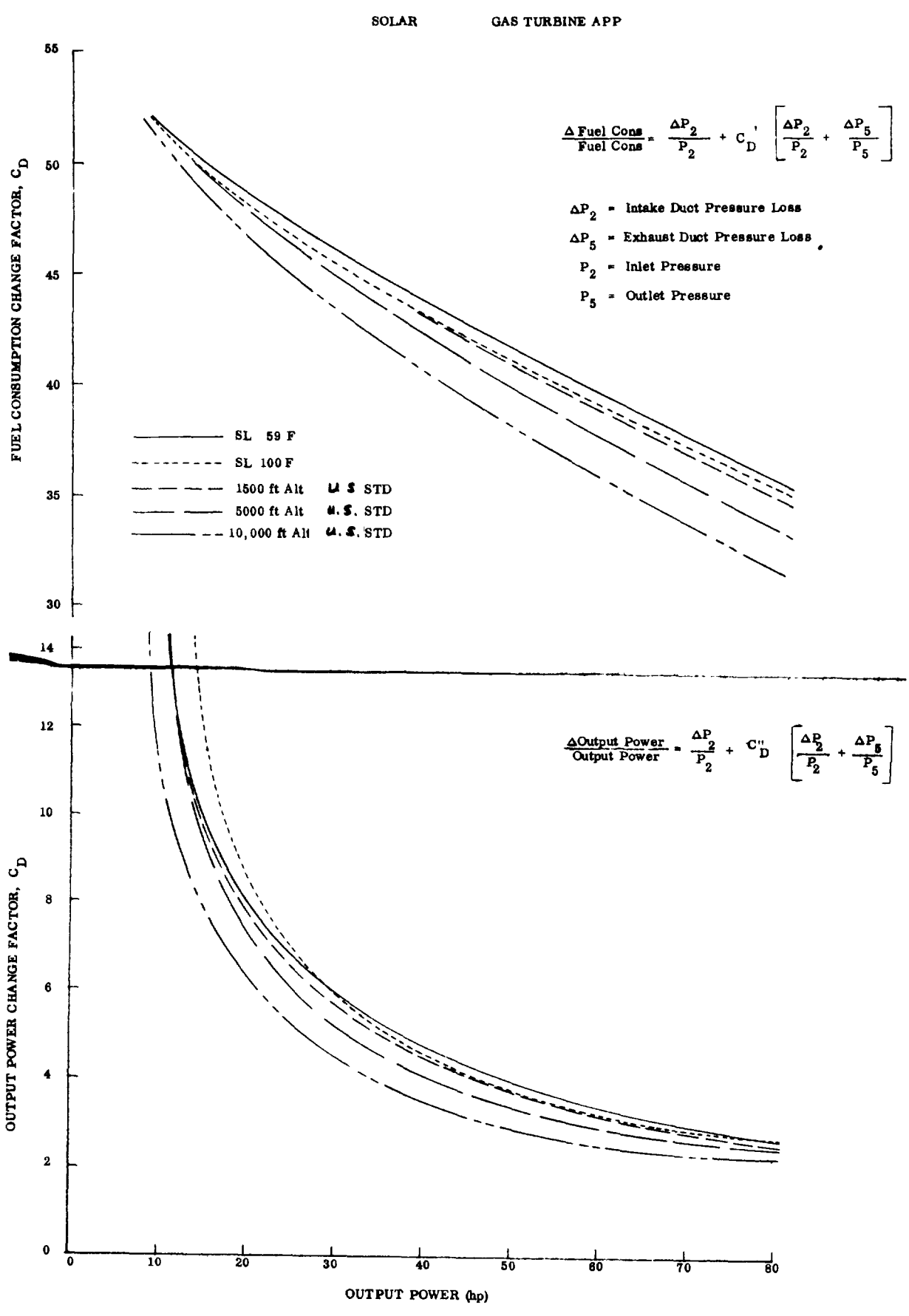

FIGURE 5 PERFORMANCE CORRECTION FOR INLET AND EXHAUST DUCT LOSSES

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Ⓑ Ⓓ

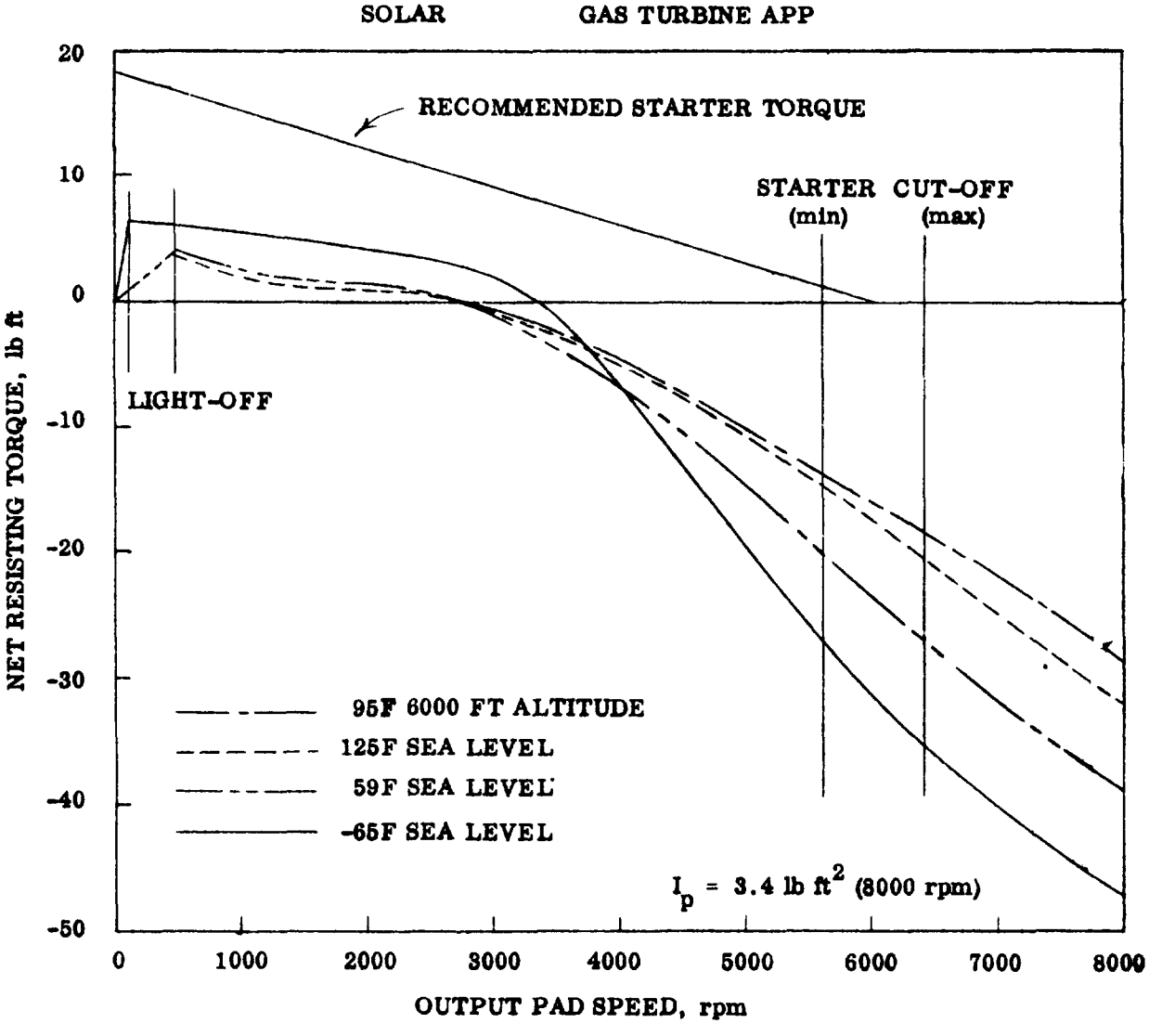

FIGURE 6. ESTIMATED APP STARTING CHARACTERISTICS

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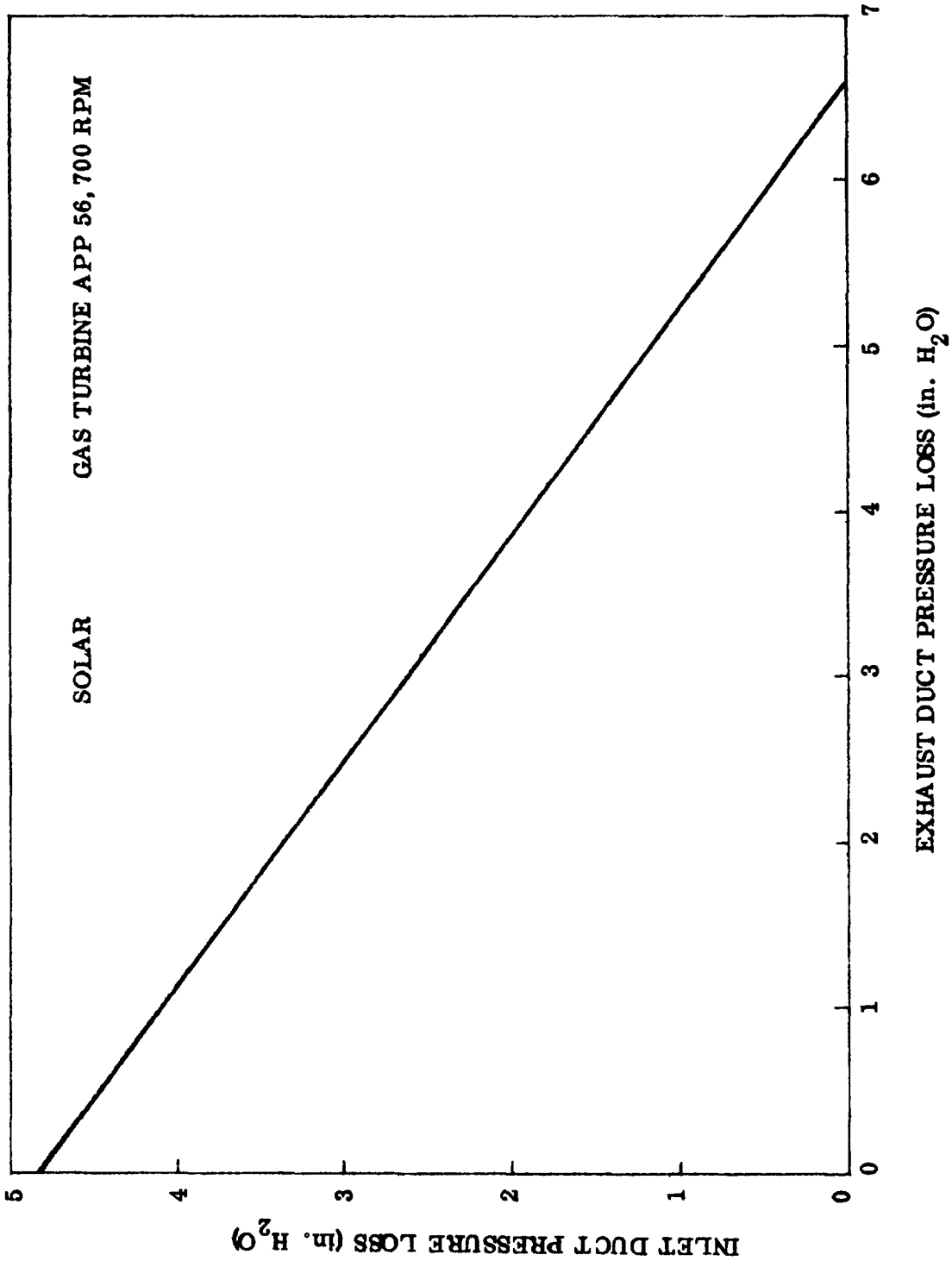
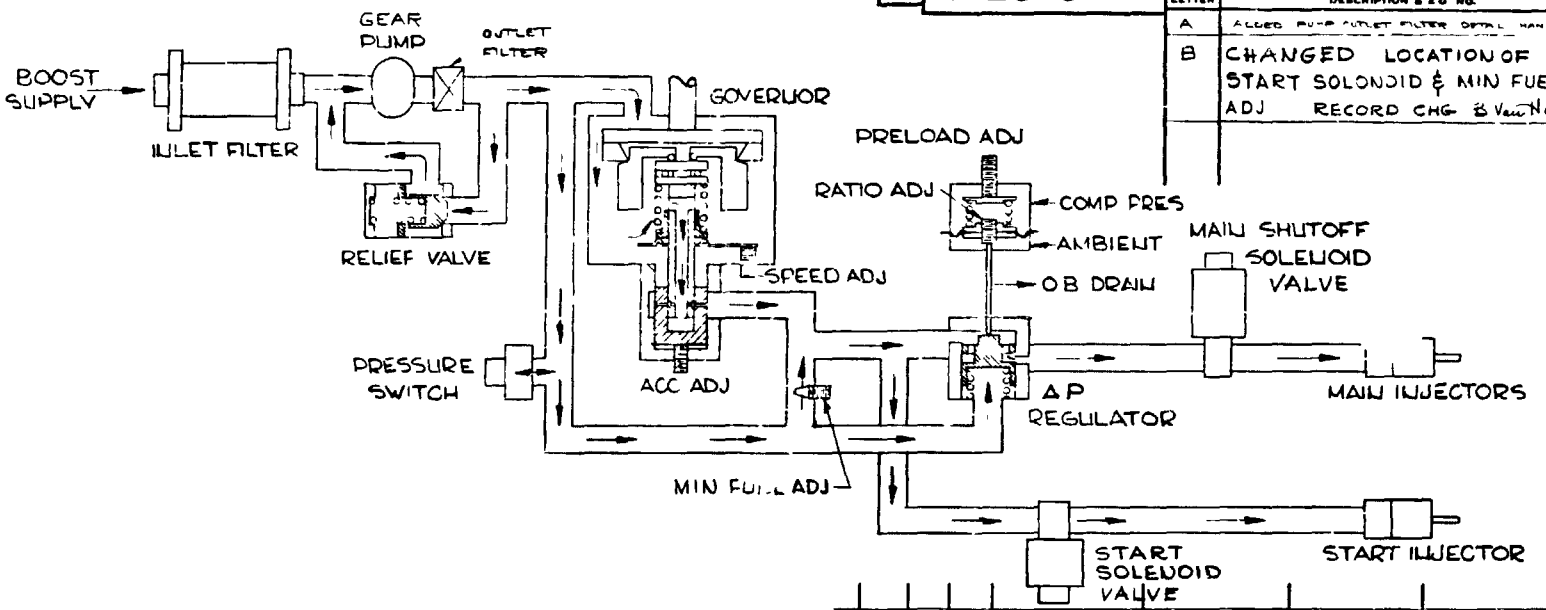


FIGURE 7. ALLOWABLE COMBINED INLET AND EXHAUST PRESSURE LOSSES

B DWG NO 26764

REVISIONS			
LETTER	DESCRIPTION & E.O. NO.	DATE	APPROV
A	ADDED PUMP OUTLET FILTER DETAIL HAN ET	7-7-60	
B	CHANGED LOCATION OF START SOLENOID & MIN FUEL ADJ RECORD CHG B Van Nouw	2-11-64	



REQD	REQD	REQD	PART NO	DESCRIPTION	MATL	MATL SPEC	UNIT

LIST OF MATERIAL

UNITS PER ASS'Y

ASSY

ISSUE NO.	DATE
EFFECTIVE ENGRG ORDERS	
1	
2	
3	
4	
5	
6	

APPROVED BY
CHIEF K Y Gill 4.13.60
STAFF
PROJ ENGR
DESIGN
CHECKED
DRAWN R Dwyer 4-13-60

DRAWING TITLE

CONTROL ASSY, FUEL SYSTEM SCHEMATIC

SCALE NONE

SOLAR AIRCRAFT COMPANY SAN DIEGO 12, CALIFORNIA

CODE IDENT NO. 55820

DWG. NO. 26764

DWG SIZE B

SHEET 1 OF 1

2. DO NOT SCALE DRAWING — WORK TO DIMENSIONS GIVEN
1 ALL DIMENSIONS WITHOUT LIMITS ARE BASIC AND CARRY NO TOLERANCE UNLESS OTHERWISE SPECIFIED.

NOTES:

SACO 1287 REV 9-59

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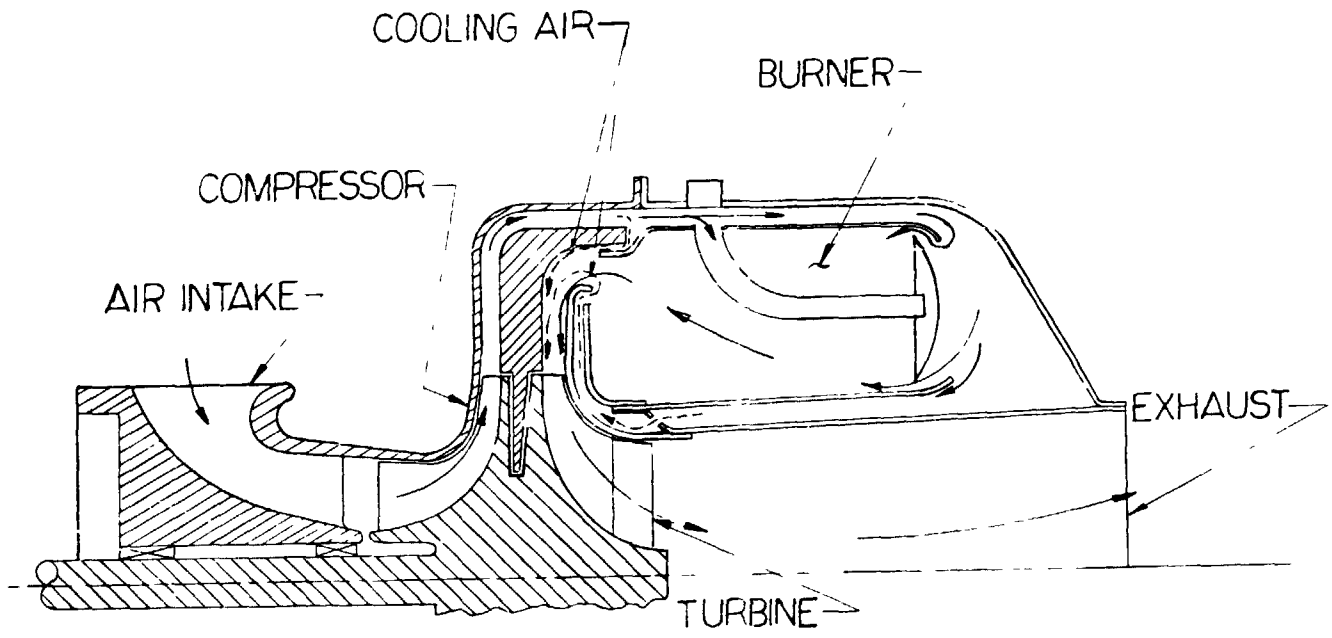
REV	DESCRIPTION	DATE	APP



DRAWN KRAFT	DATE 8-12-60	NAME AIRFLOW DIAGRAM FOR
CHECKED ALO	8-31-60	
APPROVED 9-1-60		
APPROVED Cummard	9-1-60	
SCALE NONE	SOLAR	DWG NO 27507
		REF

SACO 1775 7 58

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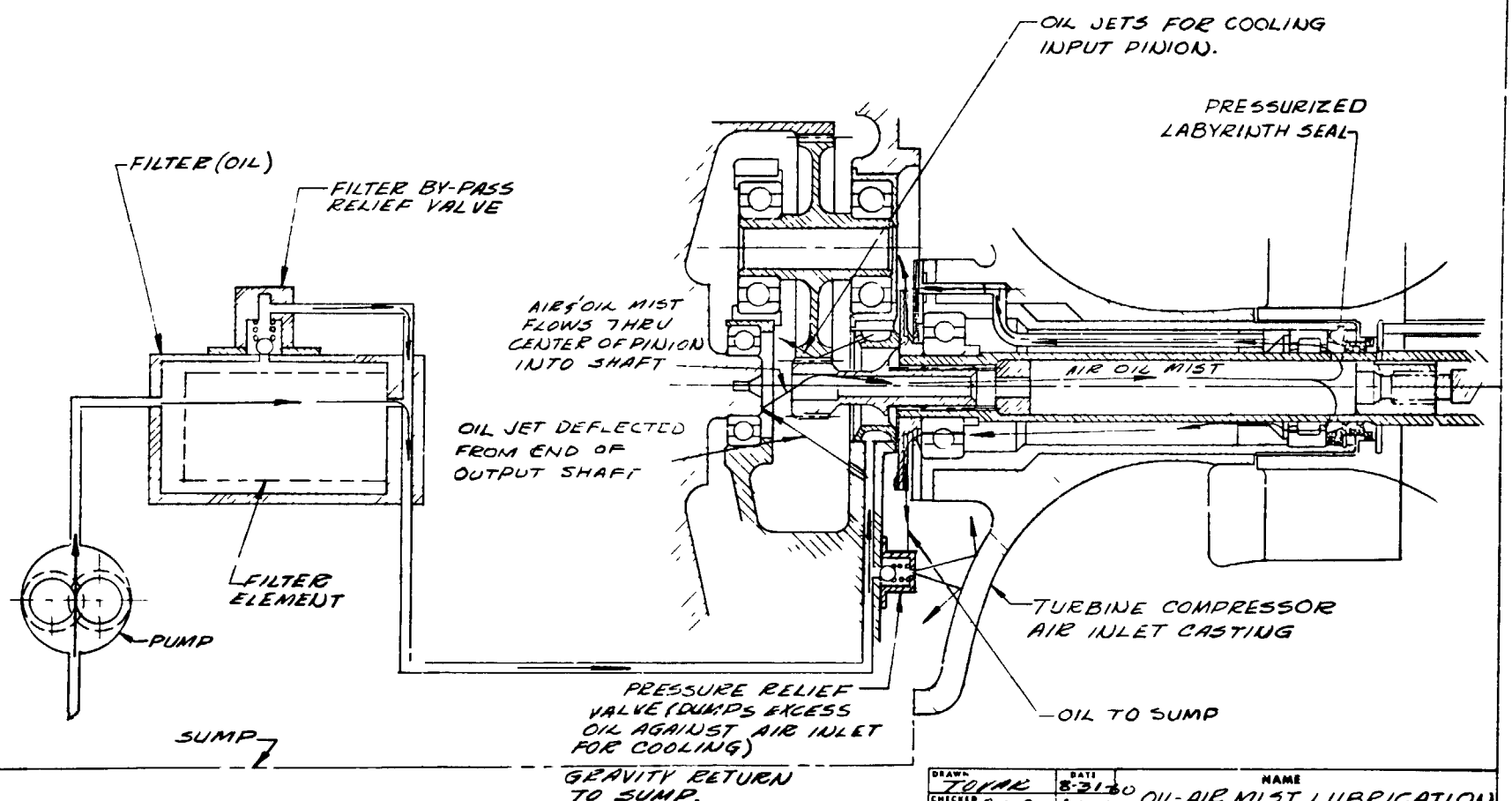
REV	DESCRIPTION	DATE	APP



DRAWN TOMAR	DATE 8-31-60	NAME OIL-AIR MIST LUBRICATION SYSTEM FOR (RECIRCULATING)
CHECKED ALO	8.31.60	
APPROVED JJZ	9.1.60	
APPROVED E. Blumenau	9 1 60	
SCALE NONE	SOLAR	DWG NO 27525
		REF ONLINE

SACO 1775 7 58

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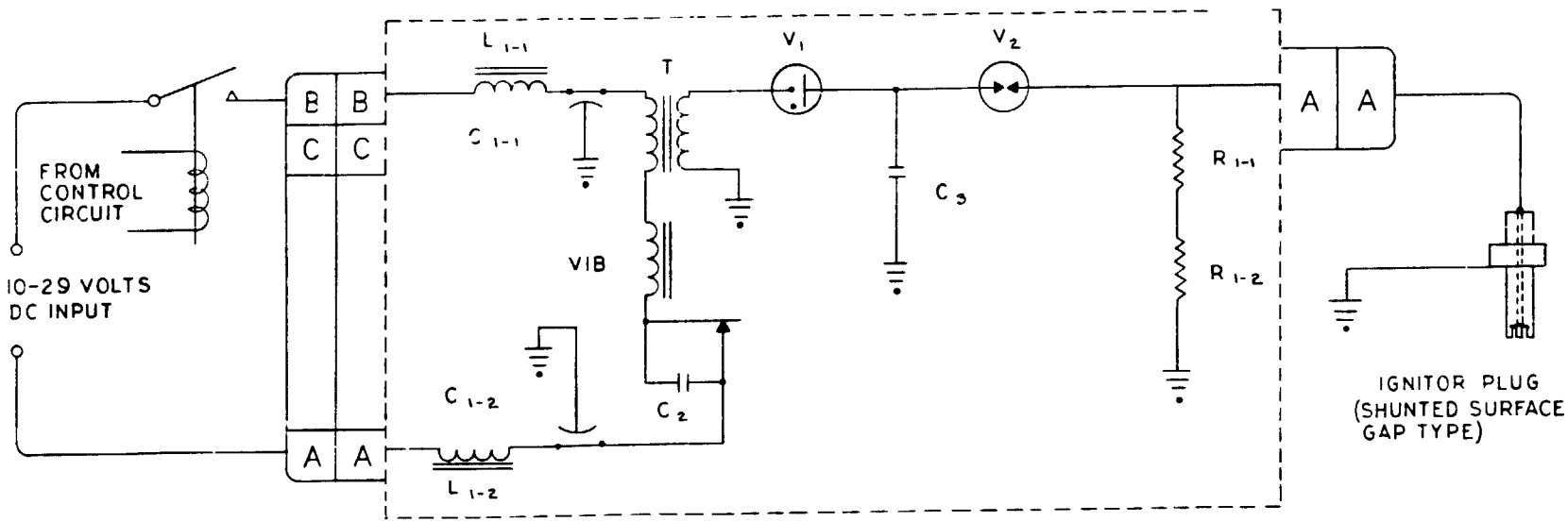
REV	DESCRIPTION	DATE	APP

LEGEND
C1 CAPACITOR
C2 CAPACITOR
C3 CAPACITOR
L INDUCTOR
R RESISTOR
T TRANSFORMER
VIB VIBRATOR
V1 ELECTRON TUBE RECTIFIER
V2 ELECTRON TUBE DISCHARGER



DRAWN Wilkinson	DATE 8-31-60	NAME SCHEMATIC- IGNITION SYSTEM
CHECKED ALO	8-31-60	
APPROVED	9 1 60	
APPROVED	9-1-60	
SCALE NONE	SOLAR	DWG NO 27615
		REF PAGE

SACO 1775 7 58

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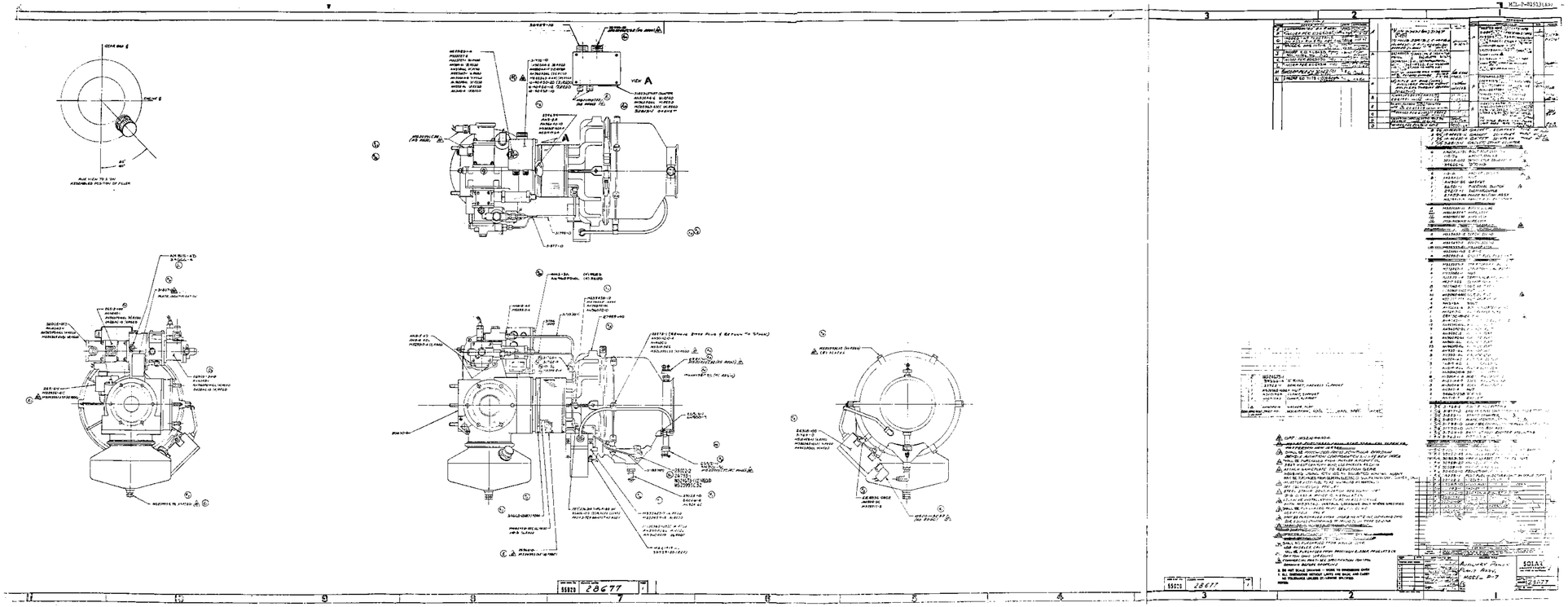

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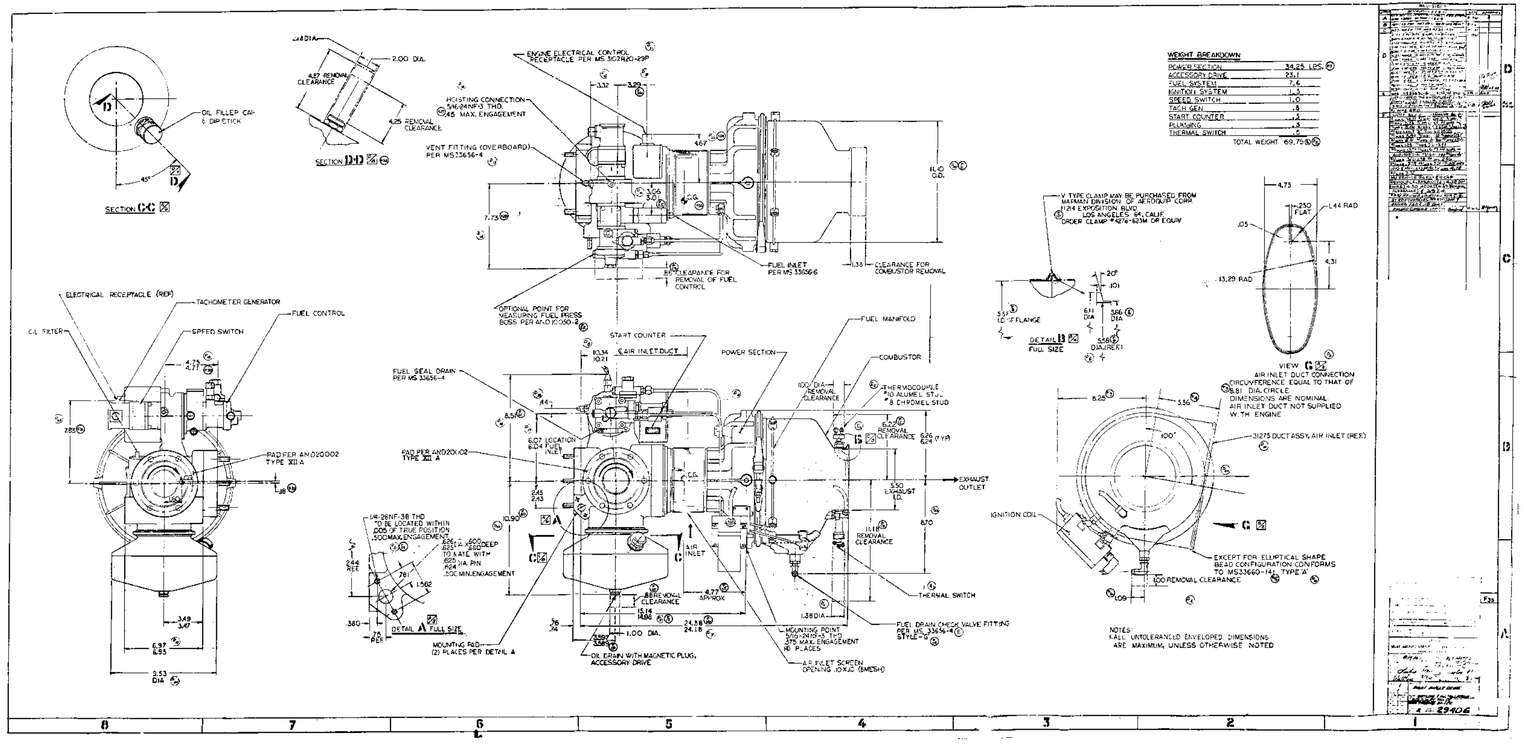

WEIGHT BREAKDOWN	
POWER SECTION	34.25 LBS.
ACCESSORY DRIVE	23.1
FUEL SYSTEM	7.6
IGNITION SYSTEM	1.5
SPEED SWITCH	1.0
TACH GEN.	.8
START COUNTER	.4
PLUMBING	.5
THERMAL SWITCH	.6
TOTAL WEIGHT	69.75

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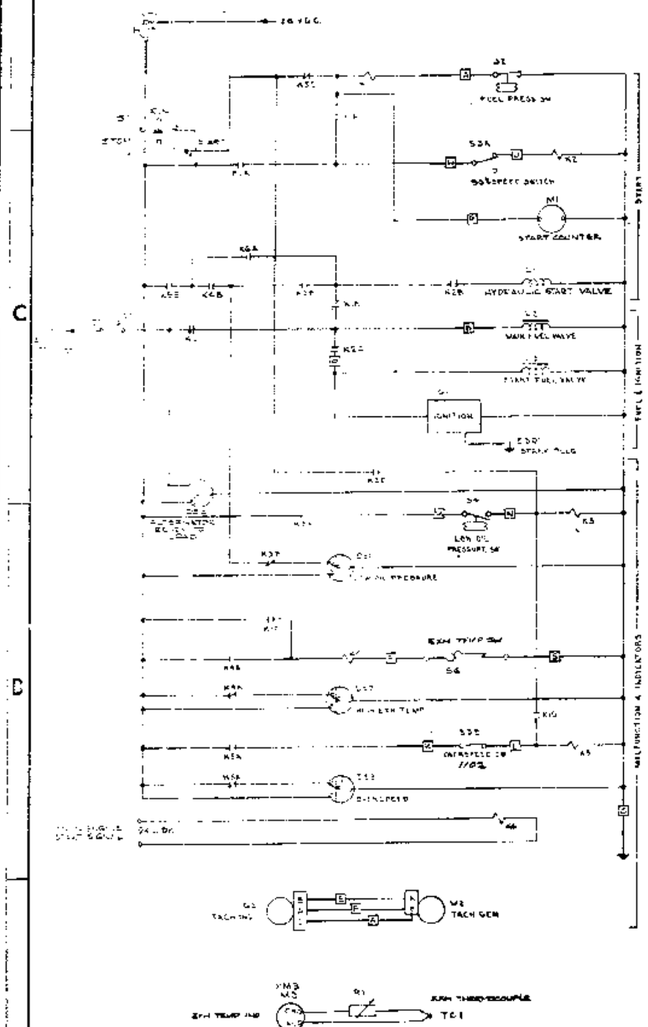

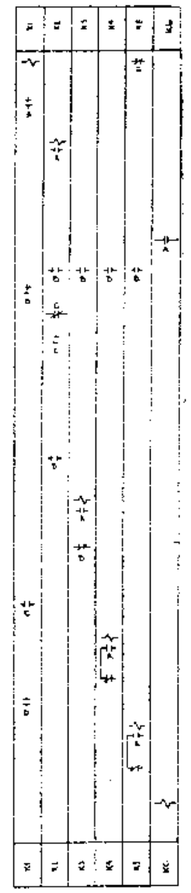

ITEM	PART NO	DESCRIPTION	SPECIFICATION
CB1	MS25244-10	CIRCUIT BREAKER	
DS1	MS35241-6	LIGHT ASSY	
DS2	MS35241-6	LIGHT ASSY	
DS3	MS35241-6	LIGHT ASSY	
DS4	MS29061-7	LIGHT ASSY	
⚠ E1,E2	16319	SPARK PLUG	
⚠ G1	16318	EXCITER IGNITION	
⚠ G2	TEMC 0011 3/A	TACHOMETER GENERATOR	
K1	MS25524-2	RELAY	
K2	MS25524-2	RELAY	
K3	AN3151-2	RELAY	
K4	AN3151-2	RELAY	
K5	AN3151-2	RELAY	
K6	AN3218-2	RELAY	
L1	37898-0	VALVE-REGULATOR	
⚠ L2	37897-0	VALVE-MAIN FUEL	
⚠ L3	37899-0	VALVE-START FUEL	
⚠ M1	31833	START COUNTER	
M2	M17800-1	TACHOMETER	
M3	M22806-1	PYROMETER	
XM3	MS28055-11	MOUNTING BEZEL	
R1	AN3556-2	RESISTOR	
S1	16506	SWITCH-START-STOP	
⚠ S2	27900-0	SWITCH-FUEL PRESSURE	
S3	20512	SWITCH-SPEED	
S4	16516	SWITCH-LOW OIL PRESSURE	
S5	MS24528-25	SWITCH-ALTERNATOR, ON-OFF	
S6	22521	SWITCH-EXHAUST TEMP	
⚠ TC1	29217	THERMOCOUPLE	

NOTES

1. SYMBOLS [A] (TYP) INDICATE PIN DESIGNATIONS AT CUSTOMER CONNECTION. SEE WIRING DIAGRAM.

⚠ ENGINE MOUNTED COMPONENTS

ELECTRICAL SCHEMATIC

50238