Report No. VSE/ASG/0067-87/1[illegible]

ENGINEERING EVALUATION AND ANALYSIS FOR THE IMPROVEMENT OF MILITARY STANDARD GENERATORS

VOLUME 2 OF 2 VOLUMES

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Prepared For:

U.S. Army Belvoir Research, Development and Engineering Center
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Appendix G
Noise Kits for 15 and 30 kW Generator Sets

DEPARTMENT OF THE ARMY
US ARMY BELVOIR RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
FORT BELVOIR, VIRGINIA 22060-5606

REPLY TO
ATTENTION OF

STRBE-FCP 23 Jun 86

MEMORANDUM FOR VSE

SUBJECT: Noise Kits for PU789/M and Launcher 15kW Generator Sets

1. Reference Task Order 0006 for PATRIOT EPUII (PU789/M) Support.

2. Request that action be undertaken to review the current Noise Control Kit that was developed by Belvoir RDE Center for the 15kW and 30kW Generator Sets. The review should include:

a. Interface problems

b. Suggested changes in view of PATRIOT requirements as depicted by the PU789 assembly.

c. Effects of additional length and weight on towing the PU789 or installation of 15kW set on the launcher.

3. The engineering evaluation must be completed and a report submitted to the PATRIOT Support Office by COB 27 Jun 86.

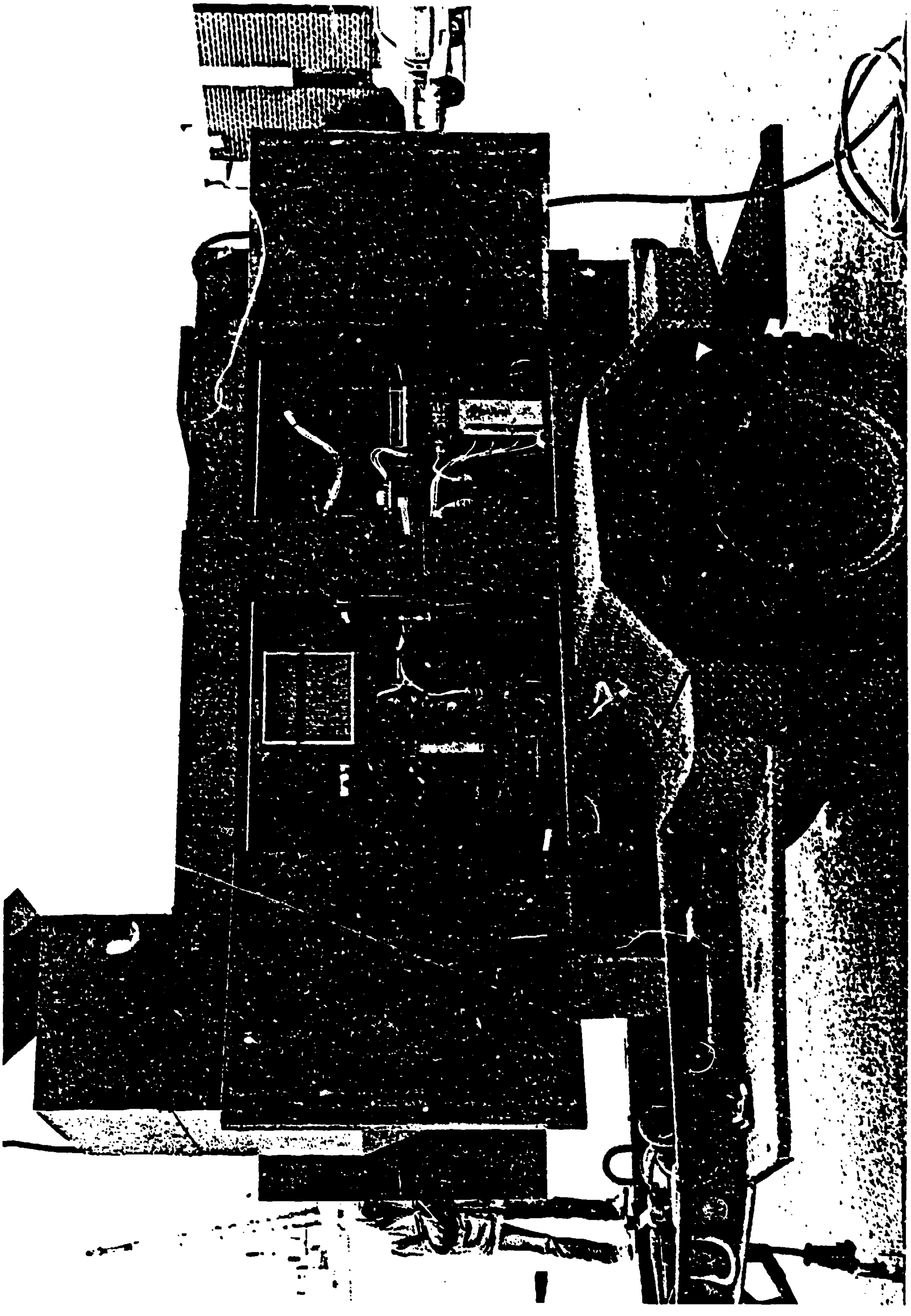
4. Pertinent information on the kit is enclosed including pictures and Purchase Description. The prototype kit is currently located behind Building 324, BRDEC.

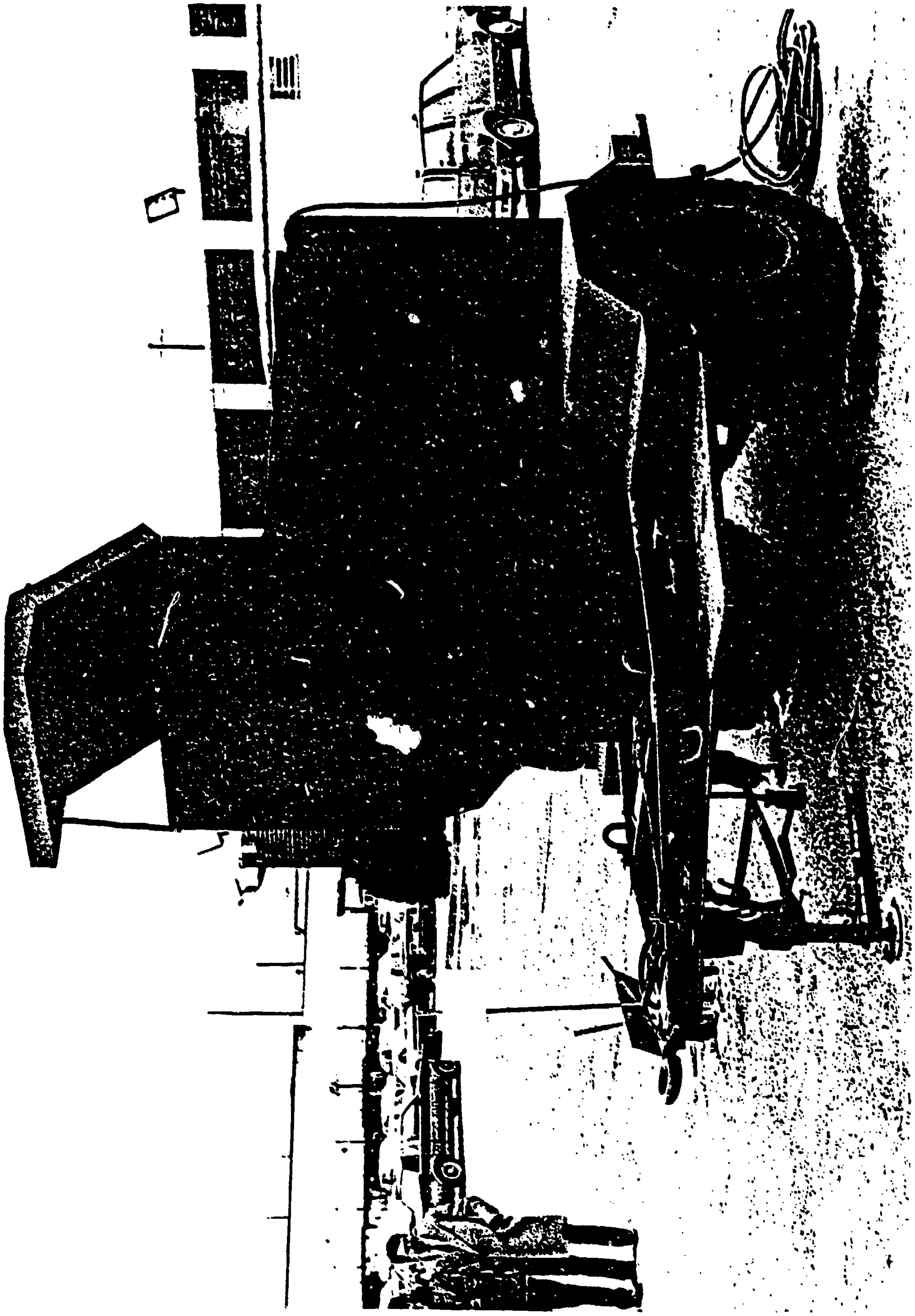
5. POC is Byrd Pritchett, 644-5871.

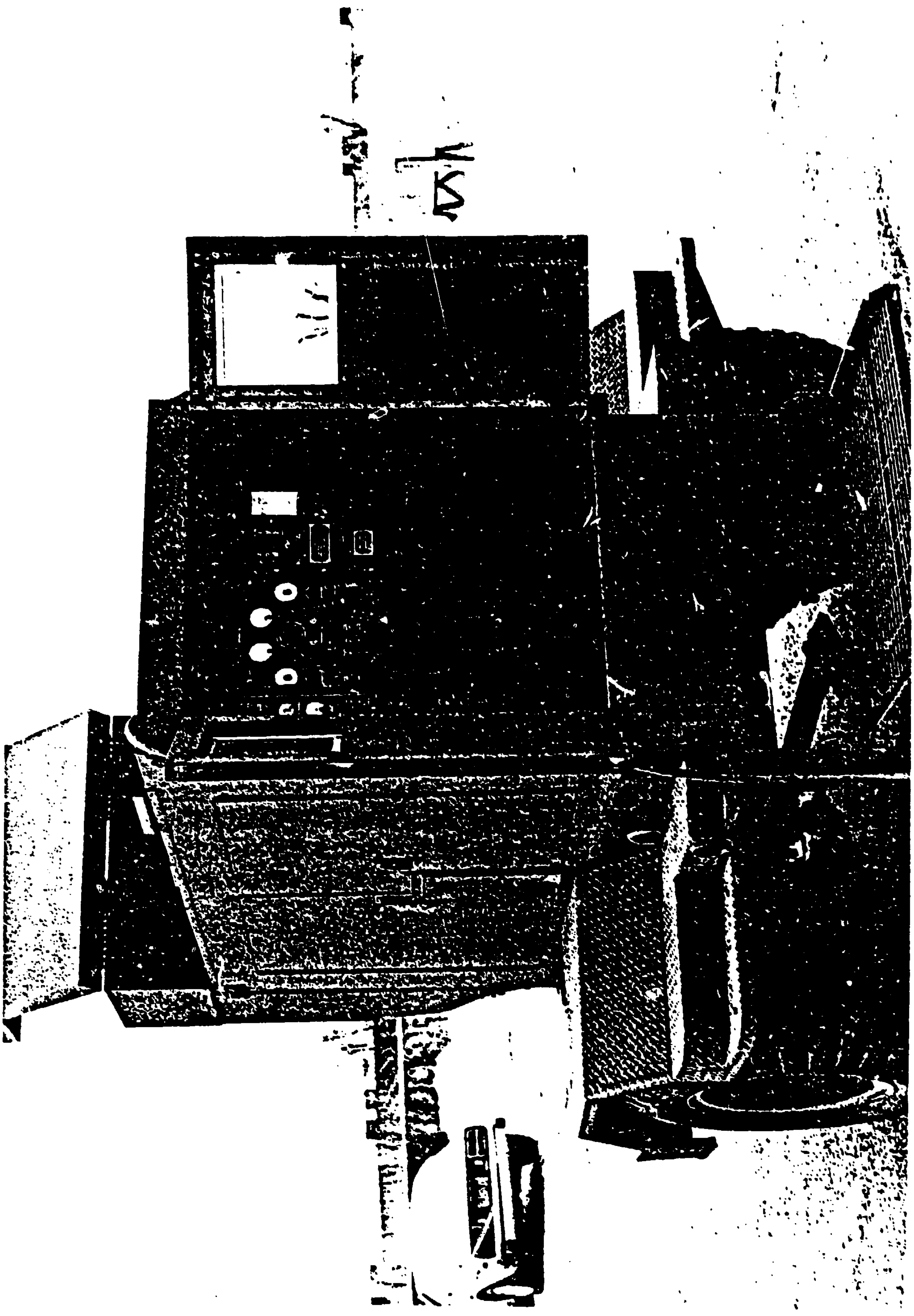
Robert M. McKechnie

ROBERT M. McKECHNIE
DPO for PATRIOT Support

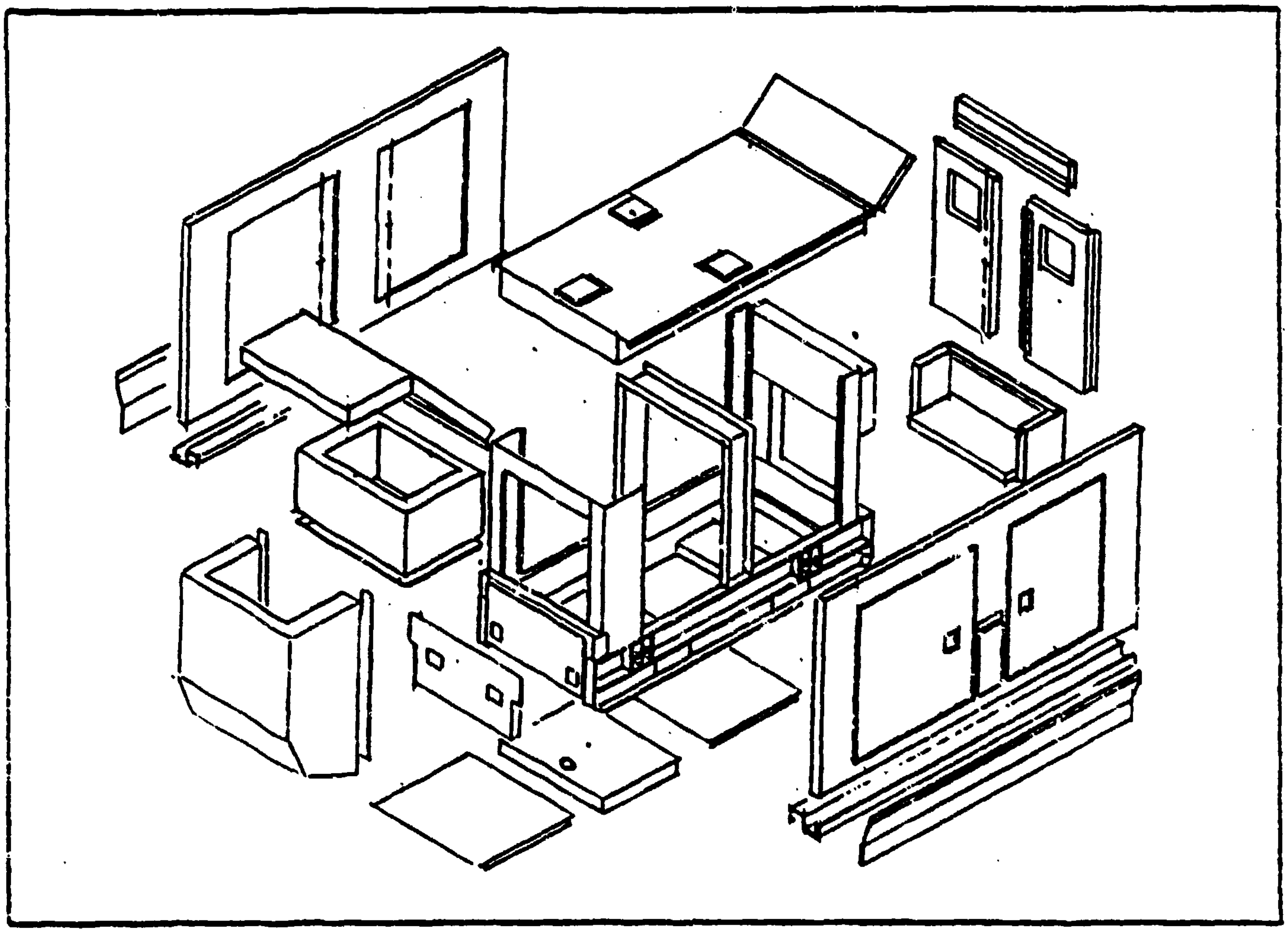
CF:
Pritchett
Currin
Brantly
Harris
Sams





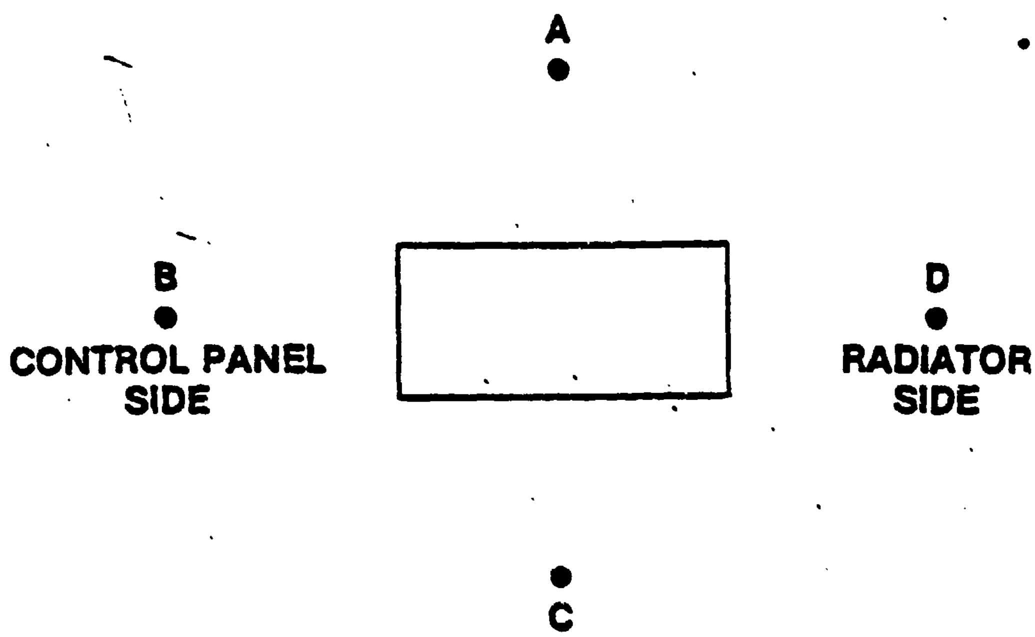


Type III Noise Control Kit
For 30 kW Diesel Generator Set Model PU 760



DESIGNED AND MANUFACTURED BY
INDUSTRIAL ACOUSTICS COMPANY
1160 Commerce Ave. Bronx, N. Y. 10462
Phone: (212) 931-8000 Telex: 12-6886 Fax: (212) 863-1138

Type III Noise Control Kit
For 30 kW Diesel Generator Set Model PU 760



Silenced Noise Levels at 7 Meters During Operation of the Improved 30 kW Diesel Generator Set Model PU 760 Using Type III Noise Control Kit

CENTER	OCTAVE BAND LEVELS IN dB Re: 0002 MICROBAR									
FREQUENCY	"A"	"C"	63	125	250	500	1000	2000	4000	8000
A	69.0	84.0	78.0	82.0	76.0	64.0	60.0	56.0	49.0	43.0
B	68.0	81.0	75.0	78.0	75.0	62.0	58.0	56.0	49.0	38.0
C	70.0	83.0	77.0	80.0	79.0	62.0	59.0	55.0	47.0	35.0
D	69.0	83.0	77.0	79.0	76.0	63.0	60.0	57.0	50.0	44.0

JUN 0 6 1986

PURCHASE DESCRIPTION

ACOUSTIC SUPPRESSION KIT, GENERATOR SET AND POWER UNIT, MILITARY STANDARD, 15kW and 30kW

1. SCOPE

1.1 Scope. This Purchase Description covers the requirements for add-on, field-installable, acoustic suppression kits for military standard, 15kW and 30kW, generator sets and power units.

1.2 Classification. The acoustic suppression kits covered by this Purchase Description shall be furnished in two separate sizes; one for use with 15kW, military standard, generator sets and power units, and one for use with 30kW, military standard, generator sets and power units.

1.3 Applications. The 15kW size acoustic suppression kit shall be suitable for use with all of the following 15kW generator set and power unit configurations and the 30kW size acoustic suppression kit shall be suitable for use with all of the following 30kW generator set and power unit configurations:

15kW Configurations

MEP 004A, NSN 6115-00-118-1241, Skid-Mounted
MEP 103A, NSN 6115-00-118-1245, Skid-Mounted
MEP 113A, NSN 6115-00-118-1244, Skid-Mounted
PU 405 , NSN 6115-00-394-9577, Trailer-Mounted
PU 732 , NSN 6115-00-260-3082, Trailer-Mounted

30kW Configurations

MEP 005A, NSN 6115-00-118-1240, Skid-Mounted
MEP 005A, NSN 6115-00-118-1240, Mounted on Pershing II Launcher
MEP 104A, NSN 6115-00-118-1247, Skid-Mounted
MEP 114A, NSN 6115-00-118-1248, Skid-Mounted
PU 406 , NSN 6115-00-394-9576, Trailer-Mounted
PU 706M, NSN 6115-00-394-9581, Trailer-Mounted

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

FSC 6115

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Specifications

MIL-T-704 - Treatment and Painting of Material

MIL-G-52884 - Generator Sets, Diesel Engine Drive, 15 thru 200 Kilowatts, 50/60 and 400 Hertz (Tactical), General Specification for.

Standards

MIL-STD-633 - Mobile Electric Power, Engine Generator Standard Family, General Characteristics.

MIL-STD-705 - Generator Sets, Engine Driven, Methods of Test and Instructions.

MIL-STD-1332 - Definitions of Tactical, Prime, Precise and Utility Terminologies for Classification of the DOD Mobile Electric Power Engine Generator Set Family.

MIL-STD-1472 - Human Engineering Design Criteria for Military Systems, Equipment and Facilities.

MIL-STD-1474 - Noise Limits for Army Materiel.

Drawings

30554-70-004 - Generator Set, Diesel Engine Driven, Tactical Utility, 15kW, 60Hz.

30554-70-103 - Generator Set, Diesel Engine Driven, Tactical Precise, 15kW, 60Hz.

30554-70-113 - Generator Set, Diesel Engine Driven, Tactical Precise, 15kW, 400Hz.

30554-70-005 - Generator Set, Diesel Engine Driven, Tactical Utility, 30kW, 60Hz.

30554-70-104 - Generator Set, Diesel Engine Driven, Tactical Precise, 30kW, 60Hz.

30554-70-114 - Generator Set, Diesel Engine Driven, Tactical Precise, 30kW, 400Hz.

97403-13214E1257 - Trailer, 2½ Ton, Modified M200A1.

97403-13214E1258 - Chassis, 2½ Ton, Modified M200A1.

2.2 Other publications. The following documents(s) form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 3951 - Standard Practice for Commercial Packaging.

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103).

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1 - Structural Welding Code - Steel.
AWS D1.2 - Structural Welding Code - Aluminum.
AWS B2.1 - Welding procedure and Performance Qualificaion, Standard for.

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, (except for associated detail specifications sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Description. The acoustic suppression kits (referred to herein as "kit" or "kits") shall consist of those materials, hardware and components necessary to achieve a complete structure that is capable of being installed as an add-on kit for 15kW and 30kW, military standard, generator sets and power units (referred to herein as "set" or "sets"). The kits shall be designed and constructed so as to comply with all of the requirements specified herein.

3.2 First article. Unless otherwise specified (see 6.2), a sample shall be subjected to first article inspection (see 4.2 and 6.4). Any changes or deviations of suppression kits from the approved first article during production will be subject to the approval of the contracting officer. Approval of the first article will not relieve the contractor of his obligation to furnish suppression kit conforming to this specification.

3.3 General set characteristics. The kits when installed on the sets shall not cause any change in the operational, performance or other characteristics of the sets as defined in MIL-STD-633 and MIL-G-52884 except as specified herein.

3.4 Audio noise. Sound pressure levels emanating from the sets with the kits installed, when operating at any loads up to and including rated load, shall not exceed 70dB(A), when the microphone is located 1.2 meters above the ground, and 7 meters measured in any direction from the perimeter of the set.

3.5 Installation and removal. The kits shall be capable of being installed on and removed from the sets in accordance with the following requirements:

a. Installation of the kits shall include any modifications to the sets, and removal of the kits shall include restoration of the sets to their original configuration.

b. Modifications to the sets for purposes of kit installation shall be limited to removal of existing, exterior enclosures, doors and panels and those changes to the frame structure necessary for kit attachment. No modifications to internal set components shall be necessary to install the kits or to comply with the requirements specified herein.

c. The kits shall be capable of being installed and removed using tools and equipment available at the Direct Support (DS) intermediate maintenance levels.

d. The kits shall be capable of being installed or removed by not more than two MOS-52D and/or MOS 44B maintenance personnel in not more than twelve clock hours.

e. The kits shall be attached to the sets by removable, reusable fasteners. Welding or rivets shall not be used to attach the kits to the sets.

f. Installation of the kits shall not permanently change any characteristics of the sets. Upon removal of the kits, the sets shall be capable of providing the same characteristics as prior to installation of the kits.

g. The kits may be designed for separate operating and transport modes. If so designed, actions necessary to transition from one mode to the other mode shall be capable of being accomplished by not more than two MOS-52D and/or 44B maintenance personnel in not more than one hour.

h. All kit sections that are removable for transport or maintenance shall have lifting handles.

3.6 Interchangeability. Each section, part or component of the kits, within each kit size, shall be identical in design within manufacturers tolerances, and completely interchangeable with like sections, parts or components of every other kit within each kit size. Each complete kit, within each kit size, shall be capable of being used with all set configurations within that size. Each kit shall accomodate tolerance stack-ups of both the generator sets and/or

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the trailer as defined by the following drawings:

30554-70-004 - Generator Set, 15kW, 60Hz, TU

30554-70-005 - Generator Set, 30kW, 60Hz, TU

30554-70-103 - Generator Set, 15kW, 60Hz, TP

30554-70-104 - Generator Set, 30kW, 60Hz, TP

30554-70-113 - Generator Set, 15kW, 400Hz, TP

30554-70-114 - Generator Set, 30kW, 400Hz, TP

97403-13214E1257 - Trailer, Modified M200A1

97403-13214E1258 - Chassis, Modified M200A1

3.7 Physical size. The length and width of the installed kits shall be limited as necessary to assure installation on the sets when mounted on the modified M200A1 trailer defined by Drawing Numbers 97403-13214E1257 and 97403-13214E1258. In addition, the maximum dimensions of the sets with the kits installed shall be limited as follows:

KIT SIZE	MODE	LENGTH	WIDTH	HEIGHT
15kW	Operating	108"	40"	80"
15kW	Transport	92"	40"	64"
30kW	Operating	108"	40"	80"
30kW	Transport	92"	40"	64"

3.8 Weight. The net weight increase of the sets with the kits installed shall be not more than 1000 pounds for both kit sizes in either the transport or operating mode.

3.8.1 Tow eye weight. The tow eye weight with the kits installed shall not exceed 600 pounds.

3.9 Accessibility. The kits when installed on the sets shall not decrease the accessibility of set components relative to the existing, military standard configurations. Hinged doors with latches shall be provided as necessary to permit access to the fuel filler opening, batteries, oil filler opening, oil level dipstick, radiator, control panel, electrical output connections/receptacles, ground stud, lifting attachments and tie-down attachments without the aid of tools.

3.9.1 Output power cable. A six inch square or six inch diameter opening shall be provided in the bottom of the control panel end of the kits to allow for exiting of output power cables. A grommet shall be provided.

3.10 Maintainability. The kits shall not require any scheduled maintenance, and when installed on the sets, shall not reduce the maintainability characteristics or increase the maintenance ratio of the sets relative to the existing, military standard configurations.

3.11 Reliability. The reliability of the sets when operated with the kits installed shall not be reduced relative to the existing, military standard configurations.

3.12 Human factors engineering. The kits as installed on the sets shall be designed in accordance with the applicable human factors requirements of MIL-STD-1472.

3.13 Safety. The kits when installed on the sets shall not create any safety hazards, or compromise the safety characteristics of the sets relative to the existing, military standard configurations. Sharp edges, protrusions and excessive length of fastening devices shall not be allowed.

3.14 Transportation requirements. The kits when installed on the sets shall comply with the transportation requirements specified below.

3.14.1 Rough handling. The kits when installed on the sets shall withstand, without damage, rough handling, shocks and vibrations encountered during rail, road and aircraft transport as defined in paragraphs 6.2.1, 6.2.2 and 6.2.3 respectively.

3.14.2 Transportation Environment. The kits shall not be damaged by transportation at temperatures from -65°F to +160°F at any possible relative humidity within this range, and at altitudes up to 50,000 feet.

3.14.3 Lifting. The kits when installed on the sets shall not compromise the characteristic of the sets to lift level within 15 degrees.

3.15 Environmental requirements. The sets with the kits installed shall comply with the environmental requirements specified below.

3.15.1 Operational Environment. The sets with the kits installed shall start, operate and meet all requirements specified herein at any of the following conditions or combination of conditions:

a. At any ambient temperature from +107°F to -10°F, and at any possible relative humidity within this range.

b. With 4±1 inches of rain per hour impinging on the sets at angles from the vertical up to 45 degrees from vertical in all directions.

c. At any altitude up to and including 3000 feet above sea level at an ambient temperature of 103°F.

d. With base of the sets in planes from level to 15 degrees from level in any direction.

3.15.2 Storage environment. The kits shall not be damaged by storage at temperatures from +160°F to -65°F at any possible relative humidity within this range.

3.16 Electrical performance. The kits when installed on the sets shall not cause any change in the electrical performance of the sets as defined in MIL-STD-1332.

3.17 Materials, components and treatments. The kits shall comply with the material, component and treatment requirements specified below.

3.17.1 Deterioration and control. The kits shall be inherently corrosion and deterioration resistant or treated to provide protection against all forms of corrosion and deterioration. Material used shall not support combustion and shall be fungus resistant.

3.17.2 Recovered materials. Used, rebuilt or remanufactured materials, components and parts shall not be incorporated in the kits.

3.17.3 Insulating material. Insulating material shall be free from perceptible odors and noxious fumes, resistant to mildew, fire retardant, unaffected by battery electrolyte or petroleum derivatives, and capable of maintaining its shape, position and consistency under all conditions specified herein.

3.17.4 Identification of materials. The specific materials, finishes or treatments used for fabrication of the kits shall be identified and made available, upon request, to the Government.

3.17.5 Fasteners. All fasteners shall be securely installed with locking devices to prevent loosening. All fasteners and attaching hardware shall be military standard parts.

3.17.6 Hinges and latches. Hinges or hinge pins shall be peened at the ends, or other means shall be provided to prevent work out of the pins. Latches shall require manual, not spring actions, for closing. All parts of the latches having relative motion with each other shall be of corrosion-resistant metal. Access door latches shall be flush mounted, non-key locking, dead bolt, quarter turn from unlatched to fully-latched, and shall not require the use of tools for operation.

3.17.7 Access doors. Means for restraining the access doors in the fully-open position shall be provided. Windows, if used, shall be break resistant.

3.17.8 Treatment and painting. All external surfaces shall be treated and painted in accordance with MIL-T-704, Type F for ferrous metals and Type G for non-ferrous metals.

3.18 Identification plate. An identification plate shall be permanently affixed to each kit.

3.18.1 Information labels. Any doors that must be in the open position during set operation shall be so labeled in accordance with MIL-STD-1472. Any door that must be in the closed position during set operation shall be so labeled in accordance with MIL-STD-1472.

3.19 Workmanship. Workmanship shall be of a quality to assure delivery of kits that are free from defects resulting from defective materials or improper manufacturing or assembly practices. The kits shall be clean of harmful, extranious materials such as sand, dirt, sprues, scale or flux.

3.19.1 Metal fabrication. Metal used in fabrication shall be free from kinks and sharp bends. The straightening of materials shall be done by methods that will not cause injury to the material. Corners shall be square and true. All bends shall be made with controlled means to insure uniformity of size and shape.

3.19.2 Welding. Surfaces to be welded shall be free from foreign matter. Welding shall be performed in accordance with AWS D1.1 for steel and AWS D1.2 for aluminum. Welding procedures shall be in accordance with AWS B2.1. Welds shall be of sufficient size and shape to develop the full strength of the parts connected by the welds.

3.19.3 Bolted connections. Bolt holes shall be accurately formed and shall have all burrs removed. Washers or lock washers shall be provided where necessary. All fasteners shall be correctly torqued and shall have full thread engagement.

3.19.4 Riveted connections. Rivets shall fill the hole completely. The upset rivet heads shall be full, neatly made, concentric with the rivet holes, and in full contact with the surface of the member.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified, the contractor is responsible for the performance of all inspection requirements as specified herein. The contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein. The Government reserves the right to perform any of the inspections set forth in this Purchase Description where such inspections are deemed necessary to assure conformance to requirements. The Government reserves the right to reject any equipment for not meeting the requirements of this Purchase Description even though not performing a test directly related to the specific requirement.

4.2 Classification of inspections. Inspections shall be classified as follows:

a. First Article Inspection

b. Quality Conformance Inspection

4.3 Inspection models. The contractor shall furnish the inspection models described below.

4.3.1 First article models. The contractor shall furnish four first article kits for each kit size. The first article kits shall be installed on Government-furnished generator sets and power units (referred to herein as "set" or "sets").

4.3.2 Standard sample model. One standard sample model of each kit size shall be selected from the first article kits to remain in place at the contractor's facilities for comparison with all other kits.

4.4 First article inspection. The Contractor shall subject the first article kits to the First Article Inspection. The First Article Inspection shall include the examination of those items listed in Table I, and the tests specified in Table II. The First Article Inspection shall be conducted with the kits installed on the Government-furnished sets. The Government-furnished sets shall be assigned Set Numbers by the Government. Each set of each kit size shall be subjected to the Table I examination, and the tests designated by an "X" in the applicable Set Number column of Table II. The tests may be conducted in any order, except the audio noise test shall be the first and the last test conducted on each set.

PD 6115-0038
TABLE I. EXAMINATION

Major		Requirements paragraph
101.	Interchangeability not as specified.	3.6
102.	Physical dimensions not as specified.	3.7
103.	Weight not as specified.	3.8
104.	Human factors not as specified.	3.12
105.	Safety not as specified.	3.13
106.	Materials, components, and treatements not as speified.	3.17
107.	Materials are not resistant to corrosion and deterioration or treated to be resistant to corrosion and deterioration for the applicable storage and operating environments.	3.17.1
108.	Used, rebuilt, or remanufactured materials components and parts not as specified.	3.17.2
109.	Insulating materials not as specified.	3.17.3
110.	Contractor does not have documentation available for identification of material, material finishes, or treatment.	3.17.4
111.	Fasteners not as specified.	3.17.5
112.	Hinges and latches not as specified.	3.17.6
113.	Access doors not as specified.	3.17.7
114.	Treatment and painting not as specified.	3.17.8
115.	Identification plate not as specified.	3.18
116.	Workmanship not as specified.	3.19
117.	Metal fabrication not as specified.	3.19.1
118.	Welding not as specified.	3.19.2
119.	Bolted and riveted connections not as specified.	3.19.3 and 3.19.4

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TABLE II. Test Requirements.

SET NUMBER 1	2	3	4	TEST	TEST METHOD MIL-STD-705 or TEST PARA	REFERENCE PARA
X				Installation/Removal Demonstration	4.6.1	3.5
X				Maintainability/Accessibility Demonstration	4.6.2	3.9, 3.10
X	X	X	X	Audio Noise	4.6.13	3.4
X	X			Endurance	690.1, 4.6.3	3.3, 3.11
		X		Road	4.6.4	3.14.1
		X	X	Railroad Impact	740.5, 4.6.5	3.14.1
		X	X	Drop (Free-fall)	740.2, 4.6.6	3.14.1
		X	X	Lifting	4.6.7	3.14.3
		X	X	High Temperature	710.1, 4.6.8	3.15.1
		X	X	Starting and Operating, Moderate Cold	701.2, 4.6.9	3.15.1
		X	X	Rain	7.11.3	3.15.1
		X	X	Altitude Operation	720.1, 4.6.10	3.15.1
		X	X	Inclined Operation	660.1, 4.6.11	3.15.1
		X	X	Storage, Extreme Cold	731.1, 4.6.12	3.15.2
		X	X	Storage, Extreme Hot	732.1	3.15.2
		X	X	Humidity	711.1	3.15.2
X	X	X	X	Audio Noise	4.6.13	3.4

4.4.1 Inspection failure. Failure of a first article kit to meet any requirements specified herein shall be cause for rejection of the first article, until evidence has been provided by the contractor that corrective action has been taken to eliminate the deficiencies. Correction of such deficiencies, including any retest, shall be accomplished by the contractor at no cost to the Government.

4.4.2 First article report. A First Article Test Report shall be submitted to the Contracting Officer. The report shall conform to the data requirements of the contract.

4.5 Quality conformance inspection. The contractor shall subject every kit to the Quality Conformance Inspection. The Quality Conformance Inspection shall consist of the examination of those items listed in Table I. The Standard Sample Model shall serve as a basis of comparison in the performance of the Quality conformance inspection.

4.5.1 Inspection failure. Failure of any kit to meet any requirement specified herein shall be cause for rejection of that kit, until evidence has been provided by the contractor that corrective action has been taken to eliminate the deficiency. Correction of such deficiencies, including any re-inspection, shall be accomplished by the contractor at no cost to the Government.

4.6 Test Procedures. Tests shall be conducted in accordance with MIL-STD-705 test methods referenced in Table II, and as specified below. Test instruments shall be of the laboratory type, and shall have been calibrated within 30 days of the start of the testing. Instruments used in calibration shall have at least five times the accuracy of the instruments being calibrated. Direct-reading instruments shall have at least 0.5 percent accuracy, and shall be connected to indicate the most accurate portion of their range.

4.6.1 Installation/Removal Demonstration. Installation and removal of the kits shall be demonstrated by two personnel using the tools and test equipment specified herein. A record of the installation and removal shall be maintained. The record shall include the total time to install the kit including any set modifications, and the total time to remove the kit including restoration of the set to its original configuration. The record shall also describe any modifications to the set, and shall list all tools and equipment used during the installation and removal. If the kits are designed for separate operating and transport modes, the transition from one mode to the other mode shall be demonstrated. A record, as described above, shall be maintained for the mode transition demonstration.

4.6.2 Maintainability/Accessibility Demonstration. Access to the set fuel filler opening, batteries, oil filler opening, oil level dipstick, radiator, control panel, electrical output connections/receptables, ground stud, lifting attachments, and tie-down shall be demonstrated. The maintainability characteristics of the sets with kits installed shall be demonstrated by performance of the following maintenance actions:

a. Inspect for loose conections or leaks

b. Check and add lubricating oil

c. Drain fuel filters and water separator

d. Check and change air cleaner

e. Check and change battery

f. Check injection nozzles

g. Check valve tappet clearances

h. Check belts

i. Check and add coolant

4.6.3 Endurance test. The length of the endurance test shall be 300 hours per set. Test 608.1, Short Term Frequency and Voltage Regulation, Stability and Transient Response Test shall be performed at 100-hour intervals for rated load only. Fuels and lubricants shall be as specified in MIL-G-52884. The disassembly inspection contained in Test Method 690.1 is not required.

4.6.4 Road test. The road test shall consist of subjecting the set to the 400-mile road endurance cycle as defined in paragraph 6.2.2. A visual inspection of the set with the kit installed shall be conducted before and after subjecting the set to the road endurance cycle. A record of the test shall be maintained describing the results of the inspections, times, speeds and weather conditions experienced during the road endurance cycle, and any events, adjustments, maintenance or servicing required during the road endurance cycle.

4.6.5 Railroad impact test. The railroad impact test shall consist of two impacts each, in progressive steps, at 4, 6 and 8 miles per hour.

4.6.6 Drop test. The free-fall drop test shall consist of 3 flat drops from a height of 12 inches.

4.6.7 Lifting test. The level lift characteristic of the sets will be demonstrated with the kits installed. With the set lifted using the set lifting eyes, determine the angle that the set deviates from level.

4.6.8 High temperature test. The high temperature test shall be conducted at an ambient temperature of +107°F. Engine oil sump temperatures shall not exceed

4.6.9 Starting and operating at moderate cold test. The moderate cold starting and operating test shall be conducted at an ambient temperature of -10°F.

4.6.10 Altitude operation test. The altitude operation test shall be conducted at 5000 feet, +103°F.

4.6.11 Inclined operation test. The inclined operation test shall be conducted at an angle of 15 degrees from the horizontal.

4.6.12 Storage at extreme cold test. The extreme cold storage test shall be conducted in accordance with the specified test method 731.1 except at an ambient temperature of -65°F.

4.6.13 Audio noise test.1 Instrumentation and procedures for the audio noise test shall conform to MIL-STD-1474. Sound pressure levels in dB(A) shall be measured at eight points evenly spaced around the set with the set operating at no load and rated load. The microphone shall be located 7 meters from the set surface at a height of 1.2 meters.

5. PACKAGING

5.1 Packaging and marking. Packaging and marking shall be to commercial standard to insure safe delivery at destination in accordance with ASTM D 3957.

6. NOTES

6.1 The kits are intended to provide audio suppression for military standard generator sets and power units. It is intended that the kits be field installable with minimal modifications to existing sets. Initial use will be with 15kW and 30kW, military standard sets for Corps and Division Headquarter and Pershing II applications. The Government intends to subject the kits to extensive field evaluation, and an Initial Production Test.

6.2 Ordering data. Acquisition documents should specify the following:

a. Title, number, and date of this purchase description.

b. When a first article is required for inspection and approval and number of units required (see 3.2).

6.3 Definitions. Definitions of terms used herein are provided below.

6.3.1 Rail transport. Rail transport is transport when mounted on a flatcar and subjected to mean humping speeds up to and including 8 miles per hour under the test conditions specified in MIL-STD-705, method 740.5.

6.3.2 Road transport. Road transport is transport when mounted on a suitable Army trailer and subjected to the conditions encountered during the following road endurance cycle:

a. 250 miles of primary highway at speeds up to 55 mph.

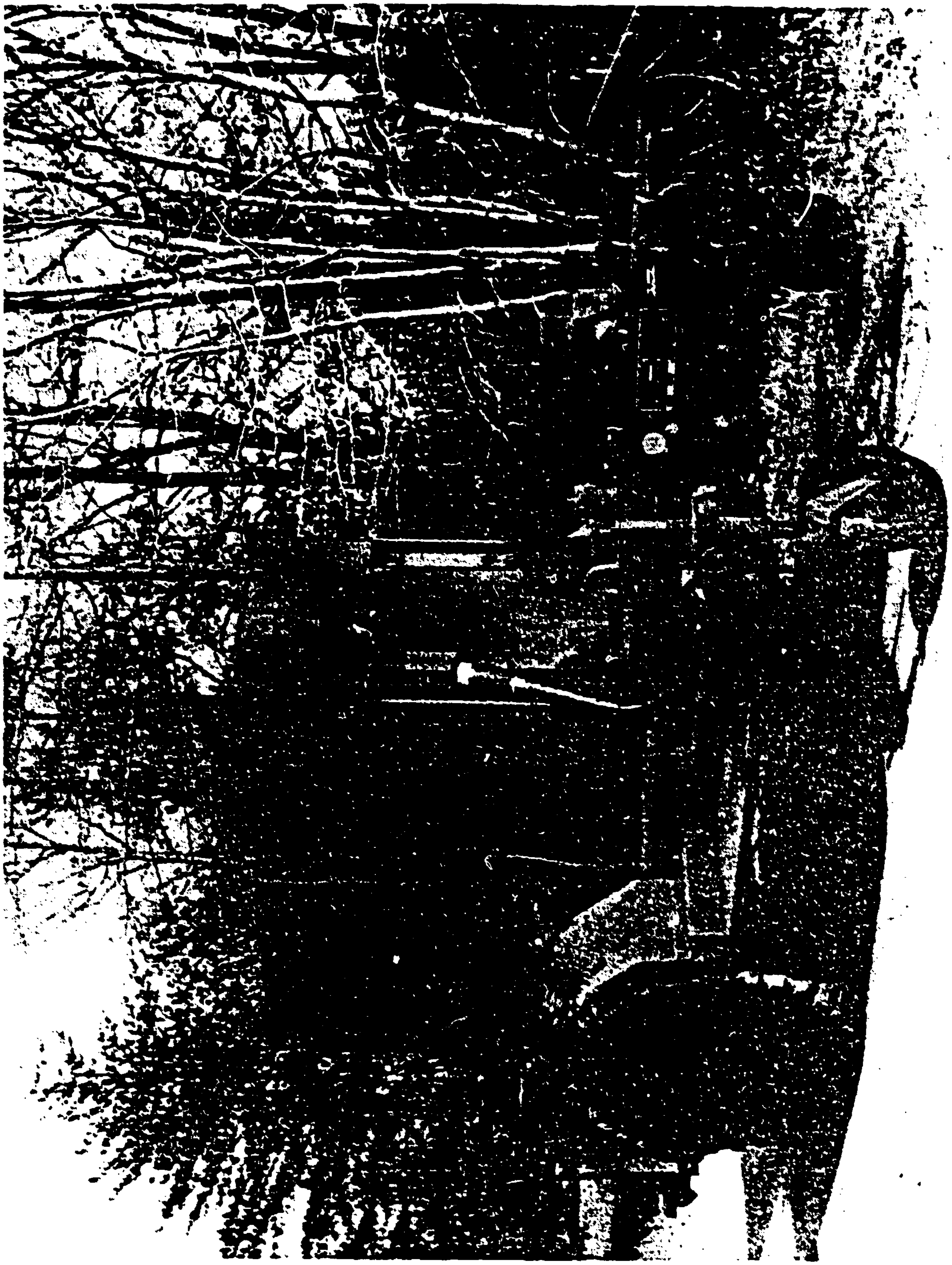
b. 100 miles of unpaved roads at speeds up to 30 mph.

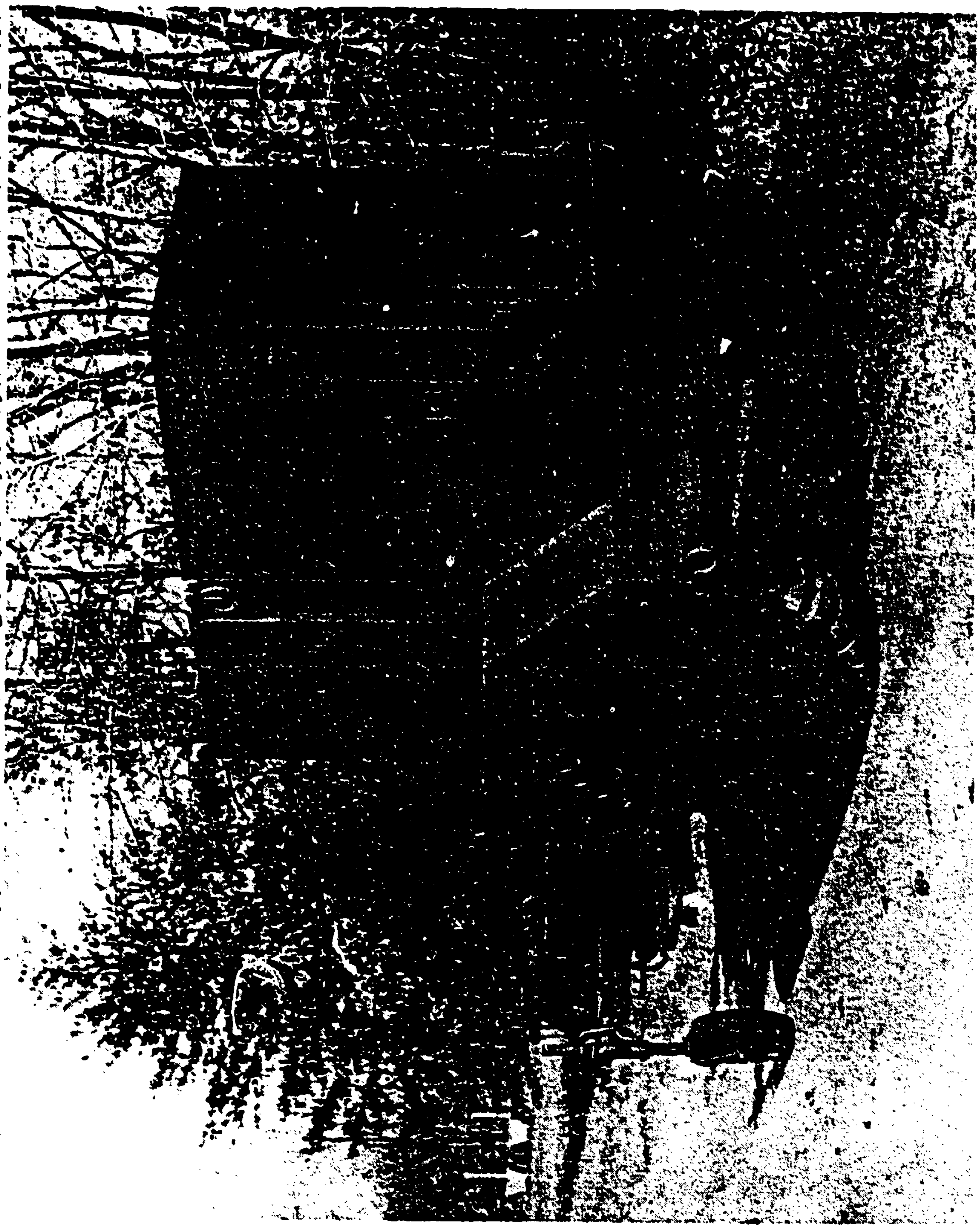
c. 50 miles of off-road terrain at speeds up to 20 mph.

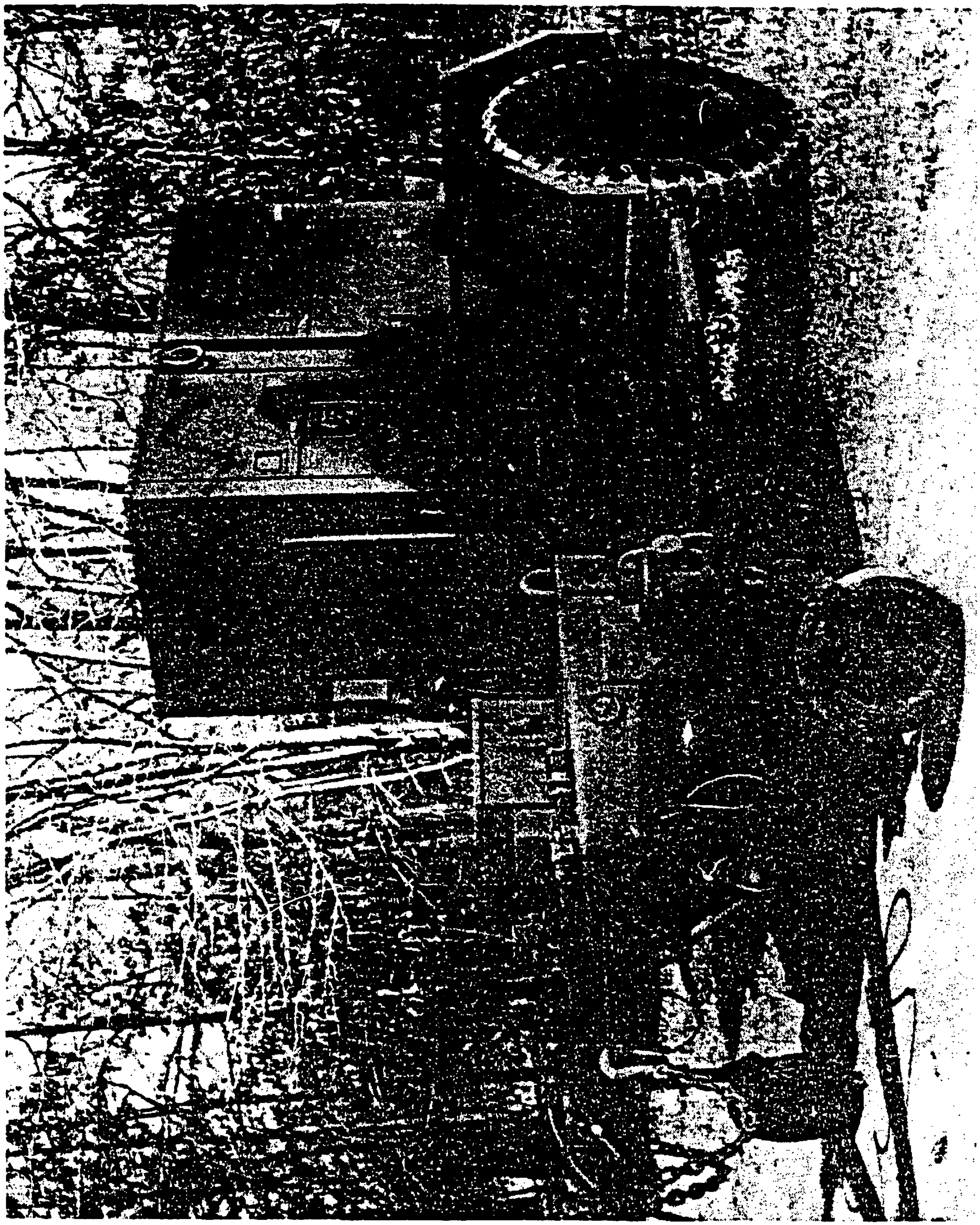
6.3.3 Aircraft transport. Aircraft transport is transport that includes the conditions encountered when subjected to a 12-inch free-fall drop under the test conditions specified in MIL-STD-705, Method 740.2.

6.4 First article. When a first article inspection is required, the items should be a preproduction model. The first article should consist of 4 units. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, tests, and approval of the first article test results and disposition of the first article.

6.5 Infrared signature. Infrared radiation from the sets with the kits installed should be minimized. It is desired that infrared emissions be reduced so that specific identity of the sets cannot be detected or cause detection of supported system functions or locations on an integrated battlefield.







Appendix H
MIL-STD Generator Set Towed Assemblage

Appendix H-MIL-STD Gen Set Towed Assemblage Weights

	5kw (60HZ)	10kw (60HZ)	10kw (400HZ)	15kw (60HZ)	30kw (60HZ)	60kw (60HZ)	100kw (60HZ)
1) Trailer Payload (lbs) Capacity	(1) 1965	(1) 1965	(1) 1965	5000	5000	5000	6800
2) Gen Set Weight (lbs)							
a) Per MIL-STD-633	930	1240	1325	2450	2850	4240	
b) actual (dry)(2)	966	1274	-	2711	-	4595	7500(4)
c) actual (filled)(2, 3)	1038	1406	-	2892	-	4960	-
3) Trailer Specification (MS)	53028 (3/4T)	53028 (3/4T)	53028 (3/4T)	53030 (2 1/2T)	53030 (2 1/2T)	53030 (2 1/2T)	53031 (3 1/2T)

Notes:
1 - Rates payload capacity for cross country travel
2 - Actual weight as reported by Belvoir
3 - Includes weight of all fluids (i.e., lube oil, coolant, diesel fuel)
4 - Per the Tech Manual

Appendix I
Electromagnetic Pulse (EMP) Analysis on the Electronic control System of the MEP-114A 30 kW DED Generator Set

U.S. Army Belvoir Research, Development
and Engineering Center
Fort Belvoir, VA 22060-5606

ELECTROMAGNETIC PULSE (EMP) ANALYSIS ON THE
ELECTRONIC CONTROL SYSTEM OF THE MEP-114A
30-kW DIESEL ENGINE DRIVEN GENERATOR SET

August 1985

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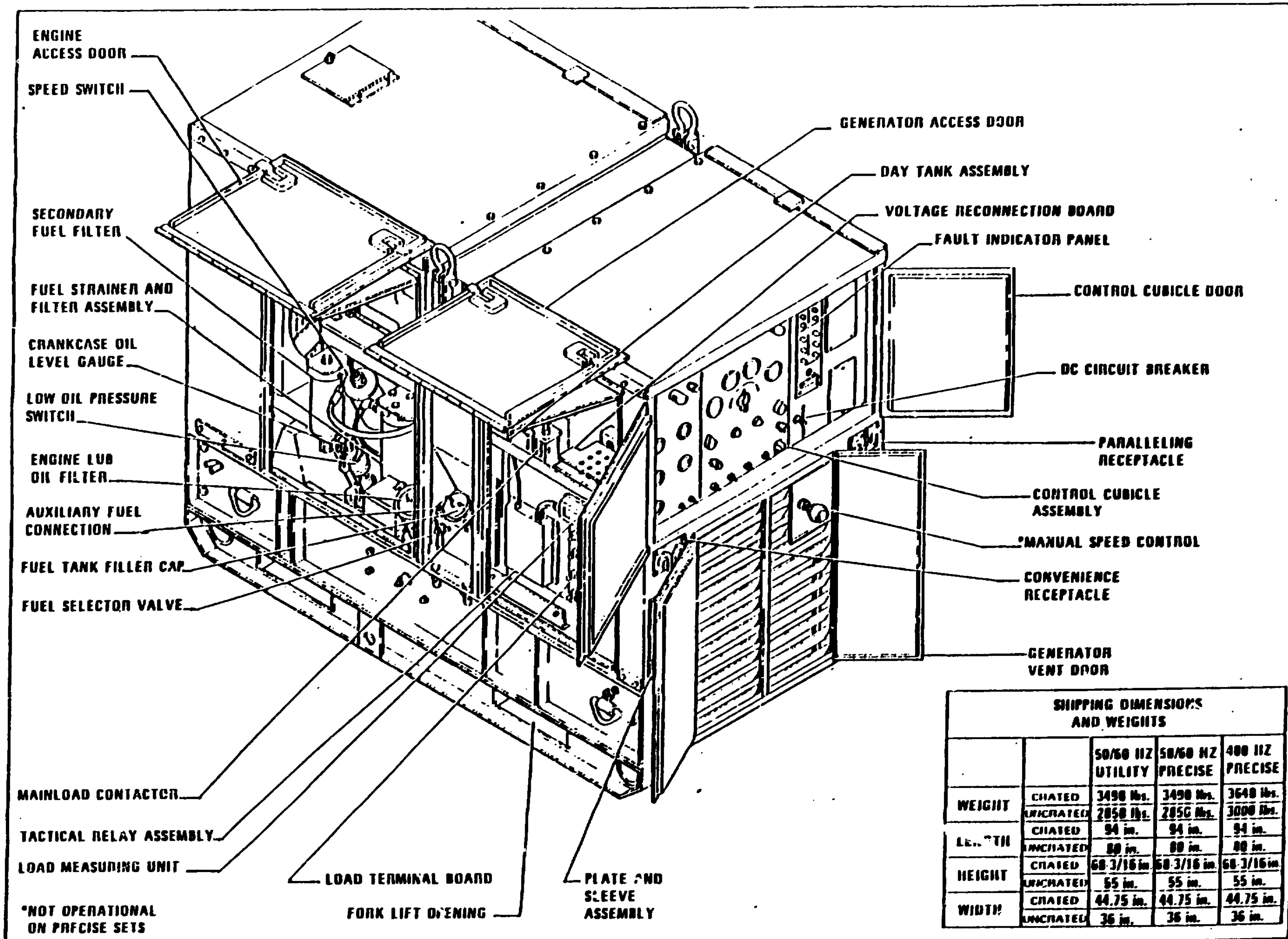
SECTION 1
INTRODUCTION TO ANALYSIS

This report presents the results of an Electromagnetic Pulse (EMP) analysis on the electronic control system of the DoD Model MEP-114A 30-kW, 400 Hz, Tactical precise Diesel Engine Driven Generator Set retrofitted with the American Bosch CU 673C-26 Electric Governor Control Unit. The analysis was performed for the U.S. Army Belvoir Research and Development Center under Contract No. DAAK70-84-C-0066. The remainder of Section 1 will present a description of the generator set and electric governor control unit, as well as detailing the methods used to perform the analyses.

1.1 DESCRIPTION OF GENERATOR SET

The MEP-114A generator set, shown in Figure 1.1-1, is a fully enclosed, self contained, skid mounted portable unit. It is equipped with controls, instruments and accessories necessary for operation as a single unit or in parallel with one or more units of the same class and mode. The generator has a rated load capacity (at 2000 rpm) of 30-kW at 400 Hz.

Power source of the generator set is a six cylinder, four cycle, fuel injected liquid cooled diesel engine. The engine electrical system contains a cranking motor, two 12 volt batteries in series, and a battery charging alternator with integral rectifier and voltage regulator. The engine is also equipped with a fuel filter and strainer assembly, a secondary fuel filter, a lubricating oil filter, and an air cleaner. Cooling water is circulated through the engine by a water pump. Safety devices automatically stop the engine during conditions of high coolant temperature, low oil pressure, no fuel, over-speed or over-voltage.



SHIPPING DIMENSIONS AND WEIGHTS

		50/60 HZ UTILITY	50/60 HZ PRECISE	400 HZ PRECISE
WEIGHT	CRATED	3490 lbs.	3490 lbs.	3640 lbs.
	UNCRATED	2850 lbs.	285G lbs.	3000 lbs.
LENGTH	CRATED	94 in.	94 in.	94 in.
	UNCRATED	80 in.	80 in.	80 in.
HEIGHT	CRATED	68-3/16 in.	68-3/16 in.	68-3/16 in.
	UNCRATED	55 in.	55 in.	55 in.
WIDTH	CRATED	44.75 in.	44.75 in.	44.75 in.
	UNCRATED	36 in.	36 in.	36 in.

Figure 1.1-1. Engine Generator Set, left-rear, three quarter view.

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The alternating current generators are single bearing, drip-proof synchronous, brushless, three phase, fan cooled generators. Rated voltages are maintained by excitation of the generator-exciter field by a static exciter mounted on the relay table. The cooling fan, located at the front of the generator, impels cooling air which enters the generator and passes over the windings. Safety devices are provided to protect the generator in the event of short circuit, overload, under-voltage, under-frequency, reverse power, and over-voltage.

The generator set control cubicle is located at the rear top of the generator set and contains controls and instruments for operating the engine and the generator. The control panel is grounded to protect the operator from electrical shock in the event of a short in the equipment. The generator section of the control panel contains meters for monitoring generator output, adjusting knobs for increasing and decreasing frequency and voltage, and a circuit breaker switch for interrupting all output from the generator set. Also included on the generator control panel are an operations switch and synchronizing lights for operating the set as a single unit or in parallel with other units. The engine section of the control panel contains switches for priming, starting, and stopping the engine and meters for monitoring set fuel level, oil pressure, and coolant temperature. Also included is an ammeter for the battery charging alternator.

The American Bosch CU 673 C-26 Electric Governor Control Unit replaces the Electro-Hydraulic Governing System previously utilized by the generator set. The unit contains all solid state electric circuits which sense speed from a magnetic pickup. A controlled current is provided to a proportional electric actuator for throttle control.

1.2 ANALYSIS GROUND RULES

Reference 1 documents an EMP analysis on the MEP 404B generator set, which was performed previously under this contract. The specified EMP stresses utilized in this present analysis are identical to those used in Reference 1. The specified EMP stresses, which were derived in Reference 2, are as follows:

EMP SPECIFIED STRESSES

Open Circuit Voltage At Any Connector Pin Internal to Generator Set	±90 V
Source Impedance	50 Ω
Pulse Shape	2 μs square
Magnetic Field Inside Generator Enclosure	4 A/m
Dominant Frequency For Internal Magnetic Field	4.2 MHz

The basic concept used to determine and verify equipment hardness is that of design margins. A design margin is the ratio of the actual predicted failure level and the specification level for the particular environment under consideration. The design margin for EMP for the MEP-114A generator set is defined in Reference 3. Design margins will be used to determine the Hardness Critical Item (HCI) category for all mission critical components. Hardness critical items are divided into four categories:

1. Category 1M (Low Design Margin). Items are in this category due to a low design margin. These items require lot sample screening in the nuclear environment(s) to which they are sensitive or special screens or electrical tests as nuclear hardness controls during production procurement.

2. Category 1H (Dedicated to Hardening). Items or circuits in this category are items that are dedicated to radiation hardening or that were installed to conteract the effects of a nuclear environment.

3. Category 2 (Mission Critical). This category pertains to items that are determined to be mission critical, but that have a large design margin and standard controls that are necessary to maintain the hardened design.

4. Uncategorized Items. This category is determined to be either of the following:

   a) Not mission critical (i.e., not required for the system to complete its objectives).
   b) Not sensitive to any of the nuclear weapons effects. The sensitivity threshold is a design margin greater than 40 dB for EMP.

For EMP damage the baseline analysis is performed with a 10 dB margin applied to the specified EMP stresses. In other words, it was assumed the environment contained 10 times the energy of the specified EMP stresses ($\sqrt{10}$ times the open circuit voltage and short circuit current). If the stresses at this level were within the normal specified operating limits of the device, it was rated Uncategorized. If not, the energy that could be delivered to the device for a worst case device impedance was calculated, and compared with the electrical damage threshold energy. If the threshold energy was at least a factor of 1000 (30 dB) greater than the worst case delivered energy, the device was Uncategorized. If the threshold was less than 1000 times, but greater than the worst case delivered energy, the device was placed in Category HCI-2. If the threshold was less than the worst case delivered energy, the stress on the device was recalculated for the original EMP Stress specification (i.e., without the 10 dB margin). If the stress was within the devices DC operating range, or if the threshold energy was above the worst case delivered energy, the device was assigned to Category HCI-1M; otherwise redesign is mandatory. Finally, the effect on the category assignment of using the best estimate of device impedance, rather than worst case, was evaluated.

It should be noted that this method assigns particular meanings to the requirement for 10 dB margin for HCI-2 and 40 dB margin for Uncategorized devices. The first 10 dB is assigned to the incident environment; the next 30 dB is assigned to the device damage threshold energy. This is believed to be a proper assignment. Assigning all the margin to the environment would not be a realistic assessment of the uncertainty in EMP coupling estimates. Moreover, since voltage limiting devices are frequently used as terminal protection devices (TPD's), the energy actually delivered to a downstream device would not be changed significantly by the additional input stress. Moreover, the principal reason for imposing the extra 30 dB margin on EMP for Uncategorized devices is the fact that device damage thresholds can vary greatly, even within a single device code.

The above analysis rules are summarized in Table 1.2-1.

Table 1.2-1. HCI Categories.

Relationship between calculated damage energy and damage threshold energy	HCI Category	Design Margin Calculation
W_{d2} not calculated due to stresses on the device not exceeding operating range	Uncategorized	—
W_{d2} not calculated because device is a voltage limiter operating within its range	1H	—
$W_{d1} > W_t$	Redesign Required	$20 \log_{10} S_t/S_s$
$W_{d1} < W_t < W_{d2}$	1M	$20 \log_{10} S_t/S_s$
$W_t < W_{d2}$ and stresses without 10 dB margin do not exceed operating range of device	1M	$20 \log_{10} S_t/S_s$
$W_{d2} < W_t < 10^3 W_{d2}$	2	$(10 \log_{10} W_t/W_{d2})$ + 10 dB
$10^3 W_{d2} < W_t$	Uncategorized	—

W_{d1} = energy deposited in device at specification level

W_{d2} = energy deposited in device at 10 dB margin above specification level

W_t = device damage threshold energy

S_t = applied stress at device damage threshold (e.g., open circuit voltage)

S_s = specification stress level

1.3 ANALYSIS PROCEDURE

The effects of EMP induced stresses appearing at the generator connector pins and being conducted to electronic circuits wired to these connector pins will be analyzed first. Then the stresses caused by fields penetrating the generator enclosure will be evaluated.

1.3.1 EMP Induced Connector Pin Stress Analysis Procedure

The overall procedure used to analyze EMP Induced Connector Pin Stresses is outlined by the flow chart shown in Figure 1.3.1-1. The remainder of this paragraph describes the contents of each box in the flow chart in greater detail.

Does Unit have Multiple Ground?

In some cases, a unit may have separate signal ground, chassis ground, and/or power ground.

Determine Max Possible Voltage Between Grounds

On units with separate chassis and signal grounds, interface stresses can occur between them. If they are tied together outside the unit, interface stress must be applied. If they are tied together within the unit the maximum short circuit current may appear on the two ground leads within the unit and inductively induce voltages on other signal leads. The maximum difference in potential between the leads is determined by this short-circuit current and self-inductance.

Internal Power Supply

If a unit has an internal power supply it should be examined to see if any pin stresses feed directly to the output of the supply. Since the power supply is connected to devices on other boards of the unit the stresses appearing at the device's power input pins will have to be taken into account when the worst case stresses are determined.

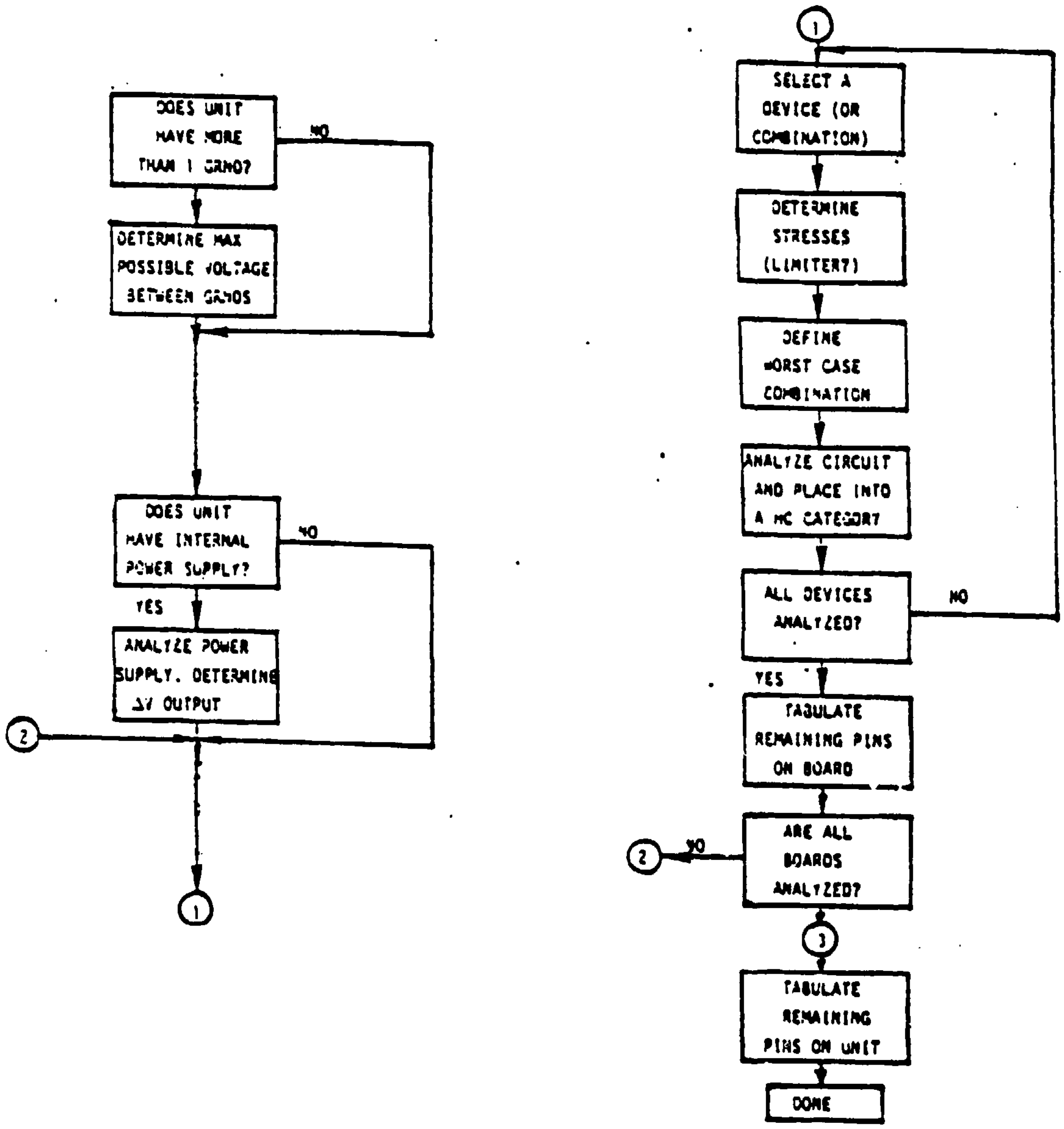

Figure 1.3.1-1. Induced connector pin stress analysis.

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Select a Device

A device (or combination of devices) connected to one or more generator connector pins is selected.

Determine Stresses

The worst case stresses that can appear at the device are determined from EMP stress specifications and TPD's.

Define Worst Case Combinations of Stresses

All stresses that can be applied to a device must be considered in combination. Usually the worst case combination involve opposite polarities on different device pins.

Analyze Circuit and Place in Appropriate HCI Category

In general, the following procedure is used:

1. Determine the maximum voltage at the device if it's non-conducting (V_{do}) and the maximum current through the device if it's in its most conducting state (I_{ds}).

2. If V_{do} and I_{ds} are within the operating envelope of the device it is Uncategorized, and no further analysis is required. The exception to this rule is if the device happens to be a voltage limiting device (e.g., Transorb) operating within its envelope, in which case it becomes HCI-1H. If subsequent analysis shows that limiting is not needed on that line it, too, becomes Uncategorized.

3. If V_{do} or I_{ds} are not within the operating range of the device, calculate the maximum energy that could be transferred to the device, W_{d2}. In performing this calculation assume a worst-case impedance for the device in its breakdown state.

4. Calculate Threshold Energy for Damage

As described in Reference 4 the threshold energy for damage is calculated from:

$$W_t = K\, t^{1/2}$$

where: W_t = threshold energy (J)
t = pulse duration (s)
K = damage coefficient

K is determined in following manner:

1. If there are recent reliable test data
   a) with good statistics, so that a standard deviation, σ, can be estimated, assuming a log normal distribution $K = K_{AV} \times e^{-3\sigma}$
   b) otherwise $K = K_{AV}/5$

2. If K_C is calculated from specification sheets, $K = K_C/50$

Calculation of K from the device specification was frequently performed according to the E.C.M.T. model (Ref. 5). It uses the room temperature breakdown voltage and maximum current to calculate the breakdown voltage at the critical failure temperature, the bulk resistance, the space charge resistance and the failure current. Traditional damage constants can be calculated from these values using the equation

$$K_c = \left[V_{BDC} \left(\frac{I_{F_{100\ ns}}}{4.5} \right) + \frac{I_{F_{100\ ns}}^2}{20} \left(R_{SC} + R_{BLK} \right) \right] (1.41 \times 10^{-3})$$

for the 2 μs specified EMP threat, where

$I_{F_{100\ ns}} = J_F \cdot \text{Area} = [8.26 \times 10^{-11} (N_D)^{0.88}]\ \text{Area}$
$V_{BDC} = 4.07 \times 10^{12} (N_D)^{-0.67}$
$R_{BLK} = \rho_{BLK}/\text{Area} = [3.61 \times 10^{10} (N_D)^{-0.81}]/\text{Area}$
$R_{SC} = \rho_{SC}/\text{Area} = [2.48 \times 10^{25} (N_D)^{-1.8}]/\text{Area}$
$N_D = 4.49 \times 10^{18} (V_{BD})^{-1.5}$
Area = Method depends on available data (Ref. 5)

5. Assign a HCI Category

Table 1.3.1-1 represents a summary of the rules used to establish the HCI. The reference labels in the last column will be used in Section 2.2.1.1 to designate the rationale for each category assignment.

Table 1.3.1-1. HCI Categories.

Relationship between calculated damage energy and damage threshold energy	HCI Category	Criterion Reference Label
W_{d2} not calculated due to stresses on the device not exceeding operating range	Uncategorized	A
W_{d2} not calculated because device is a voltage limiter operating within its range	1H	B
W_{d2} not calculated because device is an <u>unneeded</u> limiter	Uncategorized	C
$W_{d1} > W_t$	Redesign Required	D
$W_{d1} < W_t < W_{d2}$	1M	E1
Stresses without 10 dB margin does not exceed operating range of device	1M	E2
$W_{d2} < W_t < 10^3 W_{d2}$	2	F
$10^3 W_{d2} < W_t$	Uncategorized	G

W_{d2} = energy deposited at 10 dB margin R155
W_{d1} = energy deposited at specification level
W_t = device damage threshold energy

1.3.2 Field Penetration and Buried Circuit Analysis

The stresses on circuits with wires connected to connector pins are usually dominated by the specified pin stresses. For circuits not connected to such wires (i.e., buried circuits), the stresses are determined by fields inside the enclosure interacting with the wiring connected to those circuits. These fields are usually produced inside the enclosure by:

1. Diffusion of the incident field through the conducting wall of the enclosure (this contribution is almost always negligible).

2. Penetration of the incident field (usually the magnetic field) through imperfections in the enclosure, such as the cracks between the cover and the enclosure between fasteners, or an insulating layer on a joint between oxidized metal plates.

3. Apertures placed in the enclosure for various reasons, such as heat removal, optical paths, and adjustment screws, etc.

4. Currents and voltages on wires penetrating into the enclosure from outside. These are the same excitations responsible for the connector pin stresses, but in this case the concern is with the fields they produce inside the enclosure rather than the stresses they conduct to circuits.

The electric and magnetic fields produced inside the enclosure by the worst case additive sum of the above excitations can couple to buried circuits by electric and magnetic coupling. Magnetic coupling is almost always dominant, although it is possible for special circumstances to make electric coupling important. Since the buried circuits that are candidates for disturbance by the internal fields usually have a resistive impedance large compared to their inductive impedance at the important coupling frequencies, the voltage induced into the buried circuits is almost always proportional to the rate of change of the internal magnetic field.

Thus, the analysis for buried circuit excitation is performed in two steps:

1. An upper limit on the magnetic and electric fields that could be produced by each of the four contributors is estimated. Since the first three are usually small compared to the fourth, they can be estimated crudely (using upper bounds for conservatism).

2. An upper limit to the buried circuit coupling is estimated from the geometry of the PCB's and wiring.

If the stresses deduced by combining these limits are within acceptable limits, no further analysis is required. If not, additional details of the coupling geometry between the dominant sources of the internal fields (usually interface wires) and critical buried circuits can be invoked to produce a less conservative, and hopefully more favorable, result.

1.3.3 Electrical Stress Damage Data

The limits on normal device operating parameters were deduced from the device commercial specification sheets.

The data on damage coefficients of devices were acquired predominantly from two sources, the SCORCH database program at AFWL Direct Drive Lab and the Electronic Component Modeling and Testing Program report (Ref. 5).

Preference was given to experimental data over calculated values. The SCORCH data base was set up to search for experimental data first. If no data was found on a device then the search would continue for data from the most accurate model. If no data was found then it would use the next most accurate model and so on.

Where experimental data were not available, the E.C.M.T. model was used almost exclusively to establish the damage energy threshold. The energy deposition calculations assumed a worst-case device impedance (i.e., one matched to the drive circuit impedance). Where the device could not be Uncategorized, the deposited energy was recalculated using the E.C.M.T. model impedance. In no case did this change the device category.

SECTION 2
ANALYSIS

This section will present the EMP response analysis for the generator set.

Section 2.1 will present the means whereby the EMP-induced stresses are determined. There are two types of excitations:

1. Wires routed to outside connectors.

2. Surface currents on the outside of the generator enclosure.

The first is the dominant driver for both the circuits wired to connector pins and buried circuits.

Section 2.2 presents the EMP damage analysis for interface circuits wired to connector pin.

2.1 EMP STRESSES

The specified EMP stresses applicable to the generator set were listed previously in Section 1.2. However, the baseline EMP damage analysis is performed with a 10 dB margin applied to the specified EMP stresses. The values for EMP stresses obtained by applying a 10 dB margin to the specified EMP stresses are presented in Table 2.1-1. The short circuit currents are defined as the ratio of the maximum voltage stress divided by the minimum source impedance.

Table 2.1-1. +10 db margin applied to specified EMP stress.

	Pulse Shape	Source Impedance (Ohms)	Open Circuit Voltage (V_{oc}) (Volts)	Short Circuit Current (I_{sc}) (Amps)
Connector Pin Internal to Generator Set	2 μs square	50	±284	±5.7

2.2 EMP ANALYSIS

2.2.1 Definitions and Generic Analysis

During the course of the analyses of individual circuits, there are many repetitions of similar circuits. Also there are a variety of criteria used to place devices in various categories. Rather than repeat a similar analysis many times, and rather than repeating the criterion description, it is more efficient to define various general criteria and to perform some generic circuit analyses. These will then be referred to when they apply to specific circuits.

2.2.1.1 Category Assignment Criteria

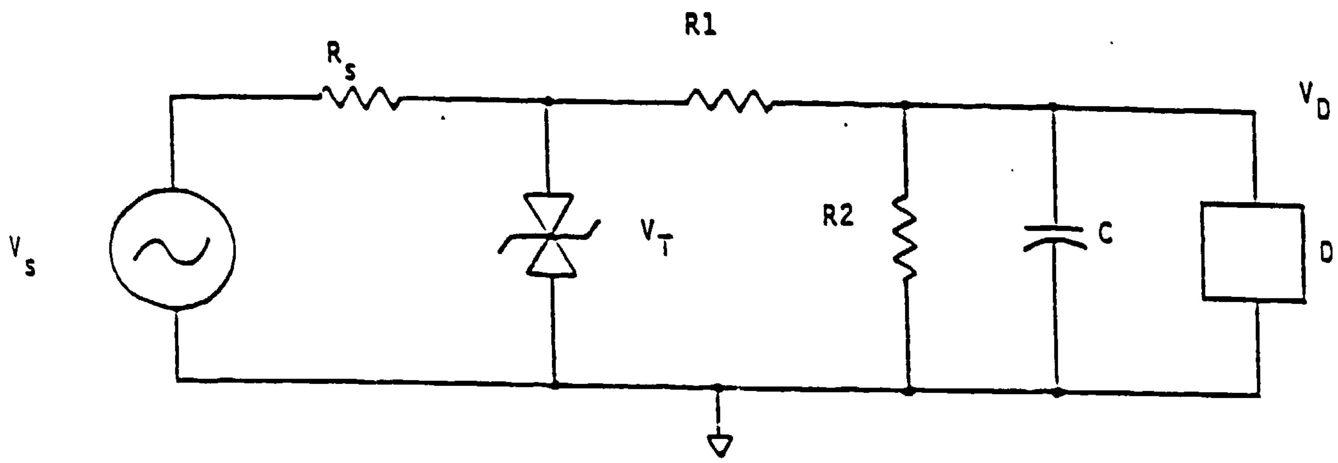
As discussed in Section 1.1 and summarized in Table 1.3.1-1, the EMP interface analysis proceeds along a standard path and can be terminated at various points with a conclusion. The basic route uses the 10 dB margin pin stresses to determine first whether the device under analysis remains within its normal specification limits. If it does, the analysis terminates by finding the device Uncategorized by Criterion A, unless the device is a needed TPD, in which case it is in Category HCI-1H by Criterion B. If it does not, the analysis proceeds to calculate the worst case energy that could be deposited in the device. If this energy is at least 30 dB below the damage threshold, the device is Uncategorized according to Criterion G. If the worst case energy is below the threshold, but not by 30 dB, then the device is in Category HCI-2 by Criterion F. If the worst case energy is above the damage threshold, another calculation is required. It starts with the pin stresses as specified without the 10 dB margin.If the device is now within its normal operating specifications, the device is in Category HCI-1M by Criterion E2. If it falls outside its normal specifications, but the worst case energy is below the damage threshold energy,it is assigned to Category HCI-1M by Criterion E1. If none of these conditions is satisfied, redesign is required by Criterion D. These criteria are summarized in Table 1.3.1-1.

2.2.1.2 Generic Circuit Analysis

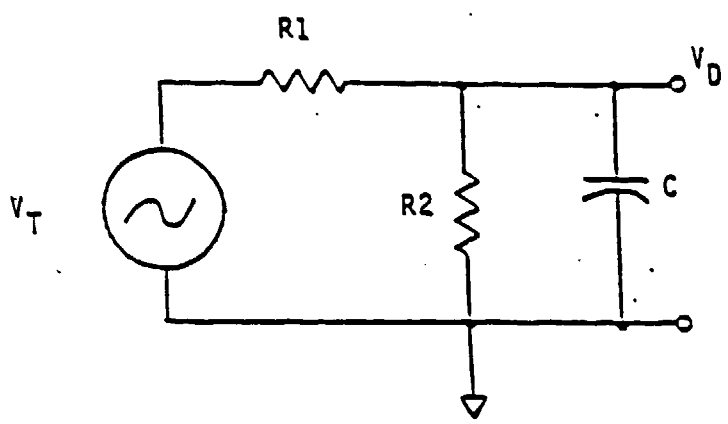
An example of a generic circuit analysis that is used frequently in the following specific circuit analyses will now be presented.

Figure 2.2.1-1a presents a circuit of general applicability, called Configuration #1. The excitation is represented by a voltage source V_s with an internal impedance, R_s. The limiter will clamp the voltage at the circuit input node to V_T, if it should rise that far. The remaining parts - R1, R2, and C - represent a typical input circuit leading to a semiconductor device, D.

The first step in the analysis is to determine whether the voltage applied to the device by the specified excitation, V_S, exceeds its normal operating specifications. For this calculation a safe bound is deduced by assuming the impedance of the device is large compared to R_2. Similarly, the voltage at the device will reach a maximum if the voltage at the circuit input is at its maximum possible value, V_T. Thus, for purpose of establishing an upper limit on the voltage at the device, the circuit can be simplified to the one shown in Figure 2.2.1-1b. The maximum voltage occurs at the end of the longest excitation pulse, t_p, and is given by:



a. Configuration #1.



b. Simplified version.

Figure 2.2.1-1. Input circuit.

R171

$$V_T \quad \frac{R_2}{R_1 + R_2}\left(1 - e^{-t_p/R_pC}\right)$$

where $R_p = R_1R_2/(R_1+R_2)$ is the parallel resistance of R_1 and R_2.

If this voltage is within the device operating specifications, the only other point that needs to be checked is whether the current through the device in its most conducting state is within its operating specifications. If the device can be highly conducting (e.g., if it's a diode, or the base-emitter junction of a bipolar transistor) the maximum current is determined by V_T/R_1. If it is not significantly conducting in normal operation (e.g., at the inputs to an OpAmp), this criterion does not apply.

Consider now the case where the transient voltage exceeds the normal operating specifications, and there is the possibility of an abnormal breakdown condition. The next step in the analysis requires that the energy deposited in the device be calculated. Since the device impedance in its abnormal state is not well known, the safest assumption is to calculate the energy transfer maximized with respect to device impedance. If the capacitor can be neglected (this assumption also increases the energy transfer), the worst case device impedance is equal to the parallel resistance of R_1 and R_2 (i.e., load impedance matched to source impedance). For this case the energy transferred to the device during a pulse of length t_p is

$$W_d = \frac{V_T^2}{4}\ \frac{R_2 t_p}{R_1(R_1 + R_2)}$$

This formula blows up as R_1 becomes small, because it assumes that the limiter continues to hold the voltage at V_T, even if the circuit impedance goes to zero. That assumption is invalid. If $V_T < V_s/2$, the maximum energy that can be delivered to the device in the limit $R_1 \to 0$ occurs when the voltage across it is just V_T and the current is the maximum that can be passed through R_s when the voltage across it is $V_s - V_T$. Thus

$$W_d = \frac{V_T\,(V_s - V_T)}{R_s}\; t_p$$

If $V_T \geq V_S/2$, the maximum energy is limited to

$$W_d = \frac{V_s^2}{4\,R_S}\quad t_p$$

which corresponds to half of the source open circuit voltage applied to the device.

The smaller of these two estimates is the correct one. When R_1 is nonzero, it is almost always the first calculation that limits the device energy. For most applications the capacitor, C, can be ignored in the energy calculation, although it can be important in limiting the voltage at the device node to within its operating specifications.

In this sam circuit configuration, it's usually necessary to establish that the protection device is operating within its rating. A reasonable upper bound on the current through the device is just the short-circuit current available from the source: V_S/R_S.

This example illustrates an important point about circuit analysis for EMP interface effects. While more accurate analyses can be performed (e.g., by modeling the circuit and the device nonlinear characteristics with a computerized circuit analysis program), the conclusions are rarely different when reasonable, simple upper bound methods are used. In addition, the simple analyses tend to be less dependent on specific assumptions, (e.g., the device impedance under overvoltage excitation), or at least make evident when such assumptions affect the conclusions.

2.2.2 Electric Governor Control Unit Analysis

Figure 2.2.2-1 presents the schematic diagram of the American Bosch CU 673C-26 Electric Governor Control Unit. The connector terminals of the unit are shown vertically on the left hand side of the figure.

The following analyses address each of the semiconductor devices that could be affected by the pin stresses detailed previously in Sections 1.2 and 2.1.

2.2.2.1 Device D_1 (MR 820)

Pins and Stresses: Pins B and D
(±284 V, ±5.7 A)

Worst Case Combination: -284 V Pin B
+284 V Pin D

Circuit: Configuration #1 $R_1 = C = 0$
$R_2 = \infty$

Analysis: The Worst Case Combination of stresses will apply a Peak Inverse Voltage of 568 V across the MR820 diode, which is far in excess of its absolute maximum rated value of 75 V.

Energy: $W_{d2} = 3.226$ mj
$W_t = 0.424$ mj (Source: ECMT)
For 90 V specification (without 10 dB margin)
$W_{d1} = 81$ μJ which is less than W_t

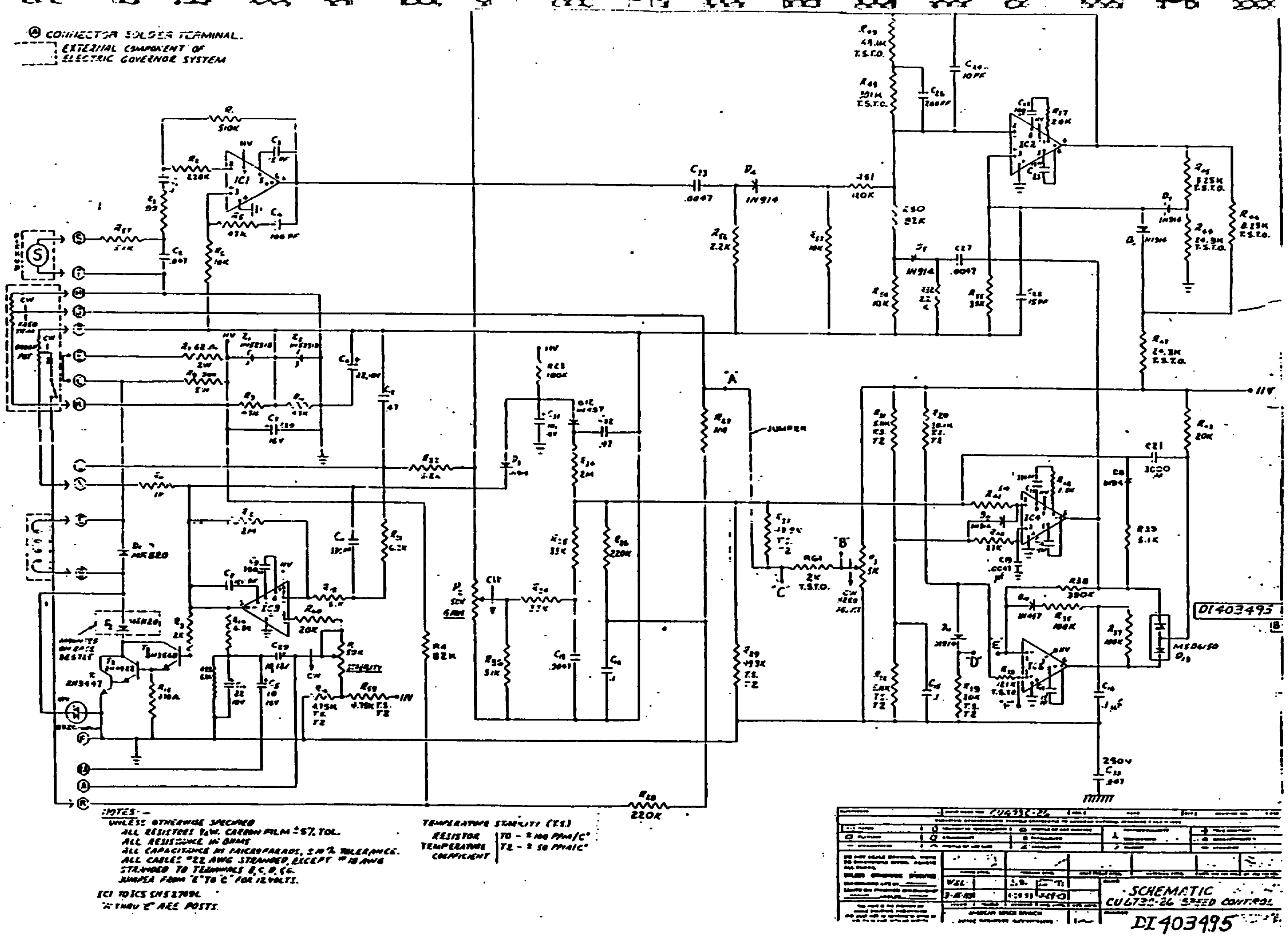


Figure 2.2.2-1. Schematic of American Bosch Electric Governor Control Unit.

R171

However, under worst case conditions, this device will be subjected to a peak inverse voltage of 180 V which exceeds its specified absolute maximum value of 75 V.

Conclusion: HCI-1M by Criterion E_1

2.2.2.2 Device D_2 (MR1120)

Pins and Stresses: Pins B and F
(±284 V, ±5.7 A)

Worst Case Combination: -284 V Pin B
+284 V Pin F

Circuit: Configuration #1 $R_1 = C = 0$
$R_2 = \infty$

Analysis: The Worst Case Combination of stresses would apply a Peak Inverse Voltage of 568 V across the MR 1120 if the 47 V Metal Oxide Varistor (MOV) was not installed between Pins B and F. The MOV will limit the peak voltage between Pins B and F to ±93 V.
Since the MR 1120 is specified as being able to tolerate non-repetitive peak reverse voltages of 100 V and peak repetitive forward current of 75 amperes, both V_{do} and I_{ds} are within the specified operating range of the device.

Conclusion: Uncategorized by Criterion A.

2.2.2.3 Device D_3 (1N914)

Pins and Stresses: Pins F and N
(±284 V, ±5.7 A)

Worst Case Combinations: +284 V Pin N
(W.C.C.) -284 V Pin F

Circuit: Configuration #1 $R_1 = 1$ K
$C = 0$
$R_2 = \infty$

Analysis: The Worst Case Combination of Stresses could apply a Peak Inverse Voltage of 568 V across the 1N914 which is far in excess of its absolute maximum rated value of 75 V.

Energy: $W_{d2} = 153.6$ μj
$W_t = 21.1$ μj (Source: Reference 5)
For 90 V specification (without 10 dB margin)
$W_{d1} = 15.4$ μj

Conclusion: HCI-1M by Criterion E_1

2.2.2.4 Device T_1 (2N3447)

Pins and Stresses: Pins B, F, and N
(±284 V, ±5.7 A)

Worst Case Combination: ±284 V Pin B
(W.C.C.) +284 V Pin F
-284 V Pin N

Circuit: Configuration #1 $R_1 = C = 0$, $R_2 = \infty$ } For stresses appearing between Pins B and F

Configuration #1 $R_1 = 3$ K, $C = 0$, $R_2 = 470\ \Omega$ } For stresses appearing between Pins F and N

Analysis: The Worst Case Combination of stresses between Pins B and F will apply a maximum collector to emitter voltage of 93 V across Device T_1. (The 47 V MOV limits the collector to emitter stress across Device T_1.) The 2N3447 has an absolute maximum Collector-Emitter voltage rating of 60 volts which will be exceeded. Additionally, the stresses which can appear between Pin N and either Pins B or F can reach -568 V which would cause the Emitter-Base and/or Collector-Base voltage ratings of the 2N3447 to be exceeded.

Energy: $W_{d2} = 7.28\ \mu j$ (for stresses between Pins F and N)
$W_t = 36\ \mu j$ (Source: ECMT)

Conclusion: HCI-2 by Criterion F

2.2.2.5 Device T_2 (2N4922)

Pins and Stresses: Pins B, F, and N
(±284 V, ±5.7 A)

Worst Case Combination: ±284 V Pin B
(W.C.C.) +284 V Pin F
-284 V Pin N

Circuit: Configuration #1 $R_1 = C = 0$, $R_2 = \infty$ } For stresses appearing between Pins B and F

Configuration #1 $R_1 = 3$ K, $C = 0$, $R_2 = 470\ \Omega$ } For stresses appearing between Pins F and N

Analysis: The Worst Case Combination of stresses between Pins B and F will apply a maximum collector to emitter voltage of 93 V across Device T_2 (2N4922) (The 47 V MOV limits the collector to emitter stresses across Device T_2.) The 2N4922 has an absolute maximum Collector-Emitter voltage rating of 60 V which will be exceeded. Additionally, the stresses which can appear between Pin N and either pins B or F can reach -568 V which would cause the Emitter-Base and/or Collector-Base voltage rating of the 2N4922 to be exceeded.

Energy: $W_{d2} = 7.28\ \mu j$ (for stresses between Pins F and N)
$W_t = 9.6\ \mu j$ (Source ECMT)

Conclusion: HCI-2 by Criterion F

2.2.2.6 Device T_3 (2N3568)

Pins and Stresses: Pins B, F, and N
(±284 V, ±5.7 A)

Worst Case Combination: ±284 V Pin B
+284 V Pin F
-284 V Pin N

Circuit: Configuration #1 $R_1 = 470\ \Omega$, $C = 0$, $R_2 = \infty$ — For stresses appearing between Pins B and F

Configuration #1 $R_1 = 3.47$ K, $C = 0$, $R_2 = \infty$ — For stresses appearing between Pins F and N

Analysis: The Worst Case Combination of stresses between Pins B and F will apply a maximum collector to emitter voltage of 93 V across Device T_3. (The 47 V MOV limits the collector to emitter stress seen by Device T_3.) The 2N3568 has an absolute maximum collector to emitter voltage rating of 60 V which will be exceeded. Additionally, the stresses which can appear between Pin N and either Pins F or B can reach -568 V which would cause the Emitter-Base and/or Collector-Base voltage ratings of the 2N3568 to be exceeded.

Energy: W_{d2} = 45.8 μj (For stresses between Pins F and N)
W_t = 4.4 μj (Source ECMT)
For the 90 V specification (without 10 dB margin)
W_{d1} = 4.6 μj which is still above W_t

Conclusion: Device T_3 requires redesign by Criterion D

2.2.2.7 Device Z_1 (1N5231B)

Pins and Stresses: Pins K and P
(±284 V, ±5.7 A)

Worst Case Combination: +284 V Pin K
(W.C.C.) -284 V Pin P

Circuit: Configuration #1 $R_1 = C = 0$
$R_2 = 4.7$ K

Analysis: The Worst Case Combination of stresses will cause the absolute maximum peak nonrepetitive reverse surge power rating of Device Z_1 to be exceeded.

Energy: $W_{d2} = 3.226$ mj
$W_t = 130$ μj
For 90 V specification (without 10 dB margin)
$W_{d1} = 324$ μj

Conclusion: Device Z_1 requires redesign by Criterion D

2.2.2.8 Device Z_2 (1N5231B)

Pins and Stresses: Pins P, T, and H
(±284 V, ±5.7 A)

Worst Case Combination: +284 V Pin P
-284 V Pin H or Pin T

Circuit: Configuration #1 $R_1 = C = 0$
$R_2 = 4.7$ K

Analysis: Same as Device Z_1
See Section 2.2.2.7

Conclusion: Device Z_2 requires redesign by Criterion D

2.2.2.9 Device IC_1 (SN52709L)

Pins and Stresses: Pins H or T, P, and S
(±284 V, ±5.7 A)

Worst Case Combination: ±284 V at Pin P
∓284 V at Pins H or T and S

Circuit: See Figure 2.2.2-2

Analysis: The SN52709 (IC1) is powered by a $V_{CC}+$ of +11 V and a $V_{CC}-$ of 0V. The absolute maximum voltage rating for either input of the SN52709L is ±10 V with respect to the zero reference level of the supply voltages where the zero reference level is the midpoint between $V_{CC}+$ and $V_{CC}-$ (i.e., +5.5 V). Since the magnitude of the input voltage must never exceed the magnitude of the supply voltage or 10 volts, whichever is less, it can be concluded that either input will be damaged if the input voltage goes more positive than +10 V or more negative than -4.5 V. The worst case combination of stresses will cause the absolute maximum input voltage ratings of the SN52709L to be exceeded.

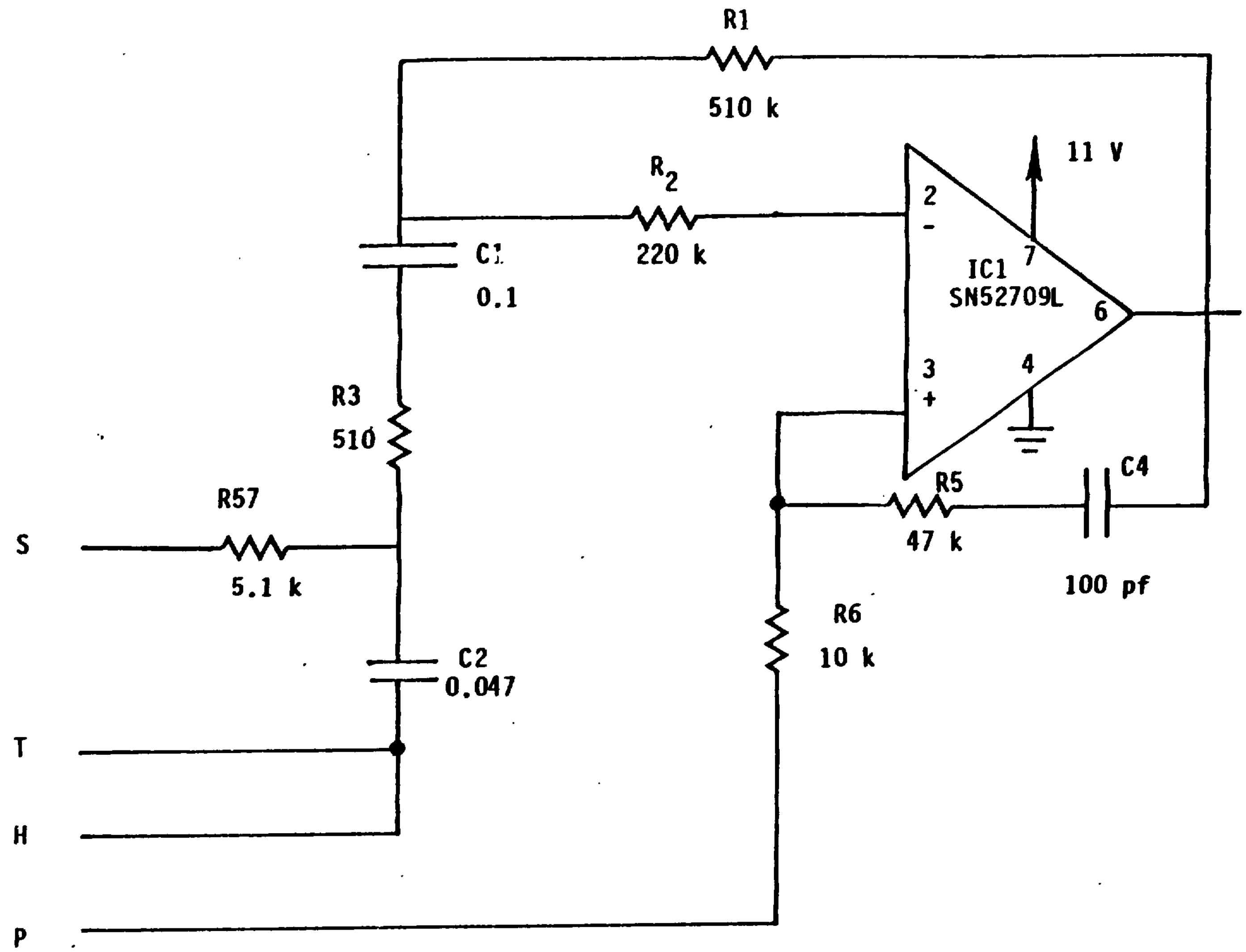


Figure 2.2.2-2. Device IC1 and associated circuitry.

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Energy: W_{d2} = 16.1 μj

W_t = 3.1 μj (Source - Reference 5)

For the 90 V specification (without 10 dB margin)

W_{d1} = 1.61 μj

Conclusion: HCI-1M by Criterion E_1

2.2.2.10 Device IC3 (SN52709L)

Pins and Stresses: A, L, N
(±284 V, ±5.7 A)

Worst Case Combination: -284 V Pins A and N
(W.C.C.) +284 V Pin L

Circuit: See Figure 2.2.2-3

Analysis: The SN52709L (IC3) is powered by a V_{CC}+ of +11 V and a V_{CC}- of 0V. The absolute maximum voltage rating for either input of the SN52709L is ±10 V with respect to the zero reference level of the supply voltages where the zero reference level is the midpoint between V_{CC}+ and V_{CC}- (i.e., +5.5 V). Since the magnitude of the input voltage must never exceed the magnitude of the supply voltage or 10 volts, whichever is less, it can be concluded that either input will be damaged if the input voltage goes more positive than +10 V or more negative than -4.5 V. The worst case combination of stresses will cause the absolute maximum input voltage ratings of the SN52709L to be exceeded.

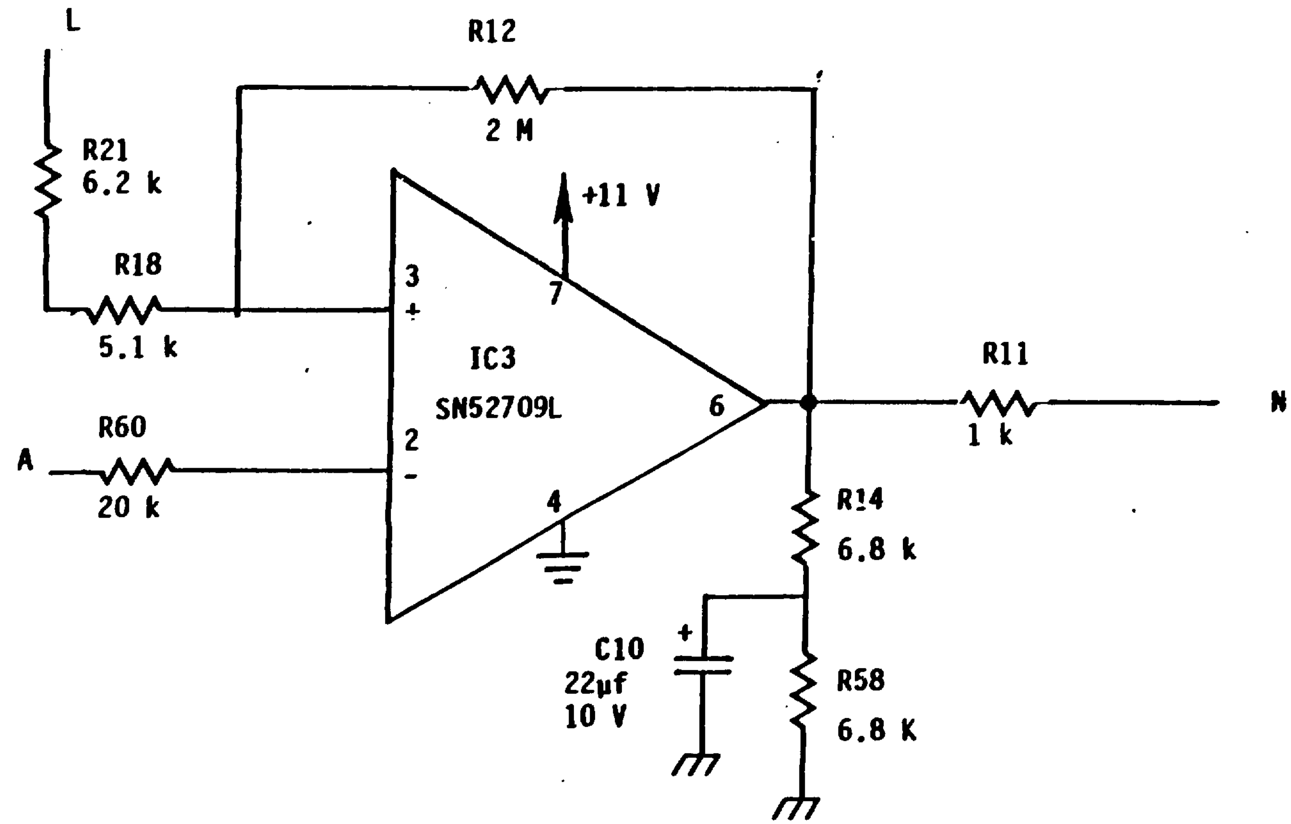

Figure 2.2.2-3. Device IC3 and associated circuitry.

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Energy: W_{d2} = 153 μj (at output of op-amp)

W_t = 3.1 μj (Source - Reference 5)

For the 90 V specification (without 10 dB margin)

W_{d1} = 15.43 μj

which is still above W_t

Conclusion: IC3 requires redesign by Criterion D

2.2.2.11 <u>47 V Metal Oxide Varistor (Panasonic ERZC-10 DK470)</u>

Pins and Stresses: Pins B and F
(±284 V, ±5.7 A)

Worst Case Combination: ±284 V Pin B
(W.C.C.) ∓284 V Pin F

Circuit: Configuration #1 $R_1 = C = 0$
$R_2 = \infty$

Analysis: The maximum energy and surge current rating of this device will not be exceeded, even with a 10 dB margin applied to the specified EMP stresses.

Conclusion: HCI-1H by Criterion B

SECTION 3
INTERNAL WIRING EXCITATION

The EMP flowdown analysis (Ref. 2), which derived the 90 V interface pin specification, also estimated the fields inside the generator enclosure to be

$$H \leq 4 \text{ A/m}$$
$$E \leq 120 \text{ V/m}$$

Actually, the electric field will be well below this value, so only magnetic coupling will be assumed.

First we must make an estimate of the largest conductor loop area for internal wires in the American Bosch CU673C-26 Electric Governor Control Unit into which the magnetic field can couple. The maximum conductor loop area in the Control Unit is estimated to be half the unit width times one-fourth its length, or approxiately 7 cm x 4.75 cm.

Using the characteristic frequency of 4.2 MHz derived in Reference 2, we calculate

$$V_{OC} = \omega\mu_0 HA$$

where

$\mu_0 = 4\pi \times 10^{-7}$ Henry/m is the permeability of free space
A = Maximum Conductor Loop Area

Therefore:

$$V_{oc} = 2\pi(4.2 \times 10^6) \left(4\pi \times 10^{-7} \frac{\text{Henry}}{\text{m}}\right)\left(\frac{4\text{A}}{\text{m}}\right) (7 \times 10^{-2}\ \text{m})\ (4.75 \times 10^{-2}\ \text{m})$$

$$V_{oc} = 0.44\ \text{V}$$

Applying a 10 db margin to this value, we obtain

$$V_{oc} = 1.39\ \text{V}$$

Only upset can be produced by the internally generated transients because 1.39 V is less than the rated maximum reverse voltages of all devices in the Electric Governor Control Unit. This 1.39 V signal can appear at any point in the circuitry.

The largest time constant in the Electric Governor Control Unit is created by the combination of the 100 k resistor R_{23} and the 10 μf capacitor C_{31}. This RC circuit has a time constant of 1 second. If the 1.39 V signal causes capacitor C_{31} to discharge, it would take approximately 3 seconds (3 time constants) for the capcitor to recharge and normal circuit operation to resume. However 3 seconds is not a long enough time to cause any significant upset of generator operation to occur, because of the relatively slow response times of the electric actuator for throttle control and the generator set itself.

SECTION 4
CONCLUSION AND RECOMMENDATIONS

1. Diodes D_1 and D_3 are stressed by EMP beyond their rated peak inverse voltage, even for the basic specified EMP threat without a 10 db margin. A comparison of the energy deposited in the diodes with damage thresholds shows that both diodes can be placed in HCI-1M. Diode D_2 is uncategorized while the 47 V MOV (ERZC-10DK470) is in category HCI-1H.

2. Transistors T_1 - T_3 are stressed by EMP beyond their rated junction breakdown voltages, even for the basic specified EMP threat without a 10 db margin. A comparison of the energy deposited in the transistors with damage thresholds shows that transistors T_1 and T_2 can be placed in HCI-2, but transistor T3 falls into a mandatory redesign category. The 2N4922 is a possible replacement for T_3, assuming it will satisfy other system constraints.

3. Zener diodes Z_1 and Z_2 are stressed by EMP beyond their absolute maximum peak nonrepetitive reverse surge power ratings. The energy deposition even without the 10 db margin exceeds the damage thresholds for these devices. Therefore, redesign is required. The 1N5338 is a potential replacement for Z_1 and Z_2, assuming it meets other system requirements.

4. Operational amplifiers IC1 and IC3 are stressed by EMP beyond their absolute maximum input voltage ratings, even for the basic specified EMP threat without a 10 db margin. A comparison of the

energy deposited in the device with damage thresholds shows that IC1 can be placed in HCI-1M, but IC3 falls into a mandatory redesign category. It is recommended that transient voltage suppression devices be added at Pins A, L, and N of the Electronic Control System to reduce the transient stress to IC3 below its absolute maximum ratings.

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2. "EMP Flowdown For the MEP 404B Turbine Generator", IRT Corporation report, Appendix I.

3. "TOMAHAWK Ground Launched Cruise Missiles System Survivability/Vulnerability Program Plan", Revision B, August 1983, GDC-GLCM-79-010, General Dynamics Convair Division, San Diego, CA.

4. R. Patrick, J. Ferry, "Nuclear Hardness Assurance Guidelines For Systems With Moderate Requirements", AFWL-TR-76-147, Air Force Weapons Laboratory, September 1976.

5. BDM Corporation, "Electric Component Modeling and Testing Program", AFWL-TR-78-62, Air Force Weapons Laboratory, March 1980.

Appendix J
Technical Data Sheet-Solar Electric Battery Charger

SOVONICS
Solar Systems
A subsidiary of
Energy Conversion Devices, Inc.

THE MPV-3010 SHATTERPROOF SOLAR ELECTRIC VEHICULAR BATTERY CHARGER

Maintain Full Battery Charge

The MP-3010 from Sovonics Solar Systems is a flexible, field rugged, lightweight generator which converts sunlight to electricity. It powers rechargeable batteries in all types of military vehicles and keeps them fully charged even during prolonged storage. The MPV-3010 provides charging current of over 300 mA at 28.5 volts. It can maintain battery charge of two 100 Amp-hr 12 volt batteries connected in series for 24 volt systems. A built-in blocking diode prevents battery discharge at night.

Enhance Vehicle Readiness

The state of readiness of a military vehicle can be seriously impaired by self-discharge and low charge retention. The MPV-3010 enhances vehicle readiness by compensating for self-discharge and thereby maintaining full battery charge at all times and under all climatic and weather conditions.

Extend Battery Life

Low state of charge is one of the main causes of shortened battery life. By always maintaining a high state of charge the MPV-3010 will extend the life of the batteries in military vehicles.

Reduce Battery Maintenance

By maintaining a high state of charge, maintenance due to periodic recharging is eliminated by the use of the MPV-3010. Further reduction in maintenance results from a less frequent battery replacement schedule.

Shatterproof, Rugged, Damage-Resistant

The MPV-3010 is a unique product that takes advantage of proprietary technology, in which amorphous silicon alloys are deposited in thin film layers on flexible substrate. The MPV-3010 is lightweight, tough, non-breakable and in most cases, continues operating even after being pierced by a bullet.

Easy to Install

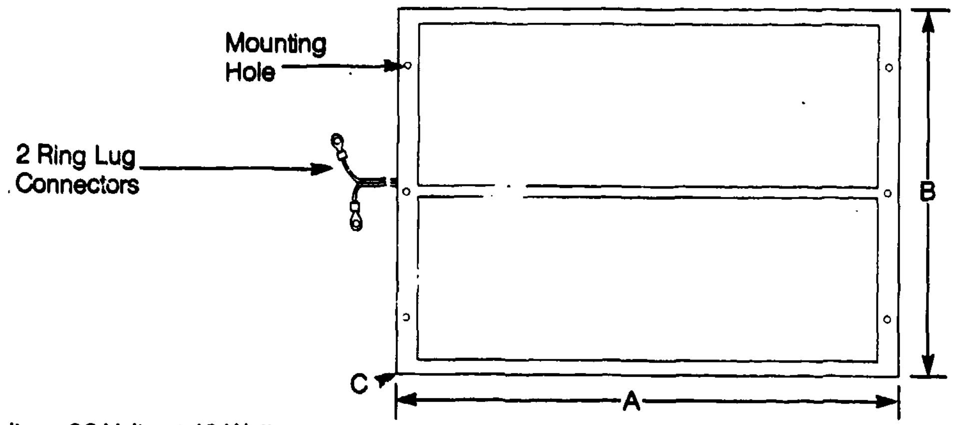
The MPV-3010 can be attached to the roof of a vehicle with screws. Alternately, optional magnetic backing is provided to attach the module to any steel surface. For vehicles utilizing more than one pair of batteries, an additional MPV-3010 unit per pair is suggested.

Available Now

For additional price and technical information contact:

Sovonics Solar Systems
1100 West Maple Road
Troy, Michigan 48084
Telephone (313) 362-3120
Fax (313) 362-4442
Telex 230648

Specifications



Maximum voltage 32 Volts at 10 Watts
Cell surface: Dark blue with non-reflective surface
Cell underside: Weather proof polymer; optional magnetic backing
Weight: 2.2 pounds (1.0 kg)

Panel Size
A. Length: 23.75"
B. Width: 17.5"
C. Depth: 0.125

Mounting:
Attach to a solid surface with screws. Optional magnetic backing is available for installation on steel surfaces of vehicles.

Battery Characteristics For Sovonics MPV-3010*

Charging Current For 24 Volt Batteries Amp-Hr./Day

Location	Spring	Summer	Autumn	Winter
USA (Tennessee)	1.7	2.2	1.3	0.8
USA (Minnesota)	1.6	2.1	1.0	0.7
USA (Massachusetts)	1.6	2.0	1.0	0.7
USA (Texas)	2.0	2.5	1.6	1.1
Western Europe	1.6	2.1	1.1	0.6
North Africa	2.4	2.4	2.2	1.4

Charging Output For 24 Volt Batteries At Various Light Levels

Insolation	Charging Current (mA)	Max Power (Watts)
Bright Sun (100 mW/cm²)	350	10.0
Sunny (90 mW/cm²)	315	9.0
Partly Cloudy (60 mW/cm²)	206	5.9
Cloudy (20 mW/cm²)	66	1.9
Heavy Clouds (10 mW/cm²)	33	0.9

*Module Mounted Parallel To Ground

Represented By:

Form MPV-3010-9-86

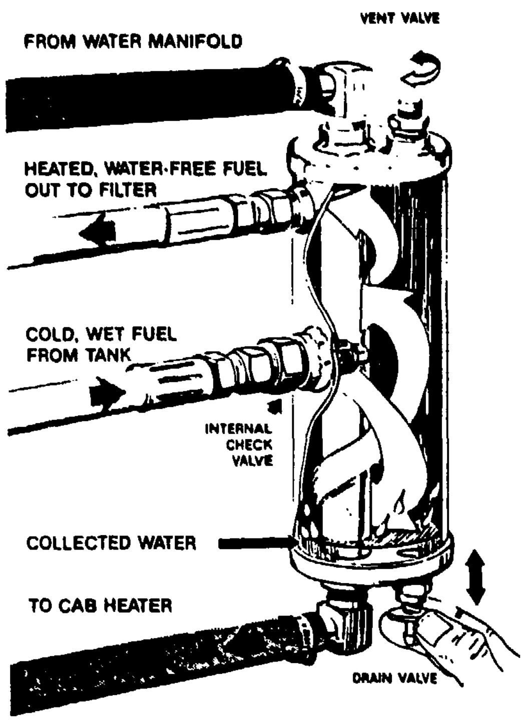
Appendix K
Technical Data Sheet-Diesel Fuel Heater/Water Separator

TECHNICAL INFORMATION

FUEL·PRO®

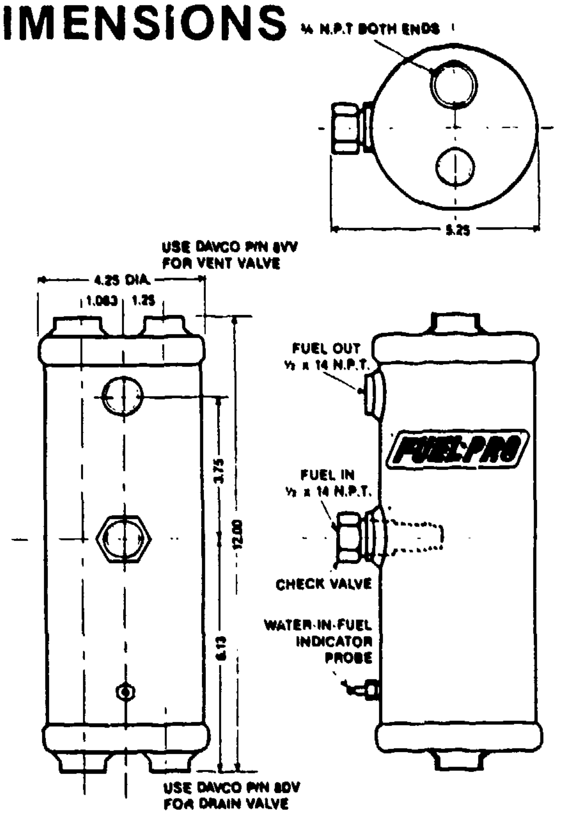
DIESEL FUEL PROCESSOR

INSTALLATION



USE DAVCO VENT (8VV) AND DRAIN (8DV)

DIMENSIONS



SPECIFYING INFORMATION

AVAILABLE THROUGH ALL TRUCK MANUFACTURERS

Be sure to specify the FUEL-PRO with DAVCO vent and drain valves.

FUEL PRO MODELS

FP-091 . . . . FUEL PRO
FP-091-P . . . . FUEL PRO with water-in-fuel light kit

MOUNTING KITS

090410 . . . . CAB-OVER-ENGINE KIT
090420 . . . . CONVENTIONAL KIT
090430 . . . . UNIVERSAL KIT

SPECIFICATIONS

LINEAR DIMENSIONS IN INCHES

WEIGHT	3 pounds, 14 ounces (1.75 kg)
FUEL CAPACITY	.45 gallon (1.7 liters)
FUEL, DRAIN & VENT CONNECTIONS	½ x 14 N.P.T.
WATER TRAP CAPACITY	38 ounces (1.1 liters)
RECOMMENDED MAX. FLOW	120 gallons per hour
DIMENSIONS	4¼"x 5¼"x 12"
MOUNTING	VERTICAL POSITION RECOMMENDED

///DAVCO
Manufacturing Corporation
4601 Platt Road Ann Arbor, MI 48104
313-973-2270 Telex: 810-223-2401

Patent No. 4368716, 4395996, 4421090, 4428351 and others Pending

FORM 093-114

Appendix L
Patriot Fuel Waxing Study of the 15 and 30 kW
MIL-STD Generator Sets

PATRIOT Fuel Waxing Program

1. <u>Background</u>:

In the European Theater of Operations, the PATRIOT power generating equipment is required to use grade DF-2 (OCONUS) diesel fuel, in conformance with NATO F-54 diesel fuel. Reports from Europe indicated that fuel waxing in power generating equipment appeared to be occurring at ambient temperatures of 25°F to 30°F, even though the "cloud point" of DF-2 fuel is 9°F. As a near-term solution, the supply of kerosene blended fuel in Europe is adequate to meet the PATRIOT fuel requirement through the winter of 1985-1986. This limited supply of blended fuel is presently available because of the reallocation of Navy dedicated resources. The kerosene based fuel used for blending is not a NATO standardized fuel and could be reallocated at any time. If blended fuel was made a NATO standard and authorized for PATRIOT users, the fuel waxing problem would be solved provided that the blended fuel is in use prior to the occurrence of waxing problems. The current blending policy of waiting to blend the fuel until a waxing problem has occurred could cause shut down of the power generating equipment. Specifically, PATRIOT users should have an agreement with USAREUR agencies to use blended fuel on a calendar date "cut-in" basis. On the condition that a tactical decision is made not to depend upon kerosene blended fuel in Europe, a development and testing program was initiated to design a heated fuel system for the MEP 113A (15 kW) and MEP 114A (30 kW) PATRIOT generator sets. This fuel waxing program will determine the minimum modifications necessary for the generator sets to successfully eliminate the fuel waxing problem.

2. Testing Results:

Two systems were developed and tested under this program. The first series of tests were conducted during the week of 21 October 1985, at 0°F, -10°F and -25°F. The two systems, hereinafter called System I and System II, were composed of the following generator set modifications:

System I - Stanadyne

1. 1/2 inch fuel lines and fittings.

2. Primary filter replaced with Stanadyne Model MS water separator.

3. Heated secondary filter.

System II - DAVCO

1. 3/8 inch and 1/2 inch fuel lines and fittings.

2. Primary and secondary filters replaced with DAVCO Model DP 100 heated filter/separators.

3. Day tank heated by DAVCO hot joint.

Both System I and System II started and operated successfully during the testing done the week of 21 October at temperature conditions of 0°F and

-10°F. The generator sets were operated for 3 hours, 2 hours at no load condition and 1 hour at full load condition. At -25°F, neither generator set started and operated as required. The MEP 113A generator set (System I fuel system) had an overspeed shutdown due to a governing system problem and it also appeared that the float switch in the day tank was hung up in solidified fuel. The day tank in this System I configuration was not heated. The MEP 114A generator set (System II fuel system) was shut down due to a broken shaft of the fuel injection pump. The pump was removed and sent to Stanadyne, the pump manufacturer, for failure analysis. A new injection pump was installed and during the week of 4 November the MEP 114A generator set was retested at -25°F. The set started and operated for a short period. Fuel was being provided successfully from the day tank to the engine, verified by the correct functioning of the day tank float switch calling for fuel to be provided from the set main fuel tank. No fuel was provided from the main tank to the day tank, indicating that the fuel in the main tank was solidified and could not be pumped by the two electric fuel pumps.

The results from the -25°F testing determined that for successful operation at that temperature the set main fuel tank must be heated. To keep generator set modifications as simple as possible and also to meet more realistic temperature requirements in Europe, it was recommended that the generator sets be required to operate properly at -10°F on DF-2 diesel fuel, not -25°F. This was based on an analysis of weather data for the European NATO countries, indicating that for 99.9% of the time during the winter months, the lowest temperature reached in these countries was -8°F.

Both PM-MEP and the PATRIOT Support Project Office agreed with the -10°F temperature requirement. The next test was conducted at -15°F to provide additional insurance that the generator sets will operate properly at -10°F in the field.

Before the next test, System I was modified to include the following components:

System I - Stanadyne

1. 1/2 inch fuel lines and fittings.

2. Heated primary and secondary filters.

3. Day tank heated by SDS heater.

During the week of 9 December, testing at -15°F showed that both systems were successful in starting and operating the MEP 113A and MEP 114A generator sets. The systems were then switched (System I from MEP 113A to MEP 114A and System II from MEP 114A to MEP 113A) and retested successfully at -15°F. This test satisfactorily proved that both System I and System II will allow the MEP 113A and MEP 114A generator sets to start and operate properly with no fuel waxing problems at temperatures down to -15°F.

A final test was conducted during the week of 13 January 1986 with the MEP 114A generator set (using System I fuel components) in an EPU II configuration. At -15°F, the MEP 114A was successful in starting and operating the EPU II for 8 hours at rated load, drawing fuel from the 93 gallon external tank. The fuel supply was then switched to the generator set main fuel tank and operated for 1 hour at rated load. This testing indicates that no further modification to the EPU II fuel system is required for successful operation down to -15°F.

3. Recommendations:

If the decision is made not to rely on blended fuel as the long-term solution to the fuel waxing problem, further development and documentation of the fuel system modifications, System I and System II, will be required. Since both systems were found to be technically satisfactory, the decision as to which system to fully document will be based on system cost and simplicity of the modifications to the generator set fuel system. Documentation for the fuel system kit will be accomplished, which includes revisions to all generator set technical manuals and an engineering drawing package for the fuel system modifications. Next, the fuel systems of the EPP II and to a lesser extent (some testing has already been accomplished) the EPU II must be addressed to ensure their successful operation at -10°F.

Test Report No: 86031

Date: 22 January 1986

REPORT OF TEST

ON

PATRIOT FUEL WAXING STUDY

OF THE

15 KW AND 30 KW MIL-STD GENERATOR SETS

FOR

LOGISTICS SUPPORT DIRECTORATE

POWER CONVERSION AND DISTRIBUTION DIVISION

SPECIAL PROJECT TEAM

BY

TEST AND EVALUATION DIVISION

PRODUCT ASSURANCE AND ENGINEERING DIRECTORATE

BELVOIR RESEARCH, DEVELOPMENT & ENGINEERING CENTER

FORT BELVOIR, VIRGINIA 22060-5606

Test Report No. 86031

Date: 22 January 1986
(bjd)

SIGNATURE

Written by: ____________________ Date: 2/10/86
Nathaniel B, Ferguson, Project Leader

Assisted by: ____________________ Date: 2/10/86
Steven C. Kurz, Engineering Technician

Assisted by: ____________________ Date: 2/10/86
Charles M. Seay, Engineering Technician

Authenticated by: ____________________ Date: 2/10/86
William C. Monaghan, Jr., C, Dynamic Component Team
(Provisional)

Approved & Released by: ____________________ Date: ________
Ivan M. Silver, C, Dynamic Branch
(Provisional)

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APPENDIX 3	15 & 30 KW at -25°F	
APPENDIX 4	15 KW at -10°F	W/O FUEL HEATERS
APPENDIX 5	30 KW at -25°F	RETEST
APPENDIX 6	15 KW at -15°F	(STANDADYNE)
APPENDIX 7	30 KW at -15°F	(DAVCO)
APPENDIX 8	15 KW at -15°F	(DAVCO)
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PURPOSE OF TEST: To determine if the MIL-STD 15 KW and 30 KW DED Generator Sets currently used in the PATRIOT System will operate at low temperature conditions, using OCONUS Referee Grade DF-2 diesel fuel and commercially available fuel system heaters incorporated into the generator sets fuel system.

DATE TESTING COMPLETED: 14 December 1985

TESTING CONDUCTED BY: Dynamic Testing Branch
Test & Evaluation Division
Belvoir Research Development & Engineering Center
Fort Belvoir, VA 22060-5606

TEST FUEL SYSTEM HEATERS:

One(1) each Fuel System Heater manufactured by Standadyne, Inc.
One(1) each Fuel System Heater manufactured by DAVCO.

TEST FUEL: OCONUS Referee Grade DF-2 Diesel Fuel furnished by Standadyne and DAVCO.

TEST GENERATOR SETS:

One(1) each 15 KW DED Generator Set
1?0/208 Volts, 100 HZ
Model MEP-113A
Serial No. RZ60358

One(1) each 30 KW DED Generator Set
120/208 Volts, 400 Hz
Model MEP-113A
Serial No. RZ40048

ABSTRACT: Both Generator Sets operated satisfactorily at low temperature to -15° Ambient on OCONUS DF-2 fuel with fuel system heaters incorporated into the generator sets fuel system. Neither generator set would operate at the -25° Ambient test condition as the generator sets electric fuel pumps were incapable of pumping fuel from the units main fuel tank to the units day tank. The OCONUS fuel at this temperature was of a semi-solid consistency.

TEST PLAN & TEST SEQUENCE: The 15 KW and 30 KW generator sets were received on 18 Oct 85. The test fuel system heaters were installed at time of receipt by the Government Contractor, Potomac Research, Inc., representing the Government in the acquisition of the fuel system heaters. The 15 KW DED generator set was equipped with the fuel system heaters manufactured by Standadyne, Inc., and consisted of heaters installed in the generator sets primary and secondary fuel filter canisters, adjacent to the MIL-STD fuel filter elements.

The 30 KW DED generator set was equipped with a fuel system heater manufactured by DAVCO. The DAVCO Fuel System Heaters consisted of replacing the primary and secondary MIL-STD fuel filter housing assemblies with DAVCO primary and secondary units having heater elements incorporated within the filter housings. A Davco heater element was also installed in the generator set day tank.

Both units were serviced for low temperature testing with coolant checks, protection checks, oil changes, filter changes, flushing the fuel systems with OCONUS fuel and refilling the fuel systems with OCONUS DF-2 (fuel by Standadyne). Thermocouples were installed in the main fuel tanks adjacent to the fuel pickup approx 1/2 inch from the bottom of the main fuel tank and in the units day tanks, approximately one inch from the bottom of the day tank. A thermocouple(set air in) was installed at the control end of the generator sets. The quick start cylinder was installed on each generator set. The fuel injection pumps were checked to insure that the fuel inlet screens were removed. It was later found that removal of these screens would result in a catastrophic failure (seizure) of the fuel injection pump.

DC voltage and current measurements of the fuel system heater operation was taken during low temperature testing. Prior to testing, both fuel system heaters were checked at +25°F to insure proper operation. Units were operated before each test environment, to insure proper instrumentation and operation. All circuit breakers on test units were pulled and cycled batteries installed prior to each test environment. Fuel samples were placed in chamber.

<u>TEST ENVIRONMENT AT 0°F AMBIENT TEMPERATURE</u>: Fuel Samples: Cloudy liquid state. After a 24 hr soak period both fuel system heaters were operated four(4) minutes prior to a start attempt. The g. rator sets started within the time allotted by the test procedure and unit operation was normal. Both units met the requirements set forth by the test procedure of rated load after 14 minutes of operation at no load, one(1) hour operation at rated load and two(2) hours operation at no load. During testing at 0°F Ambient, the manufacturing representative from DAVCO determined that the day tank heater was wired incorrectly, The day tank heater should have been installed on the secondary filter. After completion of testing at 0°F Ambient, the wiring to the day tank heater was changed per manufacturer representatives instructions.

<u>TEST ENVIRONMENT AT -10°F AMBIENT TEMPERATURE.</u>

After a 20 hour soak period and four (4) minutes of heater operation, an attempt to start the 15 KW unit resulted in a "no start", caused by a tripped speed switch. The switch was reset and a successful start was made. During testing, the 15 KW satisfied the requirements set forth in the test procedure. The 30 KW was incapable of starting on set batteries at -10°F testing. The set started and operated on 24 volt house power as set batteries were frozen during -10°F soak. During one(1) minute of fuel system heater application, it was determined that the wiring to fuel filter heater was faulty. The wiring was repaired and testing continued (four(4) minutes of heaters application reapplied). The unit started and operated normally throughout the testing and met the requirements set forth in the test procedure. After the completion of -10°F ambient, the unit remained running until chamber reached +40°F ambient, to allow the fuel in the units' tanks to warm to +80°F ambient. At this point, the units were shutdown and the chamber was operated until the fuel temperatures reached the required +80°F in the units fuel tanks. During the shutdown, the 15 KW was fitted with an indicator light to the day tank solenoid, to monitor fuel demands during -25°F ambient tests.

TEST ENVIRONMENT AT -25°F AMBIENT.

The fuel samples appeared as a semisolid slush solution. The fuel in the sets main tanks appeared as a thick slush solution. At the end of a 20 hour soak period the 15 KW fuel system heater was activated for four (4) minutes, using set batteries. After one dead crank, the first start attempt resulted in a "No Start". A second start attempt, using 2' volt house power resulted in a good start within 50 seconds. After eight(8) minutes of operation at no load the unit shutdown. Examination of the unit revealed that the MIL-STD electric fuel pumps were incapable of pumping fuel from the main tank to the day tank as a result of the fuel being in a thick slush solution. Testing on the 15 KW was terminated at the -25°F ambient. Activated the fuel system heaters on the 30 KW unit for four(4) minutes, using set batteries. The first start attempt on set batteries resulted in a slow crank and no start. Using 24 Volts house power, the unit started on the third start attempt and operated approximately one(1) minute then shutdown. Examination revealed no fuel from injection pump to #1 and #6 injection nozzles. Testing at -25°F terminated. Chamber warmed to +40°F ambient to attempt a start on the 15 KW and 30 KW sets. The 15 KW set was started and operated at +40°F ambient. Start attempts on the 30 KW were not successful. Examination of the 30 KW revealed the injection pump had seized during testing at -25°F ambient. After testing at -25°F, both units received a thorough inspection prior to further operation. The following deficiencies were noted. The 15 KW inspection and findings: Faulty wiring connections at the boost electric pump. Repaired the wiring connection and a replacement boost pump installed with the fuel strainer removed. A faulty governor control actuator was replaced. Fuel Filters in both primary and secondary cannisters were inspected. The 30 KW inspection and findings: A replacement injection pump was installed and timing set according to TM specifications. The fuel inlet strainer to the injection pump was removed.

At this point it was determined that a start attempt on the 15 KW would be performed at -10°F ambient without any fuel system heater operation. The 30 KW will be retested at the -25°F ambient environment. Both units were serviced for low temperature. Both units were equipped with an indicating light to monitor fuel demands during low temperature testing. Indicating lights were connected to the primary and secondary heaters to monitor fuel system heater operation. A manual control switch was incorporated in the thermostatic control wire to the primary heater to permit a forced operation of the primary fuel system heaters by demand and not by thermostatic control. Both units main fuel tanks were filled with Oconus fuel furnished by Standadyne. All circuit breakers pulled and cycled batteries installed as required.

-10°F AMBIENT TESTING ON 15 KW WITHOUT FUEL SYSTEM HEATERS.

The testing began with the fuel in the main tank at -8°F. The unit started in 25 seconds and operated normally during all phases of testing. The fuel demands (per indicator light) for each 2.5 minutes of operation at rated load indicate approximately 8 seconds of fuel pump operation. At no load for each 5 minutes of operation, approximately 8 seconds of pump operation.

AFTER THE COMPLETION OF -10°F AMBIENT TESTS ON 15 KW.

The 30 KW fuel system heaters were checked for proper operation using 24 volt house power. Total system current draw - 40.38 amps/23.5 volts DC.

30 KW AT -25°F AMBIENT/RETEST.

Fuel sample - semi solid state.
Fuel in main tank - semi solid state.
At the end of a 20 hour soak period, the fuel system heater was activated using set batteries. The unit required three(3) start attempts before starting.
The unit shut down after 15 minutes of operation with a low fuel indicator shown.
Examination of unit shows the inability of the electrical fuel pumps to pump the Oconus fuel in a semi-solid state as in the previous -25°F test. Testing at -25°F Ambient was terminated to avoid possible failure of the injection pump.

Both units were disconnected and returned to the contractor for modifications to the fuel system heaters for testing later.
Receipt of the units after modifications to the fuel system heaters reflected the following changes:

15 KW, 400 HZ Generator Set
Model#MEP-113A
S/N-RZ60358 — 2 ea.- 30 Amp Circuit Breakers
1 - Primary & Secondary Heater
1 - Day Tank Heater
Davco Oconus fuel in tank
Set in original configuration
Standadyne fuel heater system
Heater in primary filter assy.
Heater in secondary filter assy.
Heater in day tank w/immersion thermostat
Larger solenoid on day tank
Large diameter fuel lines
Different fuel selector valve
Larger fittings but reduced at filters, pumps and injection pump
Broken starter aid hose caused by contractor installing kit

---

30 KW, 400 HZ Generator Set
Model#MEP-114A S/N-RZ40048 1 ea. - 30 Amp Circuit Breaker
Davco Oconus fuel in set
Davco fuel heater system
Basic same as previous with the following changes:

Larger fuel lines but reduced at fittings
Larger fuel solenoid at day tank

Both the 15 KW and 30 KW were serviced for low temperature tests at -15°F Ambient.

The same instrumentation set up as in previous test was used.

The 15 KW was connected to indicator lights to monitor day tank solenoid operation (fuel demands) and day tank/secondary fuel filter heater operation. The 30 KW was connected to indicator lights to monitor day tank solenoid operation (fuel demands), day tank heater/secondary fuel filter heater operation and primary fuel filter heater operation. It was stated in a revised test procedure that the operation of the primary heaters would not be permitted during the four (4) minutes of heater operation prior to the start attempts on both generator sets. After the completion of instrumentation hook-up and set check-outs to insure proper operation, the chamber was lowered to +25°F Ambient to allow fuel system heater operation prior to performing the -15°F Ambient test. Both fuel system heaters operated as required during 25°F Ambient system check.

30 KW AT -15°F AMBIENT.

Fuel samples - thick slush state. Good start after four(4) minutes of day tank/secondary filter heater operation - 35 seconds to start. The 30 KW performed satisfactorily during -15°F ambient testing. Fuel demand at rated load for each minute of operation approx four(4) seconds of fuel pump operation.

15 KW AT -15°F AMBIENT.

Four(4) minutes of day tank/secondary heater application.
Unit started on second attempt but would not reach 400HZ(rated speed). Examination after the sixth start attempt revealed no fuel flow to the injection pump. After tapping on the fuel line, fuel started to flow. Started unit and operated for the required 14 minute warm up. Applied rated load but unit would not maintain rated speed. Shut unit down for examination. Found failed "O" ring on fuel inlet to the injection pump. Both units shut-down for fuel system heater change-over. The Standadyne fuel system heater kit was installed on the 30 KW and the Davco fuel system heaters were installed on the 15 KW. Both kits were checked fo proper operation at 25°F Ambient as in all other pre-tests.

30 KW STANDADYNE SYSTEM AT -15°F AMBIENT.

Four(4) minutes of heater application to day tank/secondary filter. Fuel samples - slurpee consistency. Three(3) start attempts - one(1) start fluid application with primary heater on. Good start in 45 seconds. During no load operation, light indicator on day tank solenoid activated approximately nine (9) seconds for each five(5) minutes of unit operation. At rated load, fuel pump operated approximately nine(9)seconds for each 1.5 minutes of unit operation The 30 KW operated normally during all phases of testing at -15°F ambient.

15 KW DAVCO SYSTEM AT -15°F AMBIENT.

Four(4) minutes of heater operation of day tank/secondary filter. Good start in 15 seconds with two(2) applications of starting aid. The primary heater remained on during the rated load operation. The fuel solenoid was on for one(1) second for every 17 seconds of operation. During no load operation, the fuel solenoid was on approximately one (1) second for each 30 seconds of operation. The 15 KW operated normally during -15°F ambient testing.

TEST RESULTS:

Both fuel system heaters operated in a satisfactorily manner at temperatures to -15°F, provided that the set batteries were fully charged. Neither fuel system heater would function at -25°F ambient because of the inability of the MIL-STD Electrical fuel pumps to pump fuel from the main set tanks to the day tanks where the fuel was heated prior to use by the generator sets.

DISPOSITION OF TEST FUEL SYSTEM HEATERS:

At the completion of testing, the fuel system heaters remained on the generator sets.

APPENDIX 1

15 KW at 0°F
30 KW at 0°F

TEST DATA

ITEM [illegible]

MFGR.

MODEL NO. [illegible]

SERIAL NO. [illegible]

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

[illegible]

[illegible]

TEST NO.

SHEET ____ OF ____

DATE [illegible]

JOB NO. [illegible]

PROJ. ENGR.

RECORDER/OBSERVER

INST →																	
READ NO																	
UNITS																	
SYM																	
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
								[illegible]									
			[illegible]			[illegible]		[illegible]									
			[illegible]			[illegible]		[illegible]									
			[illegible]			[illegible]											
	[illegible]		[illegible]			24.0		[illegible]									
	[illegible]		[illegible]			34.5		[illegible]									
	[illegible]		[illegible]			[illegible]		[illegible]									
	[illegible]		[illegible]			[illegible]		[illegible]									
	[illegible]		[illegible]			[illegible]		[illegible]									

[illegible]

NOTES

STRDE FM 13 18 (Rev)

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM 30KW DED Generator Set
400Hz 120/208 Volts

MFGR.
MODEL NO.
SERIAL NO. RZ 40048

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Warming Test At 0°F

TEST NO.
SHEET ____ OF ____
DATE 22Oct85 | 23Oct85
JOB NO.
PROJ. ENGR.
RECORDER/OBSERVER

INST → / HEAD NO / UNITS / SYM / COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	DATE		TIME		DAY TANK		MAIN TANK			SET AIR TEMP							
	–		–		°F		°F			°F							
	22 Oct		0735		0		0			0							
	23 Oct		0815		-1		-2			-7							
			0840		-1		-2			-2							
			0851		0		0			0							
			0906		85		2			6							
			0930		70		2			-7							
			1000		69		5			1							
			1015		70		10			8							
			1046		70		18			7							
			1100		73		19			5							
			1107		79		22			9							
			1120		78		21			5							
			1130		72		22			8							
			1145		68		23			4							
			1150		70		27			6							
			1210		78		25			3							

NOTES

STRBE FL 13 18 (Rev) 1 Nov 83

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

[illegible]

ITEM [illegible] 400 HZ

MFGR. ______

MODEL NO. ______

SERIAL NO. [illegible]

TEST NO. ______

SHEET ______ OF ______

DATE 23 OCT 85

JOB NO. 6004

PROJ. ENGR. ______

RECORDER/OBSERVER ______

INST ▶ / READ NO	TIME	TERMINAL VOLTAGE			LINE CURRENT			POWER				POWER FACTOR	FREQ.	EXCITER FIELD			AVG. AMB.
UNITS	HOURS	VOLTS	VOLTS	VOLTS	AMPS	AMPS	AMPS	WATTS	WATTS	WATTS	KW	DEC.	HZ	VOLTS	AMPS		OF
SYM		L1 LO	L2 LO	L3 LO	L1	L2	L3	L1	L2	L3	TOTAL						
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NOTES

[illegible]

PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL EXHAUSTED

TEST DATA

ITEM [illegible]	TEST AND EVALUATION DIVISION PRODUCT ASSURANCE & TESTING DIRECTORATE U.S. ARMY BELVOIR RESEARCH & DEVELOPMENT CENTER FORT BELVOIR, VIRGINIA	TEST NO.
	[illegible handwritten title]	SHEET ____ OF ____
	[illegible handwritten title]	DATE 23 [illegible]
MFGR.		JOB NO. [illegible]
MODEL NO.		PROJ. ENGR.
SERIAL NO. [illegible]		RECORDER/OBSERVER

INST →																	
READ NO ↓																	
UNITS / SYM																	
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
				Hours			[illegible]			Amps							
				[illegible]			[illegible]			[illegible]							
[illegible]				AT			[illegible]			[illegible]							
[illegible]	[illegible]			22.5			40.36			20.16							
[illegible]	[illegible]			[illegible]			[illegible]			20.18							
[illegible]	[illegible]			[illegible]			[illegible]			[illegible]							
[illegible]	[illegible]			[illegible]			[illegible]			[illegible]							
[illegible]	[illegible]			[illegible]			[illegible]			[illegible]							
[illegible]	[illegible]																
	[illegible]	[illegible]	[illegible]			[illegible]											
	[illegible]	[illegible]				[illegible]											
	[illegible]	[illegible]				[illegible]											
	[illegible]	[illegible]				[illegible]											
	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]											
	[illegible]	[illegible]	[illegible]			[illegible]											
	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]											
	[illegible]	[illegible]	[illegible]			[illegible]											
	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]											

NOTES

STRBE FM 13 18 (Rev)
1 Nov 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM 15KW DED Generator Set
400 Hz 120/208 Volts

MFGR.
MODEL NO. MEP 113A
SERIAL NO. RZ 60358

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Warming Test At 0°F
Stanadyne Fuel Heater in Secondary Fuel Filter

TEST NO.
SHEET ___ OF ___
DATE 22 Oct 85 / 23 Oct 85
JOB NO.
PROJ. ENGR.
RECORDER/OBSERVER

INST ▶

READ NO. ⬇

COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
UNITS																	
SYM																	
	DATE		TIME		DAYTANK		MAINTANK			SET AIR IN							
	22 OCT		0735		0°F		0°F			0°F							
	23 OCT		0815		-2°F		-1°F			-2°F							
			0840		20°F		0°F			0°F							
			0855		60°F		2°F			2°F							
			0930		90°F		12°F			0°F							
			1000		97°F		25°F			4°F							
			1015		101°F		28°F			4°F							
			1046		47°F		35°F			-1°F							
			1100		63°F		35°F			-2°F							
			1107		59°F		35°F			1°F							
			1120		54°F		35°F			-2°F							
			1130		53°F		36°F			1°F							
			1145		53°F		36°F			-3°F							
			1150		48°F		34°F			-4°F							

NOTES

STRBE FM 13 18 (Rev)

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM [illegible]

MFGR.
MODEL NO.
SERIAL NO.

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

[illegible]

TEST NO.
SHEET ____ OF ____
DATE 23 OCT 85
JOB NO. 6004
PROJ. ENGR.
RECORDER/OBSERVER

INST → / READ NO	TIME	TERMINAL VOLTAGE x	x	x	LINE CURRENT x 40	x 40	x 40	POWER x 40	x 40	x 40	x	POWER FACTOR	FREQ.	EXCITER FIELD			AVG. AMB.
UNITS	HOURS	VOLTS	VOLTS	VOLTS	AMPS	AMPS	AMPS	WATTS	WATTS	WATTS	KW	DEC.	HZ	VOLTS	AMPS		OF
SYM		L1 LO	L2 LO	L3 LO	L1	L2	L3	L1	L2	L3	TOTAL						
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
												[illegible]					
	[illegible]	120.5	121.2	120.5	2.06	2.09	2.10	[illegible]	[illegible]	[illegible]		1.0					[illegible]
		121.1	121.2	120.7	—												
		120.5	121.3	120.[illegible]	2.0[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							
		121.1	121.[illegible]	120.7	[illegible]	[illegible]											
		120.4	121.2	120.[illegible]	[illegible]			[illegible]	251	[illegible]							
		[illegible]	121.[illegible]	120.7	[illegible]												
	[illegible]	120.5	121.3	120.5	2.06	2.09	2.10	251	251	251		1.0	400				[illegible]
	[illegible]	120.6	121.2	120.[illegible]	2.06	2.11	2.10	251	251	251		1.0	400				[illegible]
	[illegible]	120.5	121.3	120.[illegible]	2.0[illegible]	2.09	2.10	251	251	252		1.0	400				[illegible]
	[illegible]	121.1	121.3	120.7	—	—	—	—	—	—		—	400				
	[illegible]	121.3	121.5	120.9	—	—	—	—	—	—		—	400				[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	—	—		—	—	—		—	401				[illegible]
	[illegible]	[illegible]	[illegible]	121.0	—	—		—	—	—		—	401				[illegible]
	[illegible]	[illegible]	121.6	120.[illegible]	—	—	—	—	—	—		—	401				[illegible]

NOTES

[illegible] PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL EXHAUSTED

APPEPNDIX 2

15 KW at -10°F
30 KW at -10°F

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

[illegible]
[illegible]

ITEM [illegible]

MFGR.

MODEL NO.

SERIAL NO. [illegible]

TEST NO.

SHEET ____ OF ____

DATE [illegible]

JOB NO. [illegible]

PROJ. ENGR.

RECORDER/OBSERVER

INST →

READ NO

UNITS / SYM / COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SYM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]										
				[illegible]			[illegible]			[illegible]							
[illegible]	[illegible]			[illegible]			[illegible]			[illegible]							
				[illegible]			[illegible]			[illegible]							
	[illegible]			[illegible]			[illegible]			[illegible]							
	[illegible]			[illegible]			[illegible]			[illegible]							
	[illegible]			[illegible]			[illegible]			[illegible]							
	[illegible]			[illegible]			[illegible]			[illegible]							
	[illegible]			[illegible]			[illegible]			[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]				[illegible]		[illegible]								
	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]										
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]										
	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]										
	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]										
	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]													
	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]										

NOTES

TEST DATA

ITEM 15KW DED Generator Set
400 Hz 120/208 Volts

MFGR.
MODEL NO. MEP 113A
SERIAL NO. RZ 60358

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Waxing Test At -10°F
Stanadyne Fuel Heater In Secondary Fuel Filter

TEST NO.
SHEET OF
DATE 23 Oct 85 / 24 Oct 85
JOB NO.
PROJ. ENGR.
RECORDER/OBSERVER

INST →
HEAD NO
UNITS
SYM

COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	DATE		TIME		Day Tank °F		Main Tank °F			[illegible] °F							
	23 Oct		1300		0		8			-9							
	24 Oct		0730		-10		-10			-11							
			0900		-10		-10			-10							
			1015		79		14			-9							
			1030		82		18			-9							
			1130		84		28			-8							
			1345		75		28			8							

NOTES

STRBE FM 13 18 (Rev)
1 Nov 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM [illegible]	TEST AND EVALUATION DIVISION PRODUCT ASSURANCE & TESTING DIRECTORATE U.S. ARMY BELVOIR RESEARCH & DEVELOPMENT CENTER FORT BELVOIR, VIRGINIA	TEST NO. ____
	[illegible]	SHEET ____ OF ____
	[illegible]	DATE 24 Oct [illegible]
MFGR. ____		JOB NO. 6004
MODEL NO. ____		PROJ. ENGR. ____
SERIAL NO. [illegible]		RECORDER/OBSERVER ____

INST → READ NO	TIME	TERMINAL VOLTAGE			LINE CURRENT			POWER				POWER FACTOR	FREQ.	EXCITER FIELD			AVG. AMB.
UNITS	HOURS	VOLTS	VOLTS	VOLTS	AMPS	AMPS	AMPS	WATTS	WATTS	WATTS	KW	DEC.	HZ	VOLTS	AMPS		°F
SYM		L1L0	L2L0	L3L0	L1	L2	L3	L1	L2	L3	TOTAL						
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
																	-10°F
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	125	125	15	1.0	399.6				
	[illegible]	[illegible]	[illegible]	[illegible]				—		[illegible]	—	—	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	[illegible]	[illegible]		[illegible]									[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	[illegible]			[illegible]									[illegible]				
[illegible]	[illegible]																
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							—	—	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]								[illegible]	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]								—	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]				

NOTES:

 PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL EXHAUSTED

TEST DATA

ITEM [illegible]

MFGR. ____

MODEL NO. ____

SERIAL NO. [illegible]

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

[illegible]

TEST NO. ____

SHEET ____ OF ____

DATE [illegible]

JOB NO. [illegible]

PROJ. ENGR. ____

RECORDER/OBSERVER ____

INST →																	
HEAD NO.																	
UNITS																	
SYM																	
CON	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
				[illegible]			[illegible]										
[illegible]	[illegible]			[illegible]	[illegible]		[illegible]										
	[illegible]	[illegible]			[illegible]		[illegible]	[illegible]		[illegible]							
	[illegible]			[illegible]	[illegible]		[illegible]	[illegible]		[illegible]							
	[illegible]			[illegible]			[illegible]	[illegible]		[illegible]							
	[illegible]			[illegible]			[illegible]	[illegible]									
	[illegible]				[illegible]			[illegible]		[illegible]							
[illegible]	[illegible]	[illegible]			[illegible]												
	[illegible]	[illegible]	[illegible]		[illegible]												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]										
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]									
[illegible]	[illegible]	[illegible]															
	[illegible]	[illegible]		[illegible]													

NOTES

STHRF FM 13 18 (Rev)

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Warming Test at -10°F

ITEM 30kW DED Generator Set
400 Hz 120/208 Volts
MFGR.
MODEL NO.
SERIAL NO. RZ 40048

TEST NO.
SHEET ___ OF ___
DATE 23 Oct 85 / 24 Oct 85
JOB NO.
PROJ. ENGR.
RECORDER/OBSERVER

CH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	Date		Time		Daytank		Main Tank		Set Air TA								
					°F		°F		°F								
	23 Oct		1500		0		5		-9								
	24 Oct		0730		-10		-10		-11								
			0900		-10		-10		-10								
			1015		58		0		-11								
			1030		46		2		-9								
			1130		69		3		0								
			1345		73		20		12								

NOTES

STRBE FM 13 18 (Rev)

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

[illegible]

ITEM [illegible]

MFGR. ______

MODEL NO. ______

SERIAL NO. [illegible]

TEST NO. ______

SHEET ______ OF ______

DATE [illegible]

JOB NO. [illegible]

PROJ. ENGR. ______

RECORDER/OBSERVER ______

INST →		TERMINAL VOLTAGE			LINE CURRENT			POWER				POWER FACTOR	FREQ.	EXCITER FIELD			AVG. AMB.
READ NO	TIME	X	X	X	X	X	X	X	X	X	X						
UNITS	HOURS	VOLTS	VOLTS	VOLTS	AMPS	AMPS	AMPS	WATTS	WATTS	WATTS	KW	DEC.	HZ	VOLTS	AMPS		OF
SYM		L1 LO	L2 LO	L3 LO	L1	L2	L3	L1	L2	L3	TOTAL						
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
																	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	[illegible]												[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				
[illegible]	[illegible]																
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				[illegible]
	[illegible]	121.1	121.2	120.6	—	—	—	—	—	—	—	—	[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				

NOTES

STEAP FL 15-46(Rev) PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL EXHAUSTED

APPENDIX 3

15 KW at -25°F
30 KW at -25°F

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Waxing At -25°F Amb

ITEM 15KW DED Gen. Set
MFGR.
MODEL NO.
SERIAL NO. RZ 60358

TEST NO.
SHEET ____ OF ____
DATE 26 OCT 85
JOB NO. 6004
PROJ. ENGR.
RECORDER/OBSERVER

INST →
HEAD NO

UNITS / SYM / COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
				Heater Voltage				Heater Current									
TIME																	
	Start	0803		24.0				36.8									
	1 MIN	0804		23.3				34.0									
	2 MIN	0805		23.3				34.0									
	3 MIN	0806		23.4				33.8									
	4 MIN	0807		23.4				33.6									
	Start Attempt Time				0807												
	Crank Time to Start				0807:50 * 50 SECONDS												
	Time to Rated Freq and Voltage					0810											
	Time End 14 Min Warm Up				[illegible]	[illegible]	[illegible]	[illegible]									
	Time Start 3 Load Cycles																
	Fuel Sample State 5																
	Starting Sequence 8'			1	Depr. Crank 10 Sec.				(2 cranks off of Set Batteries) (1st speed set ... down.)								
	*			3rd	Application of [illegible] Fluid [illegible] power. Good start.												

NOTES: (** 0810 Set start [illegible]) (George [illegible] ok to try Re-start) (0822 Re-started unit) (0823 unit down.) (Run in Battle Short) [illegible] in Battle Short ... fill day tank, it acted like the day tank was showing full, start but no run. No fuel flow. (0833 Heater turned off.)

STRBE FM 13 18 (Rev) 1 Nov 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM 15KW DED Generator Set
400 Hz 120/208 Volts

MFGR.
MODEL NO.
SERIAL NO. RZ 60358

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Waxing At -25°F

TEST NO.
SHEET OF
DATE 25 OCT 85 / 26 OCT 85
JOB NO.
PROJ. ENGR.
RECORDER/OBSERVER

INST																	
READ NO																	
UNITS																	
SYM																	
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	DATE		TIME		DAY TANK °F		MAIN TANK °F			SET AIR IN °F							
	25 OCT		1300		-28		-16			-27							
	26 OCT		0735		-25		-25			-26							
			0740		-20		-25			-25							

NOTES:

STRBE FM 13 18 (Rev)
1 Nov 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Warming At -25°C

ITEM 30 KW
DED Generator Set
400 HZ 120/208 Volts
MFGR.
MODEL NO.
SERIAL NO. RZ 40018

TEST NO.
SHEET ____ OF ____
DATE 26 Oct 85
JOB NO. 6004
PROJ. ENGR.
RECORDER/OBSERVER

INST. →																	
READ NO																	
UNITS																	
SYM																	
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
				Heater Voltage				Heater Current									
Time																	
	Start	0834		22.0				39.81									
	1 Min.	0835		22.0				38.63									
	2 Min.	0836		22.0				38.57									
	3 Min.	0837		22.0				38.60									
	4 Min.	0838		22.0				38.62									

Start Attempt Time 0838
Crank Time to Start –
Time to Watch Frequency Voltage – 0841
Time End 14 Min. Warm-up
Time Start 3 Load Cycles

Fuel Sample State

Starting Sequence
(Start Attempts) – (5-10 sec Attempt No Start) Have power bled. (0846 Heater turned off.)
(0841 Set Started) Unit Run 45 sec
(4-10 sec cranks - 1 either sheet)

NOTES

STRBE FM 13 18 (Rev)
1 Nov 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM 30KW DED Generator Set
400 Hz 120/208 Volts

MFGR.
MODEL NO.
SERIAL NO. RZ40048

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Waxing at -25°F

TEST NO.
SHEET OF
DATE 25OCT85 / 26OCT86
JOB NO.
PROJ. ENGR.
RECORDER/OBSERVER

COL.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
INST →																	
READ NO ↓																	
UNITS																	
SYM																	
	DATE		TIME		DAYTANK °F			MAIN TANK °F			SET AIR IN °F						
	25OCT		1300		-24			-16			-27						
	26OCT		0735		-25			-24			-26						
			0440		58			-26			-28						

NOTES

STRBE FM 13 18 (Rev)

PREVIOUS EDITIONS ARE OBSOLETE.

APPENDIX 4

15 KW at -10°F
W/O FUEL HEATERS

TIME	LINE VOLTAGE L1-N	L2-N	L3-N	LINE CURRENT L1	L2	L3	POWER KW	PF	FREQ. HZ
0730	---	---	---	---	---	---	0.0	1.0	0
0731	---	---	---	---	---	---	0.0	1.0	0
0740	---	---	---	---	---	---	0.0	1.0	0
0750	---	---	---	---	---	---	0.0	1.0	0
0755	---	---	---	---	---	---	0.0	1.0	0
0800	---	---	---	---	---	---	0.0	1.0	0
0810	---	---	---	---	---	---	0.0	1.0	0
0813	---	---	---	---	---	---	0.0	1.0	0
0826	---	---	---	---	---	---	0.0	1.0	0

#	15 KW #1	#2	#3	30 KW #1	#2	#3
1	-8	-11	-12	-10	-11	-12
2	-8	-11	-12	-10	-11	-12
3	-8	-11	-11	-10	-11	-11
4	-8	-11	-10	-10	-11	-10
5	-8	-11	-9	-9	-11	-9
6	-8	-11	-9	-10	-11	-9
7	-8	OTc	-13	-9	-11	-13
8	-8	-11	OTc	-9	OTc	-13
9	-8	-11	-13	-10	-11	-13

<=====TEMPERATURES

[illegible]

[illegible]

TIME	LINE VOLTAGE L1-N	L2-N	L3-N	LINE CURRENT L1	L2	L3	POWER KW	PF	FREQ. HZ
0827	---	---	---	---	---	---	0.0	1.0	0
0828	---	---	---	---	---	---	0.0	1.0	0
0830	---	---	---	---	---	---	0.0	1.0	0
0832	---	---	---	---	---	---	0.0	1.0	0
0832	118.6	117.2	117.8	---	---	---	0.0	1.0	396
0832	118.5	117.3	117.9	---	---	---	0.0	1.0	400
0834	118.5	117.3	117.9	---	---	---	0.0	1.0	399
0835	120.8	119.6	120.1	---	---	---	0.0	1.0	400
0836	120.6	119.4	120.0	---	---	---	0.0	1.0	400
0838	121.0	119.7	120.4	---	---	---	0.0	1.0	399
0840	121.0	119.8	120.4	---	---	---	0.0	1.0	400
0842	121.1	119.8	120.4	---	---	---	0.0	1.0	400
0844	121.1	119.9	120.5	---	---	---	0.0	1.0	399
0846	121.2	119.9	120.5	---	---	---	0.0	1.0	400

1__KW DED GENERATOR SET S/N 05-NOV-85

<=====TEMPERATURES

#	15 KW #1	#2	#3	30 KW #1	#2	#3
1	-8	-11	-12	-10	-11	-12
2	-8	-11	-12	-10	-11	-12
3	-8	-11	-11	-10	-11	-11
4	-8	-11	-10	-10	-11	-10
5	-8	-10	-8	-10	-11	-10
6	-9	-10	-11	-10	-10	-9
7	-8	-11	-10	-10	-11	-10
8	-7	-11	-7	-10	-12	-10
9	-6	-11	-8	-9	-11	-8
10	-8	-9	-8	-11	-11	-9
11	-8	-6	-10	-10	-10	-11
12	-4	-4	-11	-10	-12	-10
13	-7	-3	-10	-9	-12	-11
14	-4	-2	-11	-11	-10	-13

	LINE VOLTAGE			LINE CURRENT			POWER		FREQ.
TIME	L1-N	L2-N	L3-N	L1	L2	L3	KW	PF	HZ
0846	121.8	120.7	120.3	41.7	41.3	43.0	14.9	1.0	400
0846	121.9	120.6	120.3	41.7	41.4	43.0	14.9	1.0	400
0847	121.9	120.7	120.4	41.7	41.3	43.0	14.9	1.0	400
0848	121.9	120.7	120.4	41.7	41.3	43.0	14.9	1.0	400
0850	121.9	120.7	120.4	41.7	41.3	43.0	14.9	1.0	400
0852	122.0	120.8	120.4	41.7	41.4	43.0	14.9	1.0	400
0854	122.0	120.8	120.5	41.7	41.5	43.0	14.9	1.0	400
0856	122.1	120.9	120.5	41.7	41.5	43.1	15.0	1.0	399
0858	122.1	120.9	120.6	41.8	41.5	43.1	15.0	1.0	400
0900	122.1	120.9	120.6	41.8	41.5	43.1	15.0	1.0	400
0902	122.2	121.0	120.7	41.8	41.5	43.1	15.0	1.0	399
0904	122.1	120.9	120.6	41.8	41.5	43.1	15.0	1.0	400
0906	122.2	121.0	120.7	41.8	41.5	43.1	15.0	1.0	400
0908	122.2	121.0	120.7	41.8	41.5	43.1	15.0	1.0	400

[illegible] KW DED GENERATOR SET S/N [illegible] 05-NOV-85

	15 KW			30 KW		
#	#1	#2	#3	#1	#2	#3
15	-7	-5	-9	-9	-12	-12
16	-3	-7	-9	-11	-13	-13
17	-9	3	-9	-8	-10	-14
18	-3	-5	-10	-11	-9	-14
19	-6	-3	-7	-9	-12	-13
20	-4	9	-7	-8	-10	-11
21	4	13	-7	-10	-12	-12
22	5	20	-6	-9	-9	-11
23	5	18	-3	-9	-12	-9
24	1	23	-3	-9	-12	-8
25	7	34	-5	-12	-9	-9
26	8	40	-8	-11	-9	-10
27	-1	33	-6	-11	-13	-11
28	2	39	-8	-10	-9	-13

<====TEMPERATURES

TIME	LINE VOLTAGE L1-N	LINE VOLTAGE L2-N	LINE VOLTAGE L3-N	LINE CURRENT L1	LINE CURRENT L2	LINE CURRENT L3	POWER KW	POWER PF	FREQ. HZ
0909	122.2	121.0	120.7	41.8	41.6	43.1	15.0	1.0	399
0910	122.2	121.0	120.7	41.8	41.6	43.1	15.0	1.0	400
0920	122.3	121.1	120.7	41.9	41.6	43.1	15.0	1.0	399
0930	122.3	121.1	120.8	41.9	41.6	43.1	15.0	1.0	399
0940	122.3	121.1	120.8	41.9	41.6	43.1	15.0	1.0	399
0946	122.4	121.1	120.8	41.9	41.6	43.2	15.1	1.0	399

1[illegible] KW DED GENERATOR SET S/N [illegible] 05-NOV-85

#	15 KW #1	15 KW #2	15 KW #3	30 KW #1	30 KW #2	30 KW #3
1	8	46	-10	-9	-11	-13
2	8	46	-9	-8	-11	-13
3	10	39	-5	-9	-13	-9
4	8	30	-8	-12	-12	-11
5	20	19	-9	-11	-9	-11
6	20	28	-5	-8	-13	-9

<=====TEMPERATURES

	LINE VOLTAGE			LINE CURRENT			POWER		FREQ.
TIME	L1-N	L2-N	L3-N	L1	L2	L3	KW	PF	HZ
0946	121.7	120.5	121.1	---	---	---	0.0	1.0	400
0950	121.7	120.5	121.1	---	---	---	0.0	1.0	399
0957	121.7	120.5	121.1	---	---	---	0.0	1.0	400
1000	121.7	120.5	121.1	---	---	---	0.0	1.0	399
1010	121.8	120.5	121.1	---	---	---	0.0	1.0	400
1020	121.8	120.6	121.1	---	---	---	0.0	1.0	399
1030	121.7	120.5	121.1	---	---	---	0.0	1.0	399
1040	121.8	120.5	121.1	---	---	---	0.0	1.0	400
1045	121.8	120.5	121.1	---	---	---	0.0	1.0	399
1046	121.8	120.5	121.1	---	---	---	0.0	1.0	399

15 KW DED GENERATOR SET S/N KZ-W35B 05-NOV-85

	15 KW			30 KW		
#	#1	#2	#3	#1	#2	#3
1	21	27	-5	-9	-9	-9
2	20	27	-5	-10	-9	-8
3	18	45	-6	-11	-9	-12
4	22	52	-7	-10	-11	-11
5	20	63	-5	-10	-10	-9
6	22	68	-8	-11	-11	-13
7	24	67	-4	-11	-9	-11
8	26	67	-5	-11	-11	-12
9	26	69	-8	-11	-9	-14
10	28	67	-6	-10	-10	-14

<=====TEMPERATURES

- 40°F Amb.

1 Hr N/L operation

TIME	LINE VOLTAGE L1-N	L2-N	L3-N	LINE CURRENT L1	L2	L3	POWER KW	PF	FREQ. HZ
1047	122.4	121.2	120.9	41.9	41.7	43.2	15.1	1.0	399
1050	122.5	121.2	120.9	41.9	41.7	43.2	15.1	1.0	399
1055	122.4	121.1	120.8	41.9	41.6	43.2	15.1	1.0	399
1055	121.7	120.5	121.0	---	---	---	0.0	1.0	399

15 KW DED GENERATOR SET   S/N KZL0358   05-NOV-85

<=====TEMPERATURES

#	15 KW #1	#2	#3	30 KW #1	#2	#3
1	32	71	-8	-9	-11	-12
2	25	67	-6	-12	-10	-12
3	33	67	-6	-9	-12	-10
4	30	56	-7	-9	-11	-8

R/L to check ~~[illegible]~~ pump cycle at R/L. —

APPENDIX 5

30 KW at -25°F RETEST

TEST DATA

ITEM 30Kw DED Generator Set
400 Hz 120/208 Volts

MFGR. ______
MODEL NO. MEP 113A
SERIAL NO. RZ 40048

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Patriot Fuel Waxing Test at -25°F
DAVCO Fuel Heater System

TEST NO. ______
SHEET ______ OF ______
DATE 7 Nov 85
JOB NO. ______
PROJ. ENGR. ______
RECORDER/OBSERVER ______

INST →																	
HEAD NO																	
UNITS																	
SYM																	
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	DATE		TIME		AMPS		VOLTS										
	7 Nov 85		0810		30.02		23.0										
			0811		28.70		22.7										
			0812		28.72		22.6										
			0813		26.72		22.6										
			0814		28.13		22.6										
			0817		28.12		22.6										
			0821		43.99		26.5										
			0823		43.61		25.6										
			0824		48.21		25.5										
			1145		31.25		22.5										
			1149		31.03		22.6										
			1150		31.02		22.6										
			1152		43.49		25.0										

NOTES

STERBE FM 13 18 (Rev)

PREVIOUS EDITIONS ARE OBSOLETE.

[illegible] KW DED GENERATOR SET S/N RZ10048 07-NOV-85

STABILIZATION

TIME	TERMINAL VOLTS Van	Vbn	Vcn	LINE CURRENT Ia	Ib	Ic	POWER KW	PF	FREQ Hz
729	0.8	0.8	0.8	0.0	0.0	0.0	0.0	1.0	0.0
730	0.8	0.8	0.8	0.0	0.0	0.0	0.0	1.0	0.0
740	0.6	0.6	0.6	0.0	0.0	0.0	0.0	1.0	0.0
750	0.5	0.5	0.5	0.0	0.0	0.0	0.0	1.0	0.0
758	0.4	0.4	0.4	0.0	0.0	0.0	0.0	1.0	0.0
800	0.4	0.3	0.3	0.0	0.0	0.0	0.0	1.0	0.0
810	0.3	0.2	0.2	0.0	0.0	0.0	0.0	1.0	0.0
813	0.2	0.2	0.2	0.0	0.0	0.0	0.0	1.0	0.0
815	123.7	122.4	123.1	0.0	0.0	0.0	0.0	1.0	396.6
817	123.9	122.6	123.3	0.0	0.0	0.0	0.0	1.0	396.7

****

TEMPERATURES

#	#1	#2	#3	#1	#2	#3
1	-25	-25	-25	-25	-25	-25
2	-25	-25	-25	-25	-25	-25
3	-25	-25	-24	-25	-25	-24
4	-25	-25	-23	-25	-25	-23
5	-25	-25	-26	-25	-25	-25
6	-25	-25	-26	-25	-25	-25
7	-25	-25	-27	-25	-25	-27
8	-25	-25	-26	-25	-25	-25
9	-26	-25	-26	-25	-25	-23
10	-26	-25	-25	-25	-26	-23

[illegible] -25°F [illegible]

TIME	LINE VOLTAGE L1-N	L2-N	L3-N	LINE CURRENT L1	L2	L3	POWER KW	PF	FREQ. HZ
0822	124.0	122.7	123.5	---	---	---	0.0	1.0	397
0822	124.1	122.7	123.4	---	---	---	0.0	1.0	397
0823	124.1	122.7	123.5	---	---	---	0.0	1.0	397
0824	124.1	122.7	123.5	---	---	---	0.0	1.0	397
0825	124.1	122.8	123.5	---	---	---	0.0	1.0	397
0826	124.1	122.8	123.5	---	---	---	0.0	1.0	397
0827	124.1	122.8	123.5	---	---	---	0.0	1.0	397
0828	124.1	122.8	123.6	---	---	---	0.0	1.0	397
0829	124.2	122.9	123.6	---	---	---	0.0	1.0	397
0830	124.2	122.9	123.6	---	---	---	0.0	1.0	397
0830	124.0	123.2	123.5	75.7	79.5	79.6	28.8	1.0	397
0831	124.0	123.1	123.5	75.6	79.4	79.5	28.8	1.0	397
0832	---	---	---	---	---	---	0.0	1.0	0
0833	124.0	121.4	94.2	---	---	---	0.0	1.0	-9

(A)

30 KW DED GENERATOR SET S/N FZ A0046 07-NOV-85

<=====TEMPERATURES

#	15 KW #1	#2	#3	30 KW #1	#2	#3
1	-25	-26	-24	-22	-22	-19
2	-26	-25	-23	-22	-21	-18
3	-26	-25	-24	-23	-21	-17
4	-25	-26	-23	-22	-19	-17
5	-24	-26	-26	-21	-19	-16
6	-25	-25	-26	-20	-17	-18
7	-25	-25	-24	-18	-11	-16
8	-25	-25	-26	-18	-6	-15
9	-26	-25	-25	-18	14	-16
10	-24	-25	-25	-17	54	-17
11	-28	-27	-25	-21	65	-16
12	-28	-26	-31	-19	58	-15
13	-25	-25	-26	-16	59	-22
14	-25	-25	-26	-15	59	-15

(A) 30KW [illegible] warmup at N/L [illegible] Voltage and Frequency.

TIME	LINE VOLTAGE L1-N	L2-N	L3-N	LINE CURRENT L1	L2	L3	POWER KW	PF	FREQ. HZ
1110	---	---	---	---	---	---	0.0	1.0	0
1110	---	---	---	---	---	---	0.0	1.0	0
1114	---	---	---	---	---	---	0.0	1.0	0
1115	---	---	---	---	---	---	0.0	1.0	0
1120	---	---	---	---	---	---	0.0	1.0	0
1123	---	---	---	---	---	---	0.0	1.0	0
1130	---	---	---	---	---	---	0.0	1.0	0
1140	---	---	---	---	---	---	0.0	1.0	0
1150	---	---	---	---	---	---	0.0	1.0	0
1151	123.8	122.4	123.2	---	---	---	0.0	1.0	397
1152	124.2	122.9	123.6	---	---	---	0.0	1.0	397
1154	124.0	122.7	123.6	---	---	---	0.0	1.0	397
1156	124.2	122.9	123.6	---	---	---	0.0	1.0	397
1157	124.2	123.0	123.8	---	---	---	0.0	1.0	397

(A)

30 KW DED GENERATOR SET S/N [illegible] 07-NOV-85

<=====TEMPERATURES

#	15 KW #1	#2	#3	30 KW #1	#2	#3
1	-25	-24	-24	-23	104	-24
2	-25	-24	-25	-23	104	-24
3	-25	-24	-24	-23	89	-24
4	-25	-24	-24	-23	72	-24
5	-25	-24	-24	-23	66	-24
6	-25	-24	-23	-23	55	-23
7	-25	-24	-25	-23	41	-24
8	-25	-24	-28	-23	17	-27
9	-25	-24	-24	-23	11	-23
10	-26	-24	-25	-23	16	-18
11	-24	-25	-25	-23	21	-18
12	-26	-23	-24	-22	22	-19
13	-26	-24	-25	-20	24	-18
14	-26	-25	-24	-19	34	-14

(A) [illegible] fuel system modification

TIME	LINE VOLTAGE L1-N	L2-N	L3-N	LINE CURRENT L1	L2	L3	POWER KW	PF	FREQ. HZ
1200	124.2	122.9	123.7	---	---	---	0.0	1.0	397
1202	124.3	123.0	123.8	---	---	---	0.6	1.0	397
1204	124.5	123.2	123.9	---	---	---	1.0	1.0	397
1206	124.5	123.2	123.9	---	---	---	0.0	1.0	397
1207	---	---	---	---	---	---	0.0	1.0	0
1210	---	---	---	---	---	---	0.0	1.0	0

KW DED GENERATOR SET S/N -------- 07-NOV-85

#	15 KW #1	#2	#3	30 KW #1	#2	#3
15	-25	-24	-25	-16	45	-15
16	-24	-24	-26	-14	56	-14
17	-26	-24	-26	-13	58	-13
18	-25	-24	-26	-11	60	-13
19	-25	-24	-27	-11	60	-22
20	-25	-24	-27	-10	57	-25

<====TEMPERATURES

30KW at -25°F NIL OPERATION After FUEL SYSTEM MODIFICATION

APPENDIX 6

15 KW at -15°F

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Stanadyne Fuel Heater At – 15°F Amb.

ITEM 15KW DED Generator Set
400 HZ 120/208 Volts

MFGR. ____
MODEL NO. ____
SERIAL NO. ____

TEST NO. ____
SHEET ____ OF ____
DATE 12 Dec 85
JOB NO. 6031
PROJ. ENGR. Ferguson
RECORDER/OBSERVER Seay

INST. →																	
READ NO.																	
UNITS		TIME		VOLTS		AMPS		AMPS									
SYM						X 1.5											
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	A	1049:45		22.0		19.24		28.86									
	A	1050:45		22.0		18.53		27.80									
	A	1051:45		22.0		18.34		27.51									
	A	1052:45		22.0		18.45		27.68									
	A	1053:45		19.0		15.90		23.85									
	B	1058:45		18.0		15.11		22.67									
	B	1100:45		20.6		16.90		25.35									
	B	1102:45		20.5		16.59		24.89									
	B	1104:45		20.4		16.36		24.54									
	B	1106:45		23.5		18.14		27.21									
	B	1108:45		23.0		18.45		27.68									
	B	1110:45		23.0		18.48		27.72									

NOTES: (A) Represents Voltage / Current during 4 mins Heater on Day Tank and Secondary Prior to Unit Start Attempt
(B) Represents Voltage / Current during Unit Start Attempt – Unit on 20 Volt House Power, Unit would start but slow acceleration – Examination after testing termination revealed failed O-Ring at Fuel Inlet

STRBE FM 13 18 (Rev)
1 Nov 83

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Stanadyne Fuel System Heater At -15°F Amb.

ITEM 15KW DED Generator Set
400 Hz 120/208 Volts

MFGR. ______
MODEL NO. ______
SERIAL NO. ______

TEST NO. ______
SHEET ______ OF ______
DATE 12 Dec 85
JOB NO. 6031
PROJ. ENGR. Ferguson
RECORDER/OBSERVER Gray

INST. →																	
READ NO.																	
UNITS	DATE	TIME		DAY TANK		MAIN TANK		AMB AIR									
SYM																	
COL.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	11DEC85	0730		-15°F		-15°F		-16°F									
	12DEC85	0745		-15°F		-15°F		-15°F									
		0835		-15°F		-16°F		-15°F									
		1045		-16°F		-16°F		-16°F									
		1115		+96°F		-12°F		-19°F									
		1135		+100°F		+5°F		-8°F									
		1200		+70°F		+8°F		0°F									

NOTES

STRBE FM 13 18 (Rev)
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PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM 15KW DED GENERATOR SET
400 HZ 120/208 VOLTS

MFGR.
MODEL NO.
SERIAL NO.

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Stanadyne Fuel System Heater At − 15°F Amb.

TEST NO.
SHEET ____ OF ____
DATE 12 Dec 85
JOB NO. 6031
PROJ. ENGR. [illegible]
RECORDER/OBSERVER [illegible]

INST → READ NO ↓	TIME	TERMINAL VOLTAGE x	x	x	LINE CURRENT x	x	x	POWER x	x	x	x	POWER FACTOR	FREQ.	EXCITER FIELD			AVG. AMB.
UNITS	HOURS	VOLTS	VOLTS	VOLTS	AMPS	AMPS	AMPS	WATTS	WATTS	WATTS	KW	DEC.	HZ	VOLTS	AMPS		OF
SYM		L1 LO	L2 LO	L3 LO	L1	L2	L3	L1	L2	L3	TOTAL						
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
[illegible]		[illegible]	[illegible]	130.1													
[illegible]		[illegible]	[illegible]	[illegible]							372.5						
[illegible]		[illegible]	[illegible]	[illegible]							[illegible]						
[illegible]		[illegible]	[illegible]	[illegible]							372.5						

Testing at −15°F Amb. [illegible] because unit would not [illegible] [illegible]. Exhaust [illegible] [illegible] found O-ring on fuel line to injection pump [illegible] [illegible] [illegible] [illegible] pressure to [illegible] injectors.

NOTES

APPENDIX 7

30 KW at -15°F

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

DAVCO (DIESEL-PRO) FUEL SYSTEM HEATERS AT -15°F AMB.

ITEM 30KW DED GENERATOR SET
400HZ 120/208 VOLTS

MFGR. ______
MODEL NO. ______
SERIAL NO. ______

TEST NO. ______
SHEET ______ OF ______
DATE 12 DEC 85
JOB NO. 6031
PROJ. ENGR. FERGUSON
RECORDER/OBSERVER SEAY

INST →

REAL. NO. ↓

UNITS		TIME		VOLTS		AMPS		AMPS									
SYM						X.33											
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	(A)	0824		23.0		57.0		19.0									
	(A)	0825		23.0		55.5		18.5									
	(A)	0826		23.0		55.5		18.5									
	(A)	0827		23.0		55.5		18.5									
	(A)	0828		23.0		55.5		18.5									
	(B)	0829		26.2		68.0		24.6									
	(B)	0830		26.0		81.0		24.0									
	(C)	0848		26.0		23.0		7.6									
	(C)	0918		26.1		23.0		7.6									
	(C)	0948		26.1		23.0		7.6									
	(C)	1018		26.1		23.0		7.6									
	(C)	1048		26.1		23.0		7.6									

NOTES:
(A) REPRESENTS VOLTAGE/CURRENT READINGS DURING 4 MINS. HEATER APPLICATION DAY TANK AND SECONDARY FILTER
(B) REPRESENTS VOLTAGE/CURRENT. UNIT RUNNING ALL HEATERS ON
(C) REPRESENTS VOLTAGE/CURRENT READINGS HEATER TO PRIMARY HEATER ON.

STRBE FM 13 18 (Rev)
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PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

DAVCO Fuel System Heater At -15°F Amb

ITEM 30KW DED Generator Set 400HZ 120/208 Volts

MFGR.

MODEL NO.

SERIAL NO.

TEST NO.

SHEET ___ OF ___

DATE 12 Dec 85

JOB NO. 6031

PROJ. ENGR. Erickson

RECORDER/OBSERVER Sery

INST →

HEAD NO

UNITS	DATE	TIME		DAY TANK		MAIN TANK		AMB AIR
SYM				°F		°F		°F
COL	1	2	3	4	5	6	7	8
	11 DEC 85	0730		-15°F		-15°F		-16°F
	12 DEC 85	0745		-15°F		-15°F		-15°F
	↑	0808		-16°F		-15°F		-15°F
		0820		-15°F		-15°F		-15°F
		0834		+25°F		-14°F		-13°F
		0850		+71°F		-5°F		-14°F
		0908		+54°F		+2°F		-15°F
		0922		+52°F		+2°F		-17°F
		0940		+51°F		+3°F		-15°F
		0948		+51°F		+4°F		-16°F
		1018		+41°F		+3°F		-16°F
		1048		+53°F		+5°F		-13°F
	↓	1115		+87°F		+10°F		-10°F
	12 DEC 85	1200		+87°F		+15°F		-8°F

NOTES

STRBE FM 13 18 (Rev) 1 Nov 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM 30KW DED Generator Set
400 Hz 120/208 Volts

MFGR. ______

MODEL NO. ______

SERIAL NO. ______

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

DAVCO Fuel Heater System At -15°F Amb

TEST NO. ______
SHEET ______ OF ______
DATE 12 Dec 85
JOB NO. 6031
PROJ. ENGR. Ferguson
RECORDER/OBSERVER [illegible]

INST →		TERMINAL VOLTAGE			LINE CURRENT			POWER				POWER FACTOR	FREQ.	EXCITER FIELD			AVG. AMB.
READ NO	TIME																
UNITS	HOURS	VOLTS	VOLTS	VOLTS	AMPS	AMPS	AMPS	WATTS	WATTS	WATTS	KW	DEC.	HZ	VOLTS	AMPS		OF
SYM		L1 L0	L2 L0	L3 L0	L1	L2	L3	L1	L2	L3	TOTAL						
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
													[illegible]				
		[illegible]	[illegible]	121.8									403.5				
[illegible]																	
[illegible]		[illegible]8	123.?	122.2	2.07	2.04	2.05	250	250	251			403.5				
[illegible]		123.4	123.3	122.5									403.6				
[illegible]		[illegible]	123.3	[illegible]	2.09	[illegible]	[illegible]	[illegible]	250	251			403.5				
[illegible]20		[illegible]	123.2	122.5									403.6				
[illegible]		122.?	123.3	122.?	2.08	2.04	2.05	250	250	251			403.5				
[illegible]		123.5	123.3	122.5									403.6				
[illegible]		[illegible]	[illegible]	[illegible]	2.05	2.04	2.05	251	250	251			403.5				
[illegible]		[illegible]	122.7	121.9	[illegible]	[illegible]	2.04	249	248	249			[illegible]				
[illegible]		122.5	122.8	121.8	2.08	2.03	2.04	249	246	249			403.8				
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	249	[illegible]	[illegible]			[illegible]				
[illegible]		[illegible]	122	121.5	[illegible]	[illegible]		244	24?	244			[illegible]				
[illegible]		[illegible]	[illegible]	[illegible]									404.5				
[illegible]		[illegible]	123.?	122.5									404.5				
[illegible]		123.?	[illegible]	122.6									404.5				

NOTES

PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL EXHAUSTED

APPENDIX 8

15 KW at -15°F

TEST DATA

ITEM 15KW DED Generator Set
400HZ. 120/208 Volts

MFGR. ____

MODEL NO. ____

SERIAL NO. ____

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

DAVCO (DIESEL PRO) Fuel System Heaters At -15°F Amb.

TEST NO. ____
SHEET ____ OF ____
DATE 14 DEC 85
JOB NO. 8031
PROJ. ENGR. [illegible]
RECORDER/OBSERVER [illegible]

INST →																	
READ NO																	
UNITS		TIME		VOLTS		AMPS		AMPS		TIME		VOLTS		AMPS			
SYM				x1		x.6		—									
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		1106:30		23.70		32.50		19.50		1300:00		24.20		—			
		1107:30		23.50		32.14		19.28		1330:00		24.20		—			
*	(A)	1108:30		23.40		32.07		19.24		1400:00		24.50		—			
		1109:30		23.30		32.04		19.22		1430:00		24.50		—			
		1110:30		23.30		32.01		19.21									
		1110:55		26.50		46.70		24.22									
		1112:00		24.50		45.72		27.43									
		1114:00		24.50		45.53		27.32									
		1115:00		24.50		45.25		27.15									
		1116:00		24.40		45.01		27.00									
		1117:00		24.40		44.98		26.99									
**	(B)	1118:00		24.40		44.88		26.93									
		1119:00		24.40		44.86		26.92									
		1120:00		24.40		44.81		26.89									
		1121:00		24.20		44.73		[illegible]									
		1122:00		24.20		44.70		26.82									
		1125:00		24.20		44.64		26.78									
***	(C) -	1130:00		24.50		14.11		[illegible]									
		1135:00		30.00		0		—									
		1200:00		29.60		—		—									
		1230:00		29.50		—		—									

* (A) Represents Voltage / Current Readings During 4 mins Heater Application (Day Tank / Secondary Filter)
** (B) Represents Voltage / Current Reading After Unit Running [illegible] Warm-up - All Heaters ON (Day Tank; Secondary and Primary Heaters)
*** (C) Represents Voltage / Current Reading With Only Primary Heater Operating

STRBE FM 13 18 (Rev)
1 Nov 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM 15KW DED Generating Set 400Hz 120/208 Volts

MFGR. ______

MODEL NO. ______

SERIAL NO. ______

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

DAVCO Fuel System Heater At -15°F Amb.

TEST NO. ______

SHEET ______ OF ______

DATE 14 Dec 85

JOB NO. 6031

PROJ. ENGR. Ferguson

RECORDER/OBSERVER Sgoy

INST. →

READ NO

UNITS / SYM / COL	DATE 1	TIME 2	3	DAY TANK °F 4	5	MAIN TANK °F 6	7	AMB AIR °F 8	9	10	11	12	13	14	15	16	17
	13DEC85	0125		-12		-2		-17									
		0315		-15		-8		-15									
		0705		-16		-14		-15									
		0930		-16		-14		-16									
		1150		-17		-16		-18									
		1750		-18		-17		-18									
	14DEC85	0360		-16		-16		-18									
		0740		-16		-15		-16									
		0835		-22		-22		-21									
		0947		-22		-21		-21									
		1167		-19		-17		-17									
		1111		-17		-16		-18									
		1140		+62		+5		-5									
		1203		+76		+11		-5									
		1300		+74		+22		-7									
		1330		+75		+24		-8									
		1400		+70		+23		-7									
		1430		+68		+23		-6									

NOTES

STRBE FM 13 18 (Rev) 1 Feb 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

DAVCO Fuel System Heater at -15°F Amb.

ITEM 15KW DED Generator Set
400 Hz 120/208 Volts

MFGR. ______
MODEL NO. ______
SERIAL NO. ______

TEST NO. ______
SHEET ______ OF ______
DATE 14 Dec 85
JOB NO. ______
PROJ. ENGR. Ferguson
RECORDER/OBSERVER [illegible]

INST →		TERMINAL VOLTAGE			LINE CURRENT			POWER				POWER FACTOR	FREQ.	EXCITER FIELD			AVG. AMB.
READ NO	TIME	x	x	x	x	x	x	x	x	x	x						
UNITS	HOURS	VOLTS	VOLTS	VOLTS	AMPS	AMPS	AMPS	WATTS	WATTS	WATTS	KW	DEC.	HZ	VOLTS	AMPS		OF
SYM		L1 L0	L2 L0	L3 L0	L1	L2	L3	L1	L2	L3	TOTAL						
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	[illegible]	117.7	117.5	[illegible]									400				
	[illegible]	[illegible]	112.5	[illegible]									400				
	[illegible]	[illegible]	[illegible]	[illegible]									[illegible]				
	[illegible]	[illegible]	[illegible]	[illegible]									400				
	[illegible]	[illegible]	112.5	[illegible]									400				
	[illegible]	[illegible]	[illegible]	[illegible]									400				
	[illegible]	[illegible]	[illegible]	[illegible]									400				
	[illegible]	[illegible]	[illegible]	[illegible]									400				
	[illegible]	[illegible]	[illegible]	[illegible]									400.1				
	[illegible]	[illegible]	[illegible]	[illegible]									400.2				
	[illegible]	[illegible]	[illegible]	[illegible]									400.3				
	[illegible]	[illegible]	[illegible]	[illegible]									400.3				
	[illegible]	[illegible]	117.5	[illegible]	1.11	1.05	[illegible]	126	125	125			399.8				
	[illegible]	[illegible]	112.7	[illegible]									400.0				
		117.7	117.5	[illegible]	1.11	[illegible]	[illegible]	125	126	127			399.8				
		[illegible]	117.2	[illegible]									399.8				
		117.7	[illegible]	[illegible]	1.11	[illegible]	[illegible]	126	126	127			399.8				
		[illegible]	[illegible]	[illegible]									399.8				
	[illegible]	[illegible]	117.5	[illegible]	[illegible]	[illegible]	1.04	126	126	127			399.8				
	[illegible]	118.1	117.9	[illegible]	1.11	[illegible]	1.09	127	[illegible]	128			399.6				
	[illegible]	[illegible]	[illegible]	[illegible]	1.11	1.08	1.04	127	[illegible]	[illegible]			399.5				
	[illegible]	[illegible]	[illegible]	117.2	1.11	[illegible]	[illegible]	127	127	128			399.5				
	[illegible]	[illegible]	117.9	[illegible]	1.11	1.08	1.09	127	127	128			399.5				
	[illegible]	[illegible]	118.2	117.5									399.6				
	[illegible]	[illegible]	[illegible]	117.3									399.5				

NOTES [illegible] [illegible] [illegible] [illegible] 399.5

APPENDIX 9

30 KW at -15°F

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Standadyne Fuel Heater System At - 15°F Amb.

ITEM 30 KW DED Generator Set
400 HZ. 120/208 Volts

MFGR. ______
MODEL NO. ______
SERIAL NO. ______

TEST NO. ______
SHEET ______ OF ______
DATE 14 Dec 85
JOB NO. 6031
PROJ. ENGR. Ferguson
RECORDER/OBSERVER Seay

INST →																	
HEAD NO																	
UNITS		TIME		VOLTS		AMPS		AMPS									
SYM		—		—		X.75		—									
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		0838:10		23.3		24.0		18.00									
		0839:10		23.2		22.5		16.87									
*	(A)	0840:10		23.2		22.5		16.87									
		0841:10		23.2		22.5		16.87									
		0842:10		23.2		22.5		16.87									
		0842:55		24.6		34.0		29.25									
		0843:55		24.6		38.5		28.87									
		0845:55		24.4		38.0		28.50									
**	(B)	0847:30		24.4		38.0		28.50									
		0850:50		24.2		37.0		27.75									
		0856:50		24.0		36.5		27.37									
		0902:00		25.0		24.0		18.00									
		0932:00		25.2		24.0		[illegible]									
***	(C)	1002:00		25.2		24.0		[illegible]									
		1032:00		25.2		24.0		18.00									
		1102:00		25.3		24.0		18.00									
		1132:00		26.2		—		—									
		1202:00		26.2		—		—									

NOTES:
* (A) Represents Voltage/Current Readings During 4 Mins Heater Application (Day Tank and Secondary Filter)
** (B) Represents Voltage/Current Readings After Unit Running During 14 Mins. Warm-Up. All Heaters On (Day Tank/Primary and Secondary)
*** (C) Represent Voltage/Current Reading During Unit Operation At Rated Load - Primary Heater Off

STRBE FM 13 18 (Rev) 1 Nov 83

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

ITEM 30KW DED Generator Set
400 HZ 120/208 Volts

MFGR.
MODEL NO.
SERIAL NO.

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR
RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Stanadyne Fuel System Heater At −15°F Amb

TEST NO.
SHEET ____ OF ____
DATE 14 Dec 85
JOB NO. 6031
PROJ. ENGR. Ferguson
RECORDER/OBSERVER Spry

INST. →																	
READ NO.																	
UNITS	DATE	TIME		DAY TANK		MAIN TANK		AMB. AIR									
SYM				°F		°F		°F									
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	13DEC85	0125		-12		-2		-17									
		0315		-14		-8		-15									
		0705		-16		-14		-16									
		0830		-15		-14		-15									
		1150		-17		-16		-18									
		1750		-18		-17		-18									
	14DEC85	0300		-16		-16		-18									
		0740		-15		-15		-16									
		0835		-22		-22		-21									
		0847		-13		-15		-12									
		0851		+8		-20		-16									
		0901		+61		-15		-10									
		1001		+88		+4		-11									
		1031		+83		+6		-9									
		1101		+86		+9		-9									
		1140		+81		+22		+4									
		1203		+86		+22		-6									

NOTES

STRBE FM 13 18 (Rev)
1 Nov 81

PREVIOUS EDITIONS ARE OBSOLETE.

TEST DATA

TEST AND EVALUATION DIVISION
PRODUCT ASSURANCE & TESTING DIRECTORATE
U.S. ARMY BELVOIR RESEARCH & DEVELOPMENT CENTER
FORT BELVOIR, VIRGINIA

Standadyne Fuel System - Heater At - 15°F Amb.

ITEM 30KW DED Generator Set
400 HZ 120/208 Volts

MFGR. ______
MODEL NO. ______
SERIAL NO. ______

TEST NO. ______
SHEET ______ OF ______
DATE 14 Dec 85
JOB NO. ______
PROJ. ENGR. Ferguson
RECORDER/OBSERVER Sepy

INST →		TERMINAL VOLTAGE			LINE CURRENT			POWER				POWER FACTOR	FREQ.	EXCITER FIELD			AVG. AMB.
READ NO	TIME	X	X		X	X	X	X	X	X	X						
UNITS	HOURS	VOLTS	VOLTS	VOLTS	AMPS	AMPS	AMPS	WATTS	WATTS	WATTS	KW	DEC.	HZ	VOLTS	AMPS		OF
SYM		L1 LO	L2 LO	L3 LO	L1	L2	L3	L1	L2	L3	TOTAL						
COL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	[illegible]	123.9	123.6	122.9									400.5				
	[illegible]	[illegible]	123.7	122.7									400.5				
	[illegible]	123.5	123.5	122.7									400.3				
	[illegible]	123.4	123.5	122.7									400.3				
	[illegible]	[illegible]	123.5	123.									400.2				
	[illegible]	124.3	124.1	123.3									400.5				
	[illegible]	123.8	124.1	123.3	2.07	2.03	2.03	251	251	250			[illegible]				
		124.0	124.2	123.4									402.5				
		123.8	124.3	123.2	2.07	2.03	2.03	251	251	250			400.5				
		[illegible]	124.2	123.3									400.6				
		[illegible]	124.2	123.2	2.07	2.03	2.03	251	251	250			400.8				
		124.3	124.1	123.3									400.6				
	[illegible]	123.8	124.1	123.1	2.07	2.03	2.02	250	251	250			400.5				
	[illegible]	[illegible]	124.3	123.3	2.07	2.03	2.03	251	251	250			401.0				
	[illegible]	123.7	[illegible]	123.1	2.07	2.03	2.02	251	250	250			401.4				
	[illegible]	[illegible]	124.1	123.2	2.07	2.03	2.03	[illegible]	250	250			401.4				
	[illegible]	123.8	124.1	123.2	2.07	2.03	2.02	251	251	250			401.3				
	[illegible]	124.3	124.0	123.3									401.5				
	[illegible]	[illegible]	124.4	123.7									402.0				
	[illegible]	124.7	124.5	123.8									402.5				

NOTES

STEAP FL 13-46 (Rev)
1 Oct 85

PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL EXHAUSTED

APPENDIX 10

TEST PROCEDURES
FOR
PATRIOT FUEL WAXING

OCTOBER 21, 1985

PATRIOT FUEL STUDY
STARTING AND OPERATING TEST

I. PURPOSE:

To determine the 15kW and 30kW generator set changes required to permit operation at 0°F, -10°F, and -25°F with OCONUS Diesel Fuel Oil Grade DF-2.

II. APPARATUS:

A. Instrumentation for measuring load conditions, power, voltage and current; ambient and set temperature shall be as described and illustrated in MIL-HDBK-705. In addition, recording meter(s) for recording voltage and frequency (speed) shall be required. The recording meter(s) shall be as described and illustrated in MIL-HDBK-705, Methods 101.1 and 104.1. Set instrumentation may be used in lieu of laboratory instruments.

B. The climatic chamber at the Belvoir Research and Development Center shall be used for obtaining environmental conditions.

III. PREPARATION FOR TEST:

A. Install thermocouples in the main fuel tank and day tank.

B. The instrumentation for the chamber shall be the instrumentation normally employed.

C. Start and operate the generator set until the lubricating oil is warm enough to drain. Drain the coolant from the engine block, the radiator, coolant pump, and all coolant lines. Be sure that the set is completely drained. Fill the coolant system with the proper solution of antifreeze.

D. Drain the fuel from the main fuel tank and the day tank, and flush both tanks using DF-2 OCONUS fuel. Remove filters from electric transfer pumps. Install the new components that will be used for the test. Add DF-2 OCONUS fuel to the main fuel tank (2.5 gallon for the 15kW and 5 gallon for the 30kW). Prime the fuel system.

E. Drain the lubricating oil from the engine, filters, strainer and lines. Install new filter and clean strainers. Use new gaskets. Fill with proper grade lubricating oil (Arctic oil).

F. Operate the ether system. See that all controls operate properly.

G. Check instruction manual or operating and servicing instructions to see that all set requirements or recommendations have been performed.

H. Start and operate the generator set for approximately 15 minutes at no load to allow the fuels and lubricants to thoroughly circulate. During this period open oil lines at gages and safety controls to drain normal temperature oil. Shut down the set and drain the fuel from the day tank. Refill the day tank using the electric fuel pumps. Fill and label a small container with a sample (approximately 8 ounces of fuel).

I. Determine that the batteries have been cycled and completely charged (see MIL-HDBK-705, Method 222.1) before placing them in the climatic chamber.

J. Place container of fuel in the climatic chamber.

K. Place the generator set in the climatic chamber.

L. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, Method 205.1, paragraph 205.1.10 for one of the voltage connections. Connect the signal input of the recording meter(s) to the convenience receptacle of the set. (Power the recording meter(s) from the commercial utility.)

M. Where temperature measurements are made by means of thermocouples, the thermocouple leads shall be brought out of the climatic chamber to permit the temperature to be read by instruments located in normal ambient temperatures. All electrical instruments, except those provided as part of the generator set, shall be located outside the climatic chamber with the exception of shunts used in determining field current.

IV. TEST:

A. Decrease the temperature in the climatic chamber; when the ambient temperature reaches 25°F (-4°C), fill the set tank to 50% of capacity. Fill and label a small container with a sample of the fuel used. Place this sample in a location in the climatic chamber where it may be observed.

B. Expose the complete generator set (including all fuels, lubricants, coolants, and hydraulic oils to be used during this method) to 0°F until such time as all components are at 0°F temperature for 24 hours. During all steps of this test, all ambient thermocouples shall indicate temperatures equal to or colder than 0°F throughout the test.

C. Measure battery voltage and current four minutes prior to attempt to starting the set, apply power from the set batteries to the components containing heaters. Record the time when cranking is started. Record the time when the set starts.

D. Allow the engine to warm up at no load, rated voltage, and rated frequency for a period of 14 minutes.

E. Within 15 minutes after engine starts, apply rated load in one step. Leave rated load on the set for 30 seconds, then drop the load to no load in one step. Operate at no load for 30 seconds. Apply and drop rated load two more times with 30 seconds of operation at each load condition. Next apply no load to 15kW and operate the set for 2 hours, then apply rated load for 1 hour. Apply rated load to 30kW for 1 hour, then no load for 2 hours.

F. After the test at -10°F, increase the temperature of the chamber to 80°F and operate the set until the fuel temperature in the main tank and the day tank is 70°F.

V. RESULTS:

A. Observations:

(1) Determine if the fuel is flowing through the clear tubing.

(2) Determine if there were bubbles in the fuel lines.

(3) Determine the stoppage locations if the fuel did not flow, if possible.

B. Determine if the generator set was able to start and operate at no load 5 minutes after power was applied to the heated components.

C. Determine if the generator set was able to operate at no load, and rated load, rated voltage, and rated frequency for 3 hours after 15 minutes of operation at no load, rated voltage, and rated frequency.

VI. TEST CONTINUANCE:

Repeat the entire test procedure at -10°F and then at -25°F after a 20-hour soak period using slave or house power if the following occurred for each previous test temperature:

A. Clear and smooth fuel flow.

B. The generator set started 5 minutes after power was applied to the heated components.

C. The generator set operated at rated load, rated voltage, and rated frequency for 3 hours after 15 minutes of operation at no load, rated voltage, and rated frequency.

PATRIOT FUEL STUDY

STARTING AND OPERATING TEST

I. PURPOSE: To determine the 15kW and 30kW generator set ~~changes required~~ to permit operation at $0^{\circ}F$, $-10^{\circ}F$, and $-25^{\circ}F$ with OCONUS Diesel Fuel Oil Grade DF-2.

II. APPARATUS:

A. Instrumentation for measuring load conditions, power, voltage and current; ambient and set temperature shall be as described and illustrated in MIL-HDBK-705. In addition, recording meter(s) for recording voltage and frequency (speed) shall be required. The recording meters shall be as described and illustrated in MIL-HDBK-705, Methods 101.1 and 104.1. Set instrumentation may be used in lieu of laboratory instruments.

B. The climatic chamber at the Belvoir Research and Development Center shall be used for obtaining environmental conditions.

III. PREPARATION FOR TEST:

A. Install thermocouples in the main fuel tank, and day tank. ~~The thermocouples shall be located approximately 1 1/2 inches from the bottom of each tank. The wires to the main tank shall enter at the same location as the fuel sensor. The thermocouple in the day tank shall be in the fuel drain port.~~

B. The instrumentation for the chamber shall be the instrumentation normally employed.

D. ~~C.~~ Start and operate the generator set until the lubricating oil is warm enough to drain. Drain the coolant from the engine block, the radiator, coolant pump, and all coolant lines. Be sure that the set is completely drained. Fill the coolant system with the proper solution of antifreeze.

C. ~~D.~~ Drain the fuel from the main fuel tank and the day tank, and flush both tanks using DF-2 OCONUS fuel. Remove filters from electric transfer pumps. Install the new components that will be used for the test. Add DF-2 OCONUS fuel to the main fuel tank. (2.5 gallon for the 15kW and 5 gallon for the 30kW) Prime the fuel system.

E. Drain the lubricating oil from the engine, filters, strainer and lines. Install new filter and clean strainers. Use new gaskets. Fill with proper grade lubricating oil. ARTIC OIL

F. Operate the ether system. See that all controls operate properly.

G. Check instruction manual or operating and servicing instructions to see that all set requirements or recommendations have been performed.

H. Start and operate the generator set for approximately 15 minutes at no load to allow the fuels and lubricants to thoroughly circulate. During this period open oil lines at gages and safety controls to drain normal temperature oil. Shut down the set and drain the fuel from the day tank. Refill the day tank using the electric fuel pumps. Fill and label a small container with a sample (approximately 8 ounces of fuel).

I. Determine that the batteries have been cycled and completely charged (see MIL-HDBK-705, Method 222.1) before placing them in the climatic chamber.

J. Place container of fuel in the climatic chamber.

K. Place the generator set in the climatic chamber.

L. Connect the load instrumentation in accordance with the applicable figure of MIL-HDBK-705, Method 205.1, paragraph 205.1.10 for one of the voltage connections. Connect the signal input of the recording meter(s) to the convenience receptacle of the set. (Power the recording meter(s) from the commercial utility).

M. Where temperature measurements are made by means of thermocouples, the thermocouple leads shall be brought out of the climatic chamber to permit the temperature to be read by instruments located in normal ambient temperatures. All electrical instruments, except those provided as part of the generator set, shall be located outside the climatic chamber with the exception of shunts used in determining field currents.

IV. TEST:

A. Decrease the temperature in the climatic chamber; when the ambient temperature reaches 25°F (-4°C), fill the set tank to 50% of capacity. Fill and label a small container with a sample of the fuel used. Place this sample in a location in the clamitic chamber where it may be observed.

B. Expose the complete generator set (including all fuels, lubricants, coolants and hydraulic oils to be used during this method) to 0°F until such time as all components are at 0°F temperature for 24 hours. During all steps of this test, all ambient thermocouples shall indicate temperatures equal to or colder than 0°F throughout the test.

C. Four minutes prior to attempt to starting the set, apply power from the set batteries to the components containing heaters. Record the time when cranking is started. Record the time when the set starts.

D. Allow the engine to warm up at no load, rated voltage and rated frequency for a period of 14 minutes.

E. Within 15 minutes after engine starts, apply rated load in one step. Leave rated load on the set for 30 seconds, then drop the load to no load in one step. Operate at no load for 30 seconds. Apply and drop rated load two more times with 30 seconds of operation at each load condition. Next apply ~~rated~~ NO load and operate the set for 3 hours.

V. RESULTS:

A. Observations:

(1) Determine if the fuel is flowing through the clear tubing.

(2) Determine if there were bubbles in the fuel lines.

(3) Determine the stoppage locations if the fuel did not flow, if possible.

B. Determine if the generator set was able to start and operate at no load 5 minutes after power was applied to the heated components.

C. Determine if the generator set was able to operate at ~~rated~~ NO load, rated voltage, and rated frequency for 3 hours after 15 minutes of operation at no load, rated voltage, and rated frequency.

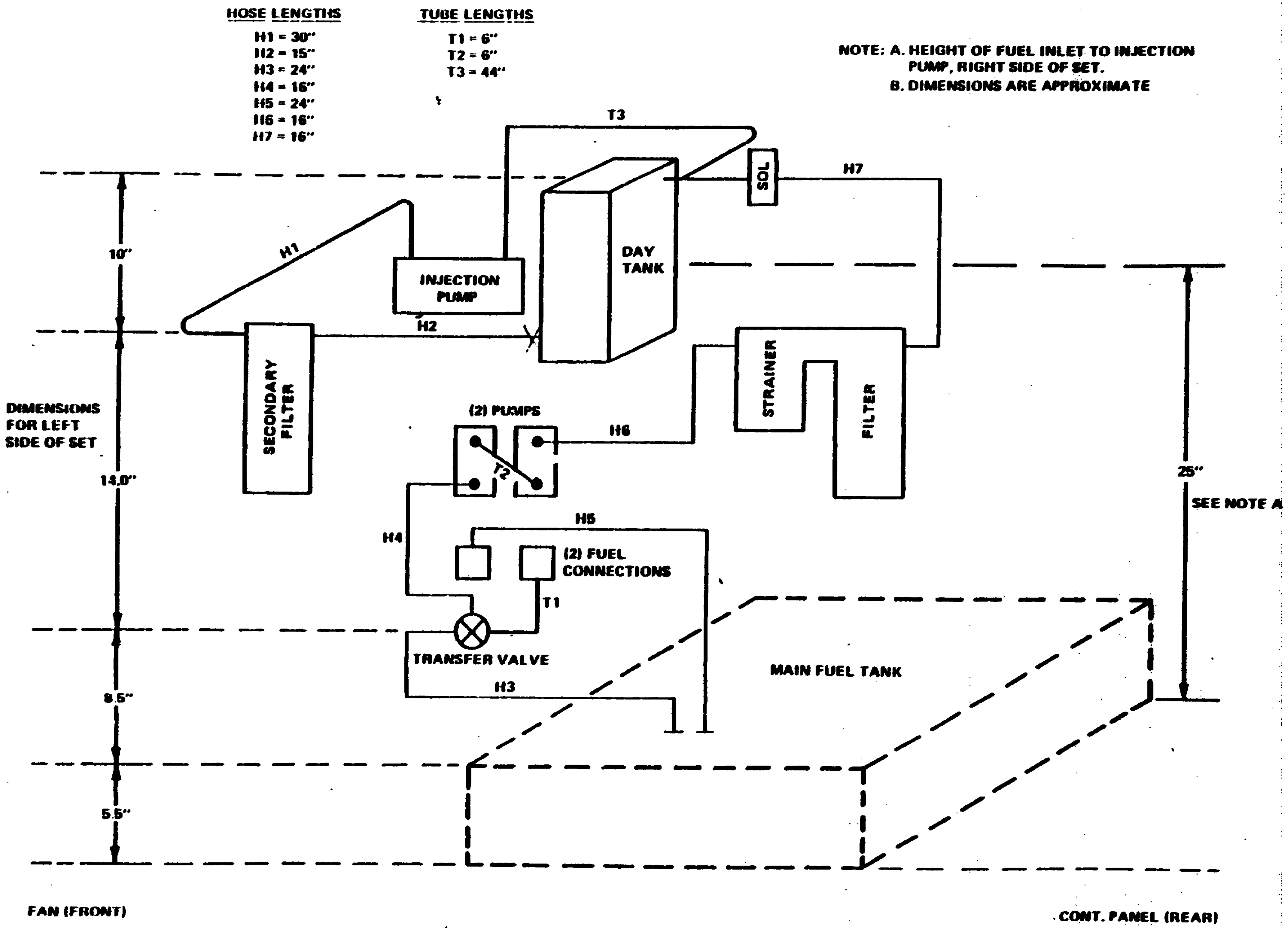
VI. TEST CONTINUANCE: Repeat the entire test procedure at -10°F and then at -25°F after a 20 hour soak period if the following occurred for each previous test temperature:

A. Clear and smooth fuel flow.

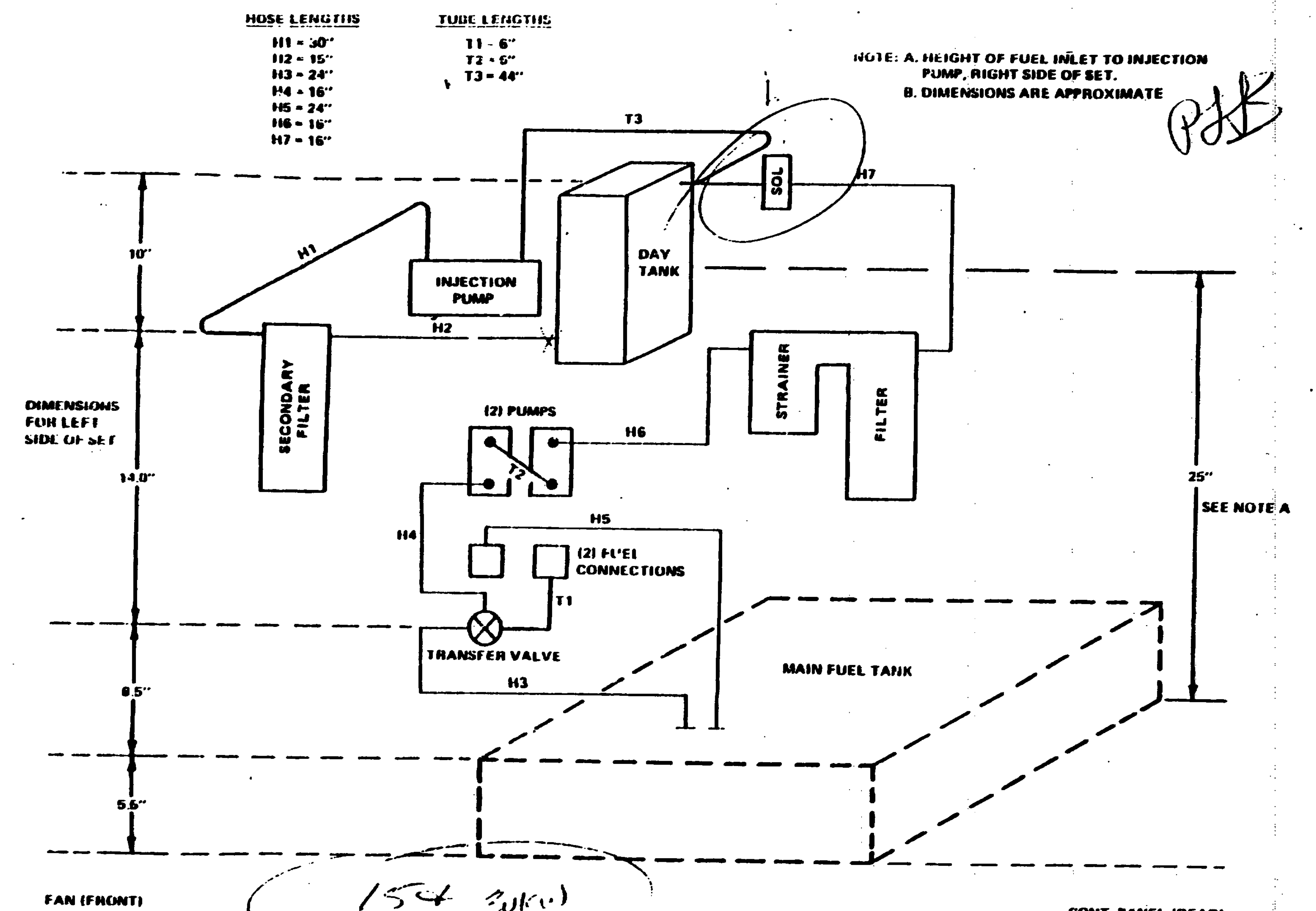
B. The generator set started 5 minutes after power was applied to the heated components.

C. The generator set operated at rated load, rated voltage, and rated frequency for 3 hours after 15 minutes of operation at no load, rated voltage, and rated frequency.

170



FUEL SYSTEM, 30 KW GENERATOR SET, MEP 114A, PATRIOT



FUEL SYSTEM, 30 KW GENERATOR SET, MEP 114A, PATRIOT

APPENDIX 11

INSTRUMENTATION LIST

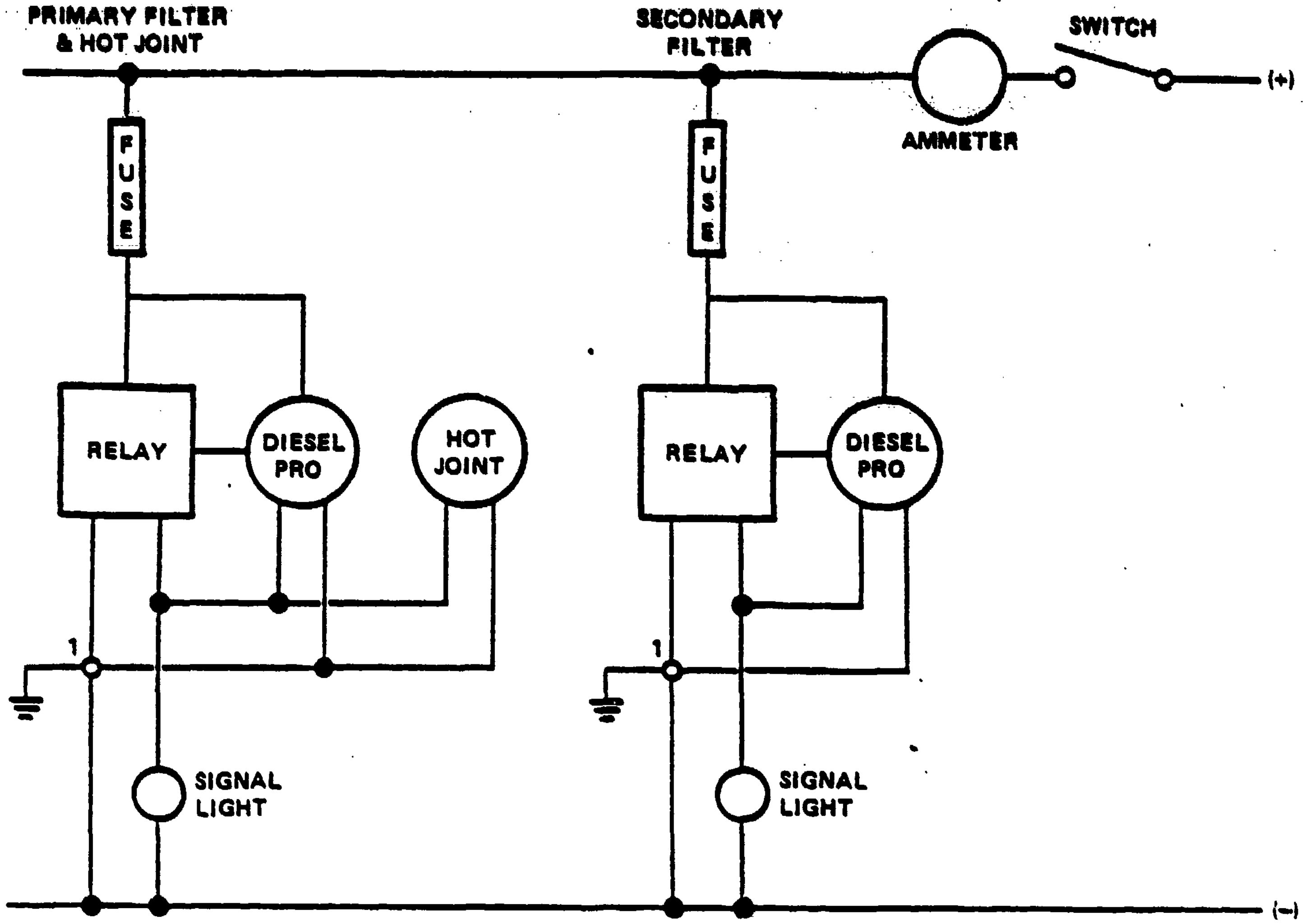
INSTRUMENTATION LIST

Manufacturer	Model #	Calibration Date
Clarke Hess	24886	6 Sep 86
Clarke Hess	25095	8 Sep 86
Clarke Hess	25096	21 Aug 86
D.C. Voltmeter	0152	18 May 86
D.C. Voltmeter	1768	18 Jan 86
D.C. Voltmeter	1282	6 Aug 88
D.C. Voltmeter	655	4 Sep 86
T.I. Recorder	2070	CNR*
T.I. Recorder	0184	CNR*
Temperature Readout	6638	8 Feb 86
D.C. Shunt	2179	5 Sep 86
D.C. Shunt	0658	21 Feb 86

*CNR - Calibration Not Required

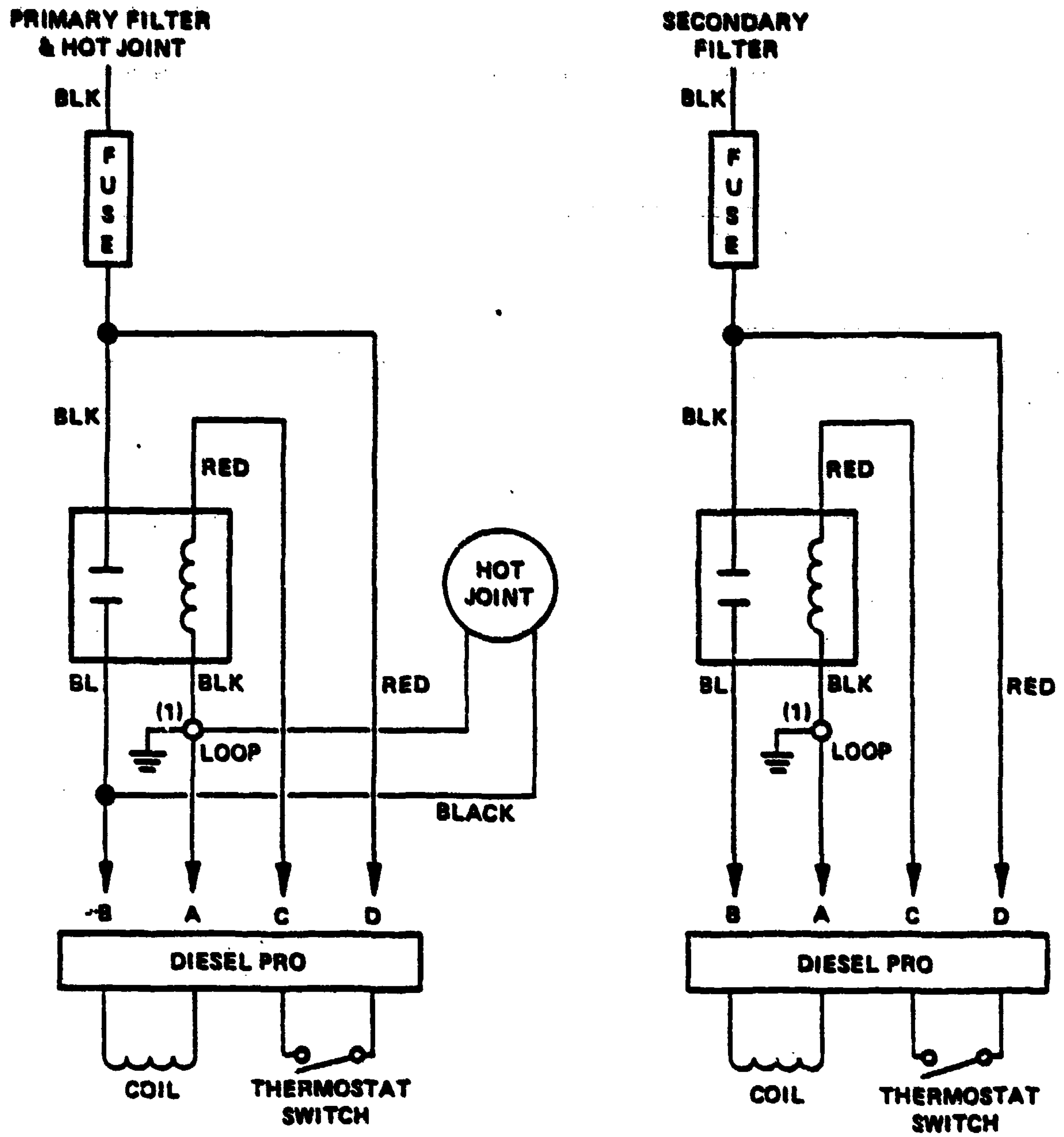
All instruments calibrated at time of usage with a standard instrument that is traceable to the National Bureau of Standards.

Paul
10 DEC 85
Fen - ED

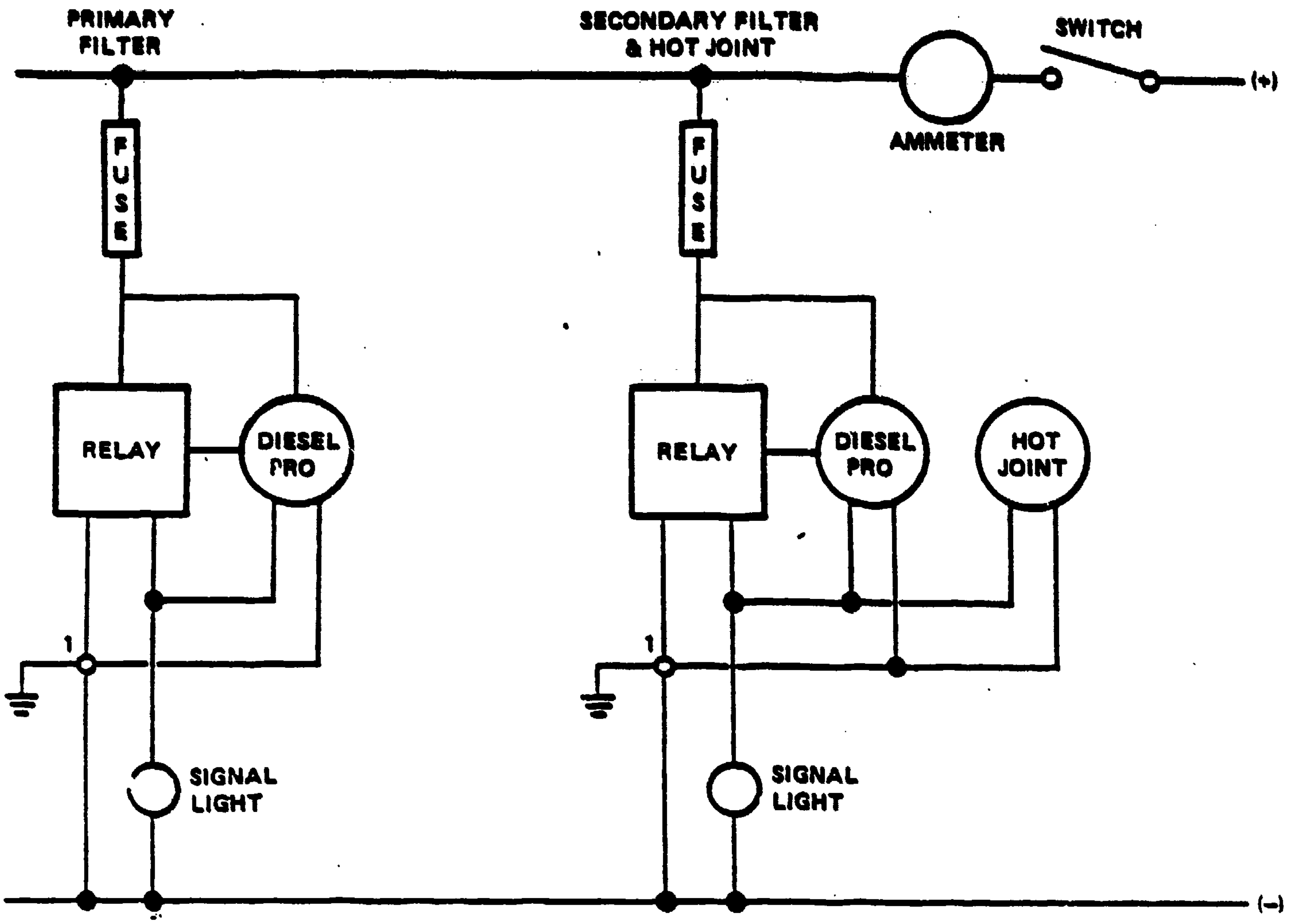


1. MOUNT RELAYS USING MOUNTING BOLT FOR "DIESEL PRO"
2. GROUND FOR HOT JOINT WILL BE CONNECTED TO MOUNTING BOLT OF DAY TANK
3. CONNECT TERMINALS "A" AND "B" TO HEATER (BLACK TERMINALS)
4. CONNECT TERMINALS "C" AND "D" TO THERMOSTAT (CLEAR TERMINALS)
5. LOOP TERMINAL ON BLACK WIRE (1) IS GROUND
6. CONNECT RED LEAD FROM THERMOSTAT TO BLACK LEAD ON RELAY SIDE OF FUSE

Test No. 1A Configuration, 30 kW Generator Set, 0°F, 23 October 1985
(Sheet 1 of 2)

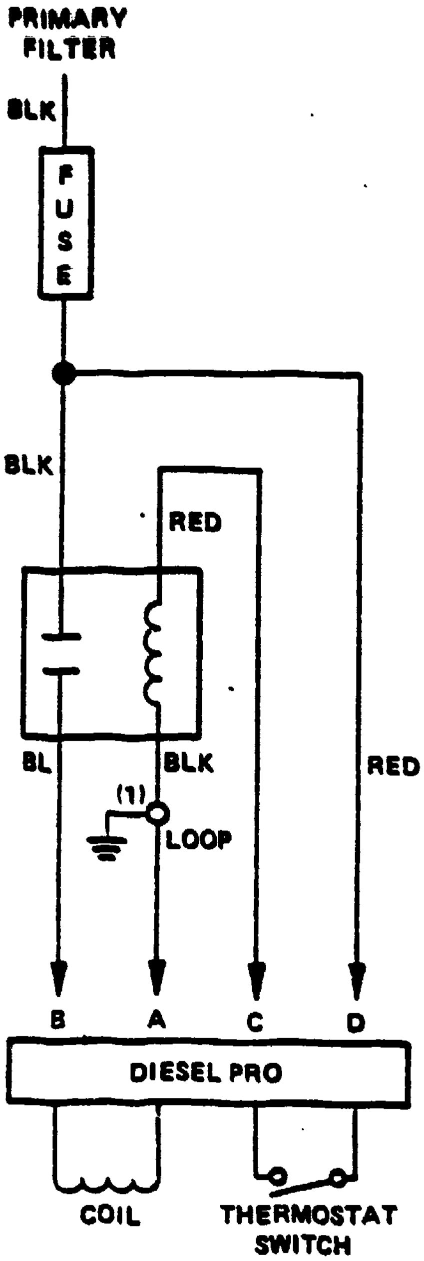


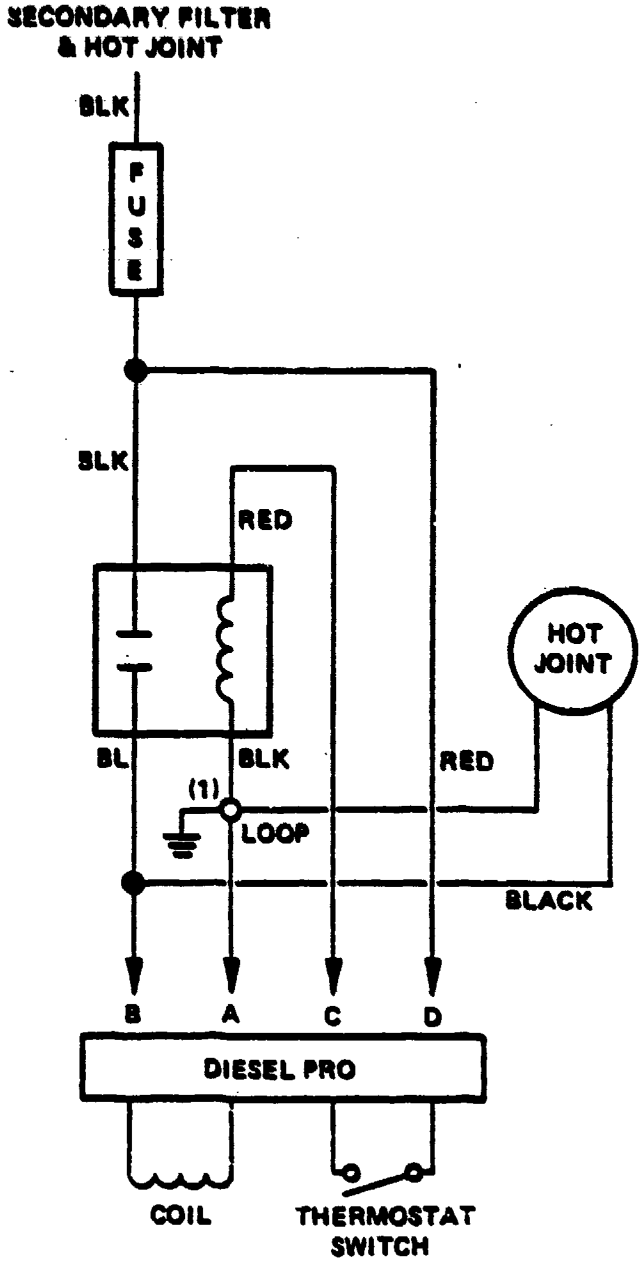
Test No. 1A Configuration, 30 kW Generator Set, 0°F, 23 October 1985
(Sheet 2 of 2)



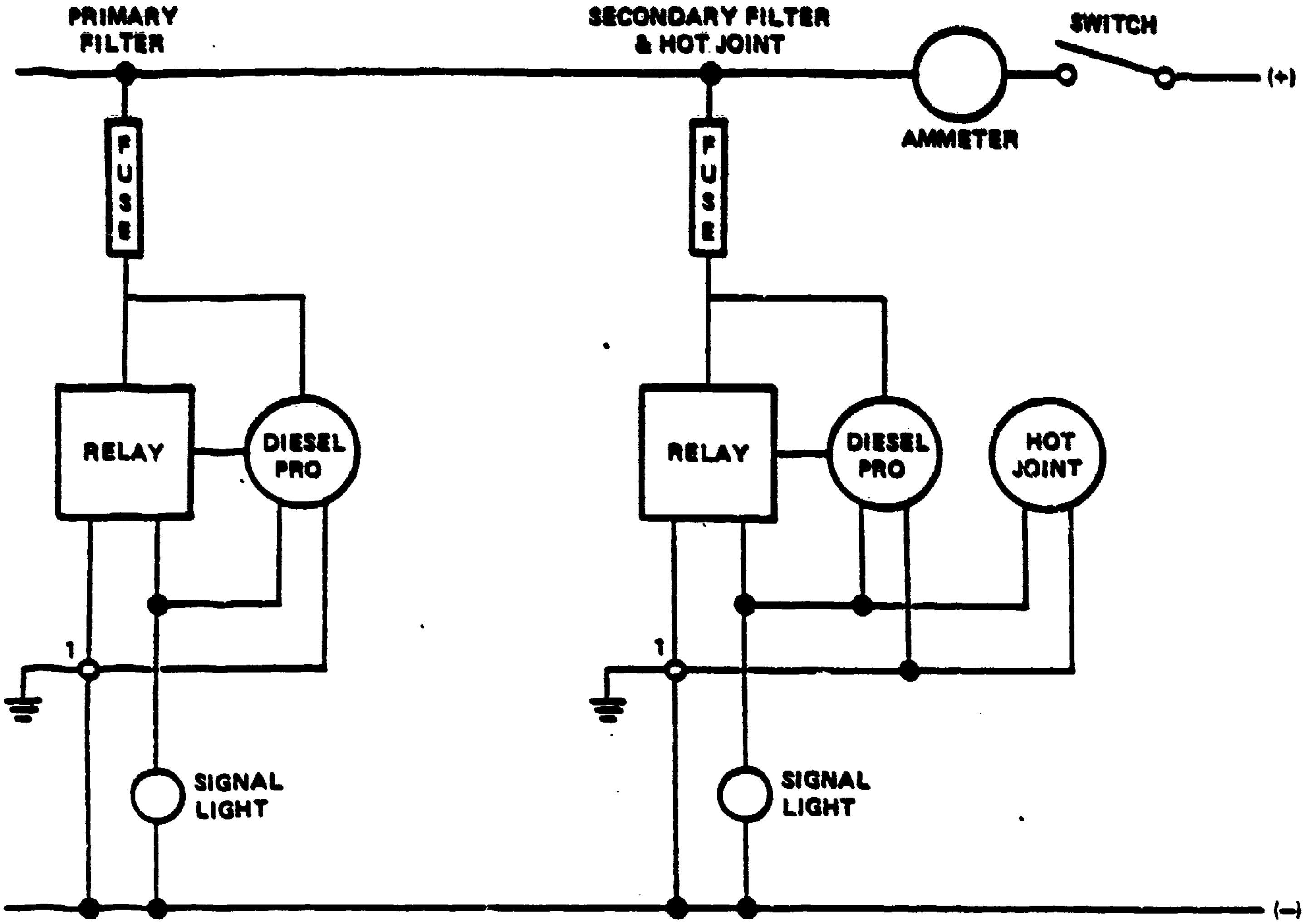
1. MOUNT RELAYS USING MOUNTING BOLT FOR "DIESEL PRO"
2. GROUND FOR HOT JOINT WILL BE CONNECTED TO MOUNTING BOLT OF DAY TANK
3. CONNECT TERMINALS "A" AND "B" TO HEATER (BLACK TERMINALS)
4. CONNECT TERMINALS "C" AND "D" TO THERMOSTAT (CLEAR TERMINALS)
5. LOOP TERMINAL ON BLACK WIRE (1) IS GROUND
6. CONNECT RED LEAD FROM THERMOSTAT TO BLACK LEAD ON RELAY SIDE OF FUSE

Test No. 1B Configuration, 30 kW Generator Set, -10°F, 24 October 1985
(Sheet 1 of 2)



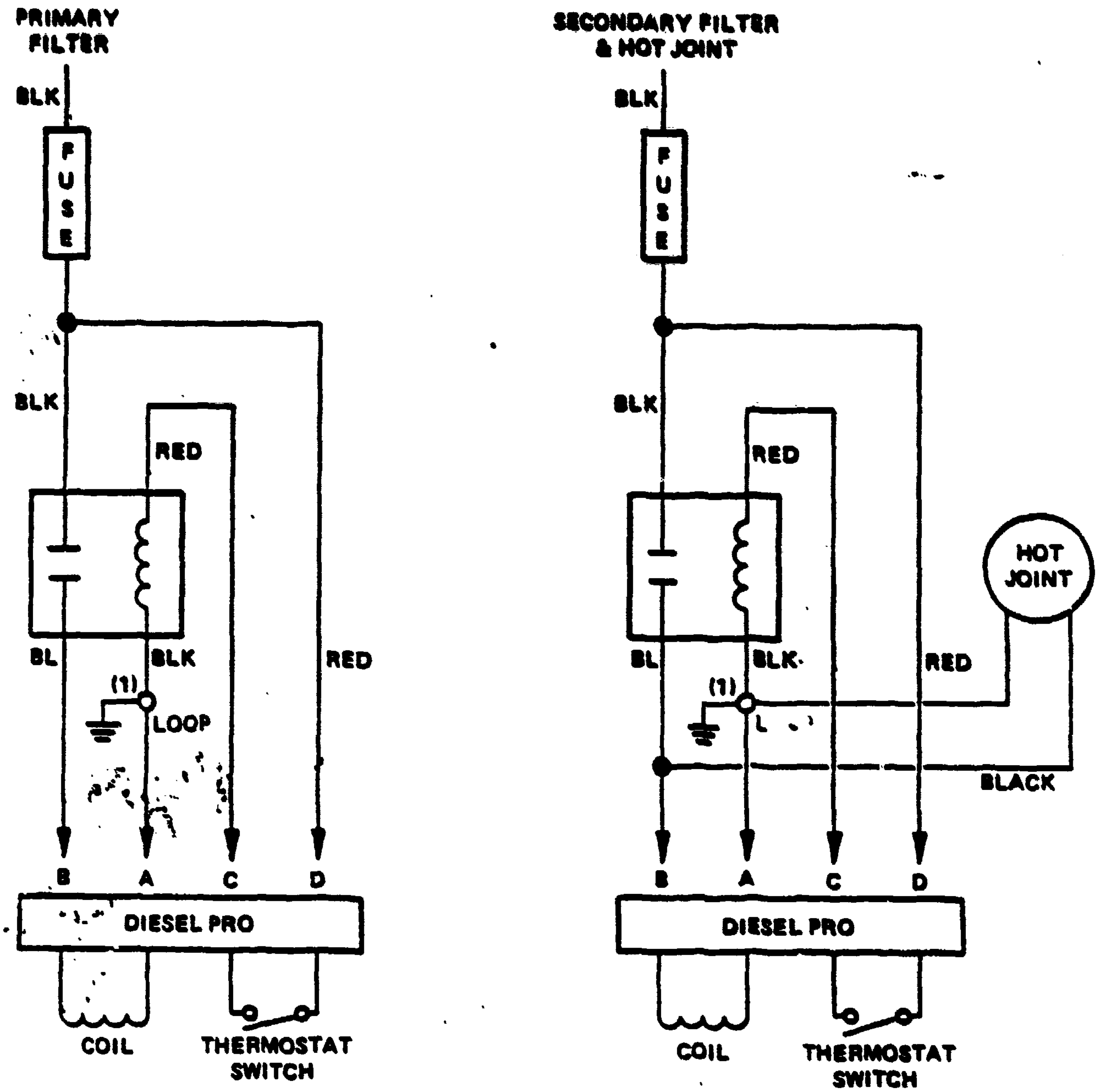


Test No. 1B Configuration, 30 kW Generator Set, -10°F, 24 October 1985
(Sheet 2 of 2)

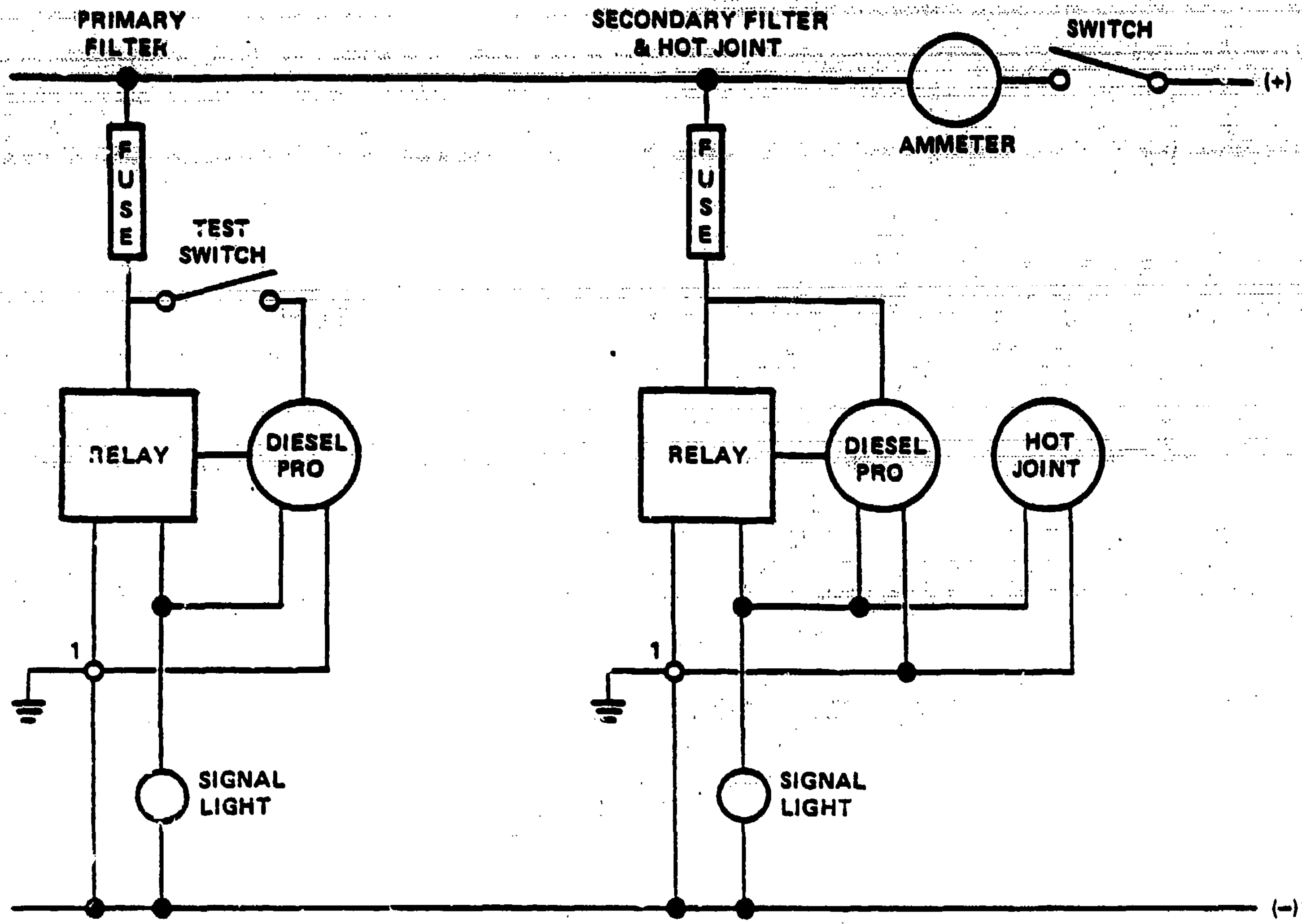


1. MOUNT RELAYS USING MOUNTING BOLT FOR "DIESEL PRO"
2. GROUND FOR HOT JOINT WILL BE CONNECTED TO MOUNTING BOLT OF DAY TANK
3. CONNECT TERMINALS "A" AND "B" TO HEATER (BLACK TERMINALS)
4. CONNECT TERMINALS "C" AND "D" TO THERMOSTAT (CLEAR TERMINALS)
5. LOOP TERMINAL ON BLACK WIRE (1) IS GROUND
6. CONNECT RED LEAD FROM THERMOSTAT TO BLACK LEAD ON RELAY SIDE OF FUSE

Test No. 1C Configuration, 30 kW Generator Set, -25°F, 26 October 1985
(Sheet 1 of 2)

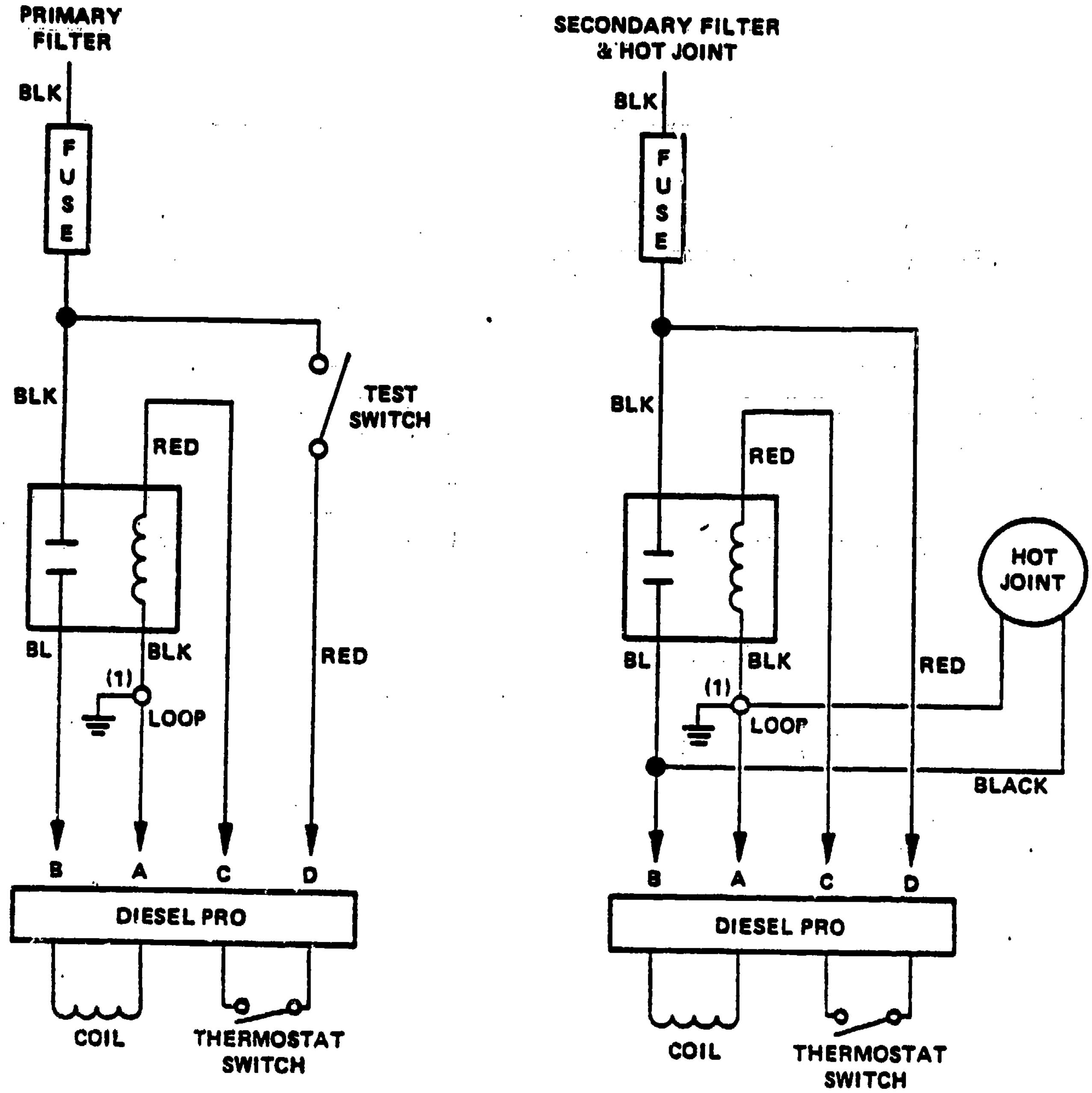


Test No. 1C Configuration, 30 kW Generator Set, -25°F, 26 October 1985
(Sheet 2 of 2)

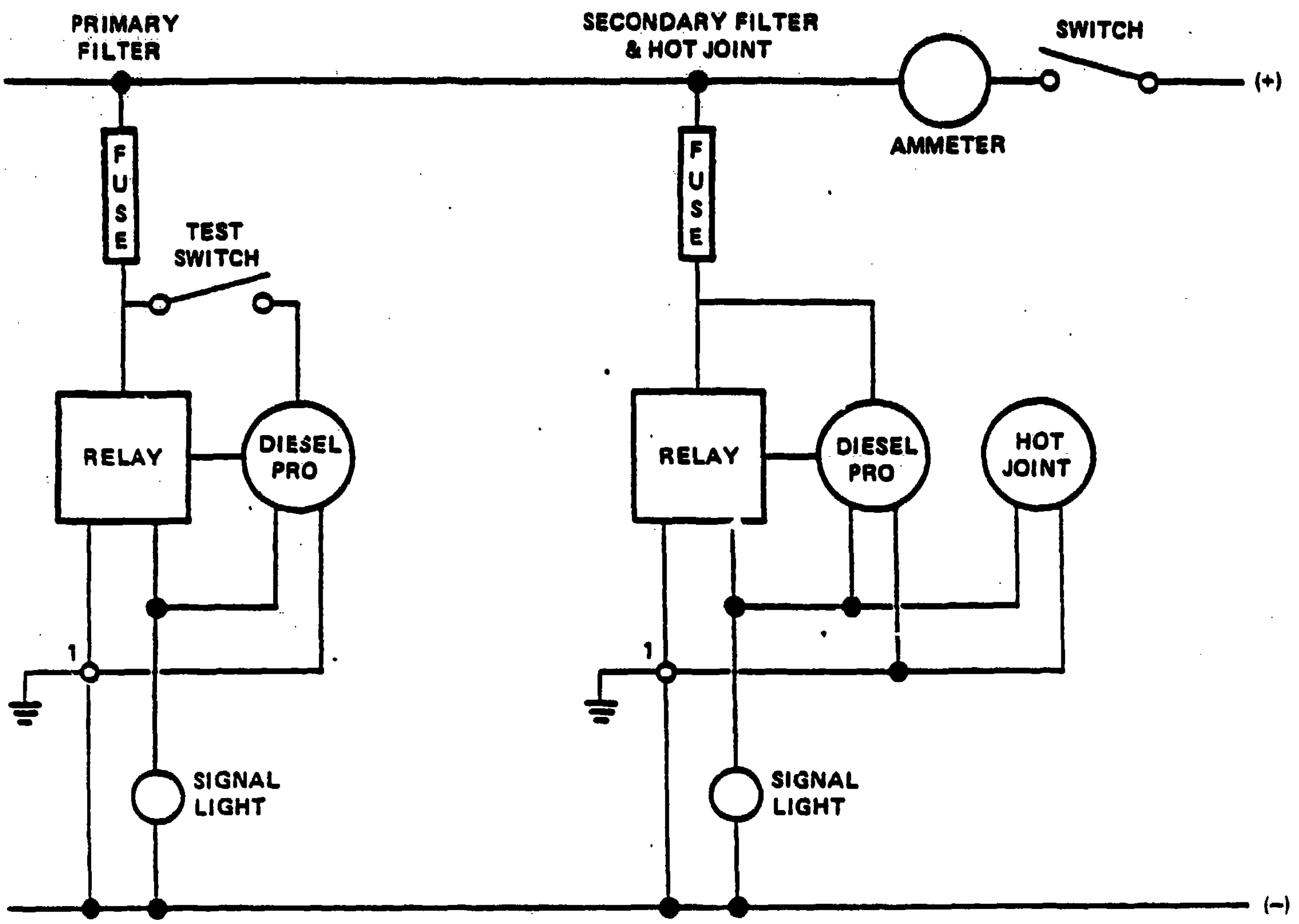


1. MOUNT RELAYS USING MOUNTING BOLT FOR "DIESEL PRO"
2. GROUND FOR HOT JOINT WILL BE CONNECTED TO MOUNTING BOLT OF DAY TANK
3. CONNECT TERMINALS "A" AND "B" TO HEATER (BLACK TERMINALS)
4. CONNECT TERMINALS "C" AND "D" TO THERMOSTAT (CLEAR TERMINALS)
5. LOOP TERMINAL ON BLACK WIRE (1) IS GROUND
6. CONNECT RED LEAD FROM THERMOSTAT TO BLACK LEAD ON RELAY SIDE OF FUSE
7. INSTALL SWITCH IN THERMOSTAT CIRCUIT OF PRIMARY "DIESEL PRO"
8. INSTALL INDICATOR LIGHT ACROSS DAY TANK SOLENOID

Test No. 2 Configuration, 30 kW Generator Set, -25°F, 5 November 1985
(Sheet 1 of 2)

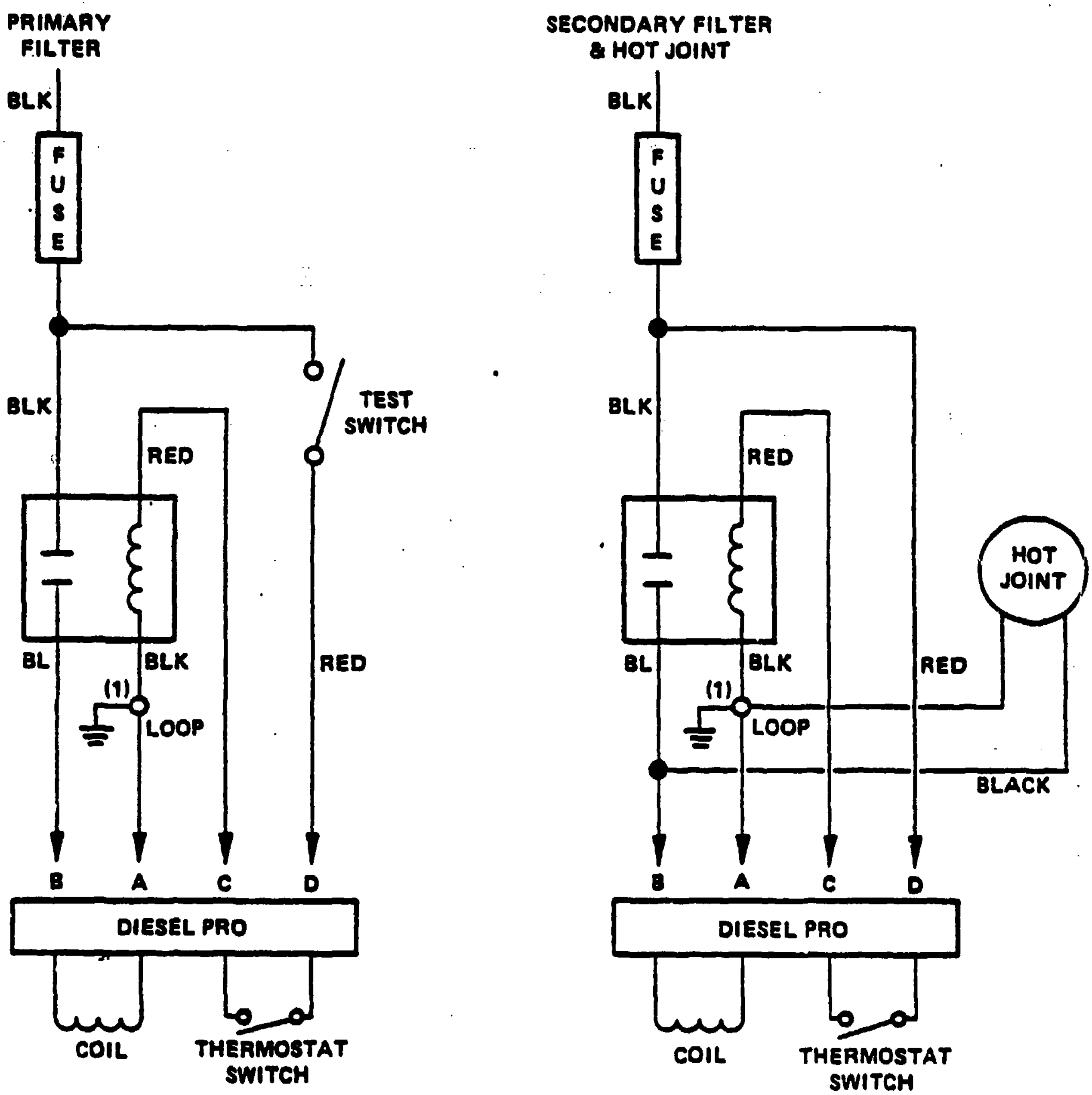


Test No. 2 Configuration, 30 kW Generator Set, -25°F, 5 November 1985
(Sheet 2 of 2)



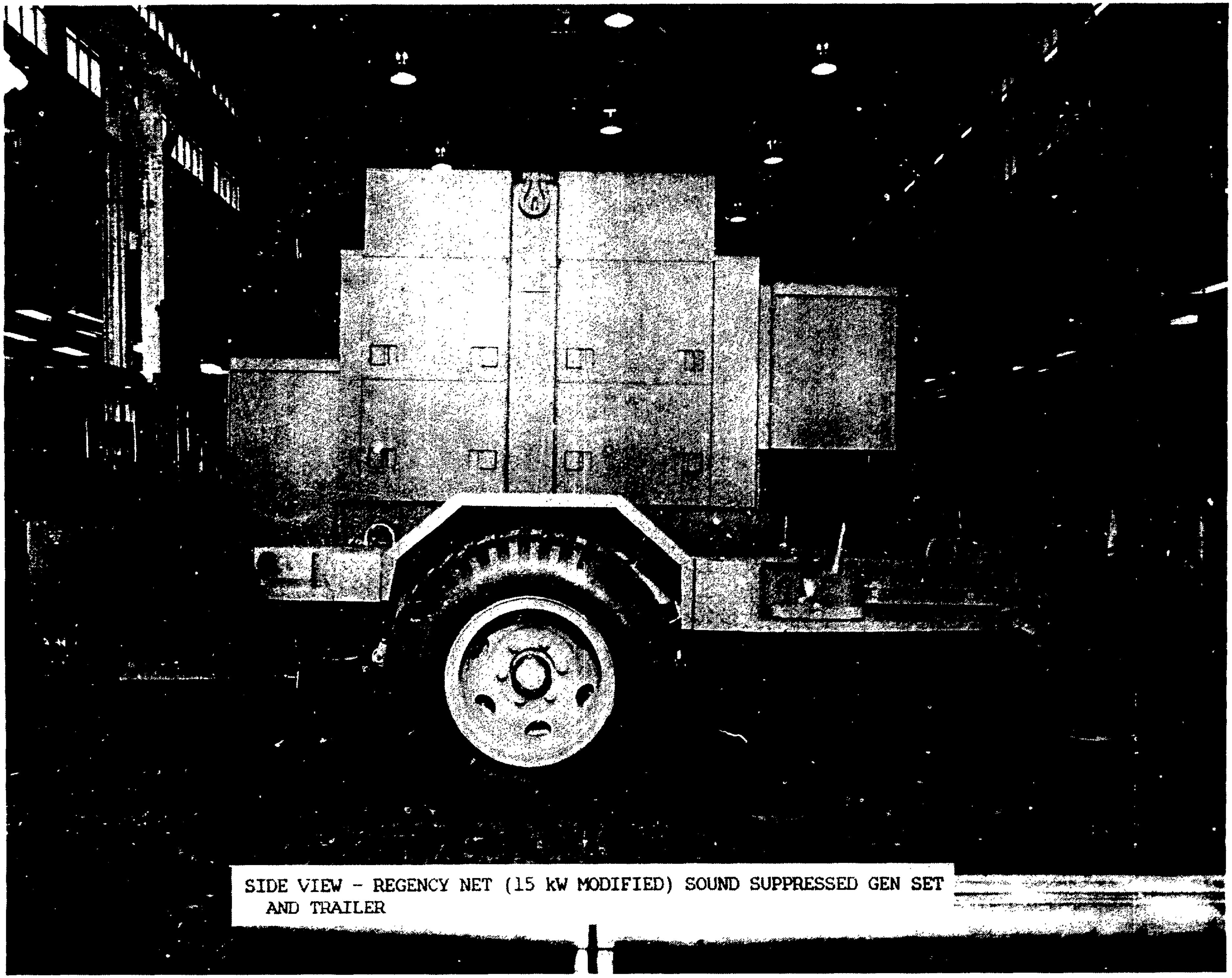
1. MOUNT RELAYS USING MOUNTING BOLT FOR "DIESEL PRO"
2. GROUND FOR HOT JOINT WILL BE CONNECTED TO MOUNTING BOLT OF DAY TANK
3. CONNECT TERMINALS "A" AND "B" TO HEATER (BLACK TERMINALS)
4. CONNECT TERMINALS "C" AND "D" TO THERMOSTAT (CLEAR TERMINALS)
5. LOOP TERMINAL ON BLACK WIRE (1) IS GROUND
6. CONNECT RED LEAD FROM THERMOSTAT TO BLACK LEAD ON RELAY SIDE OF FUSE
7. INSTALL SWITCH IN THERMOSTAT CIRCUIT OF PRIMARY "DIESEL PRO"
8. INSTALL INDICATOR LIGHT ACROSS DAY TANK SOLENOID

Test No. 3 Configuration, 30 kW Generator Set, -25°F, 7 November 1985
(Sheet 1 of 2)

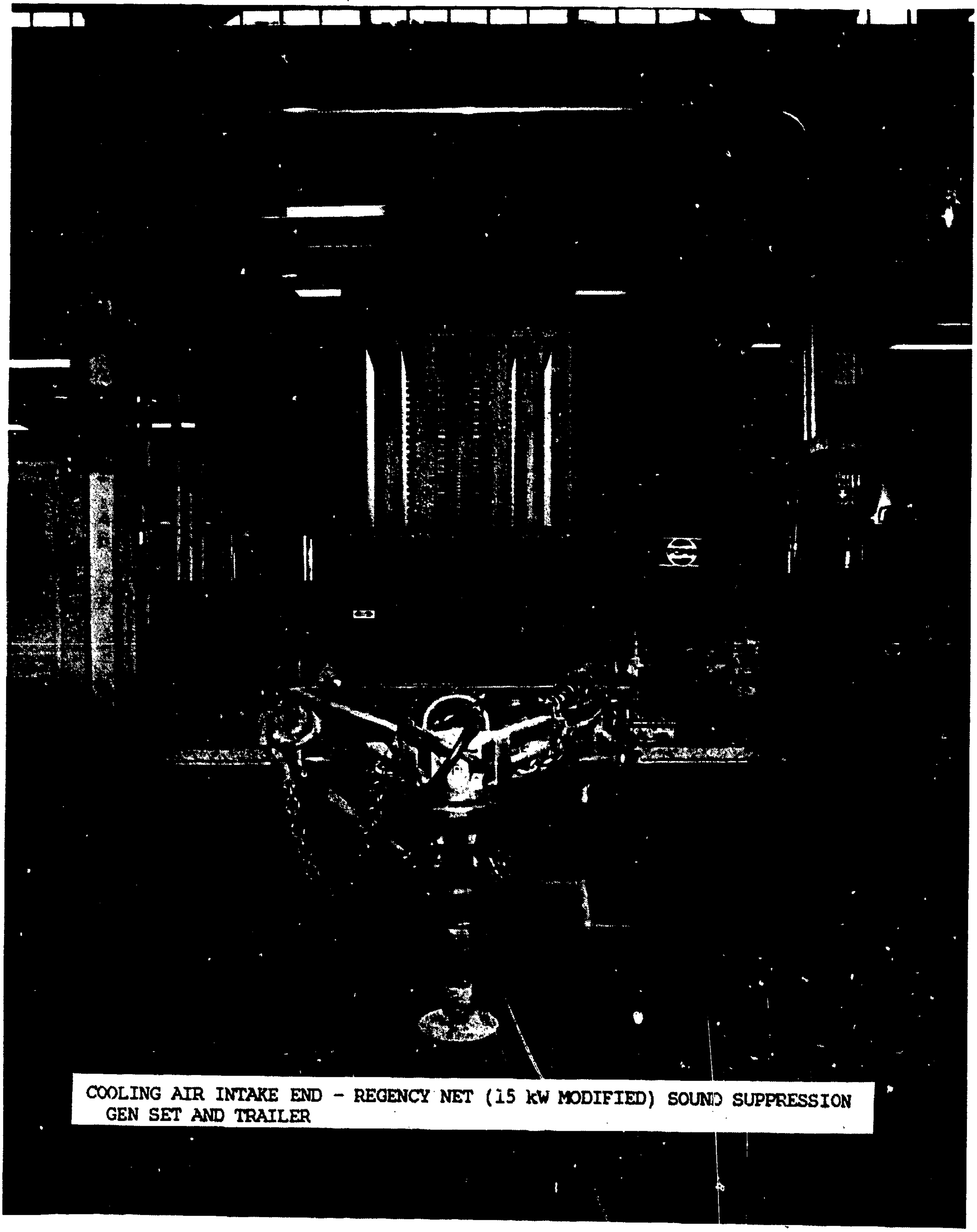


Test No. 3 Configuration, 30 kW Generator Set, -25°F, 7 November 1985
(Sheet 2 of 2)

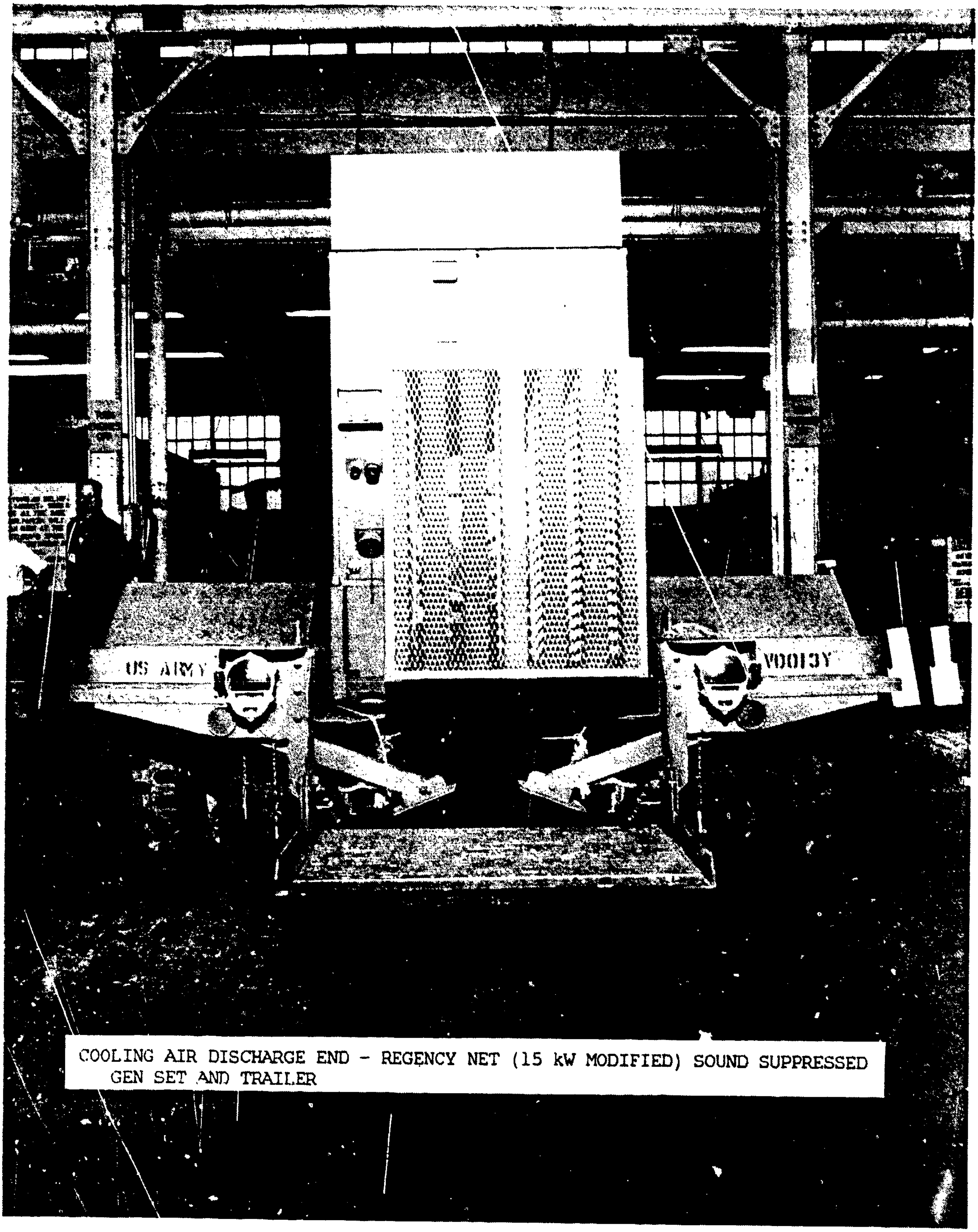
Appendix M
Photos-Regency Net (Modified 15 kW) Sound
Surppressed Generator Set Towed Assemblage



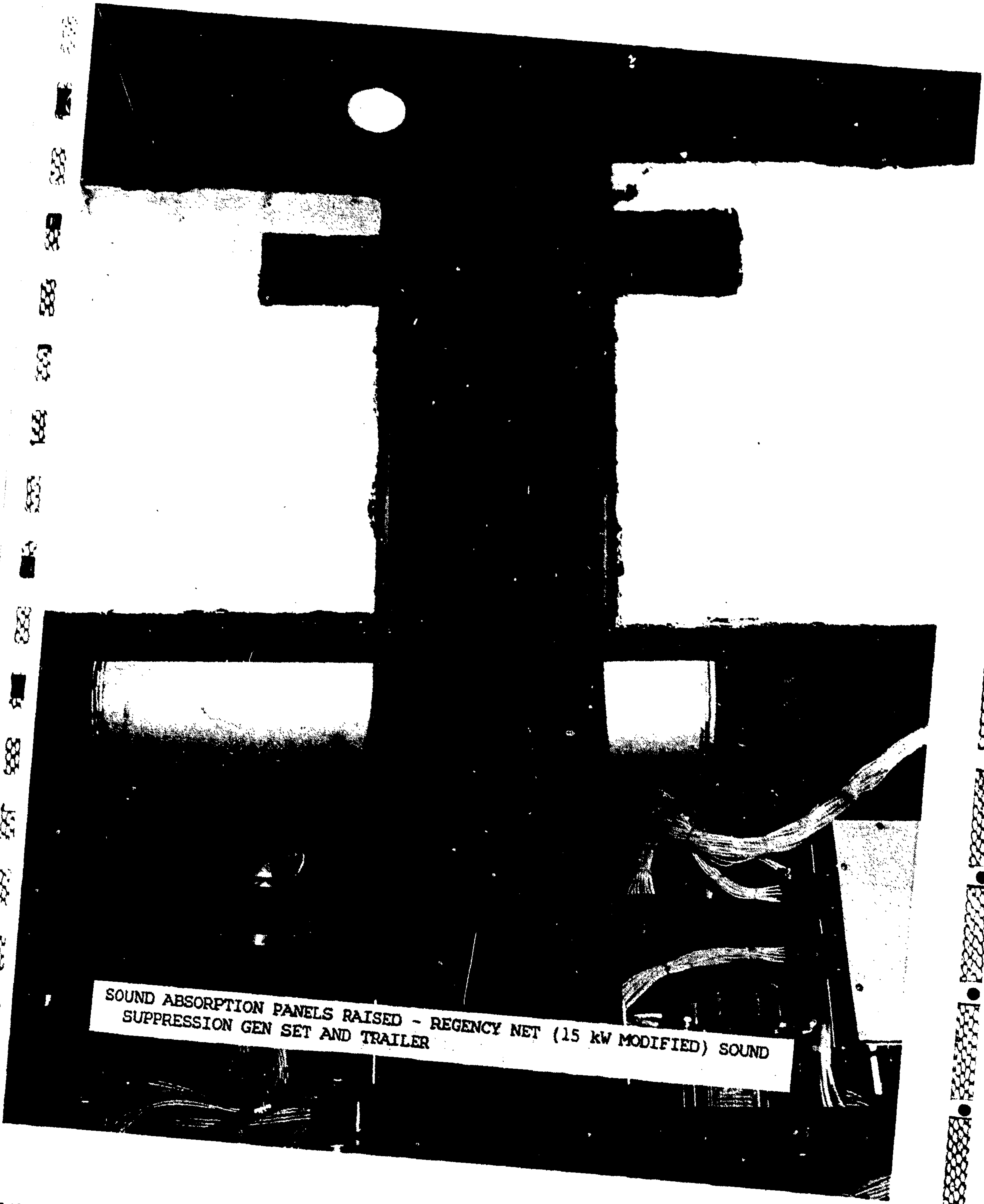
SIDE VIEW - REGENCY NET (15 kW MODIFIED) SOUND SUPPRESSED GEN SET AND TRAILER



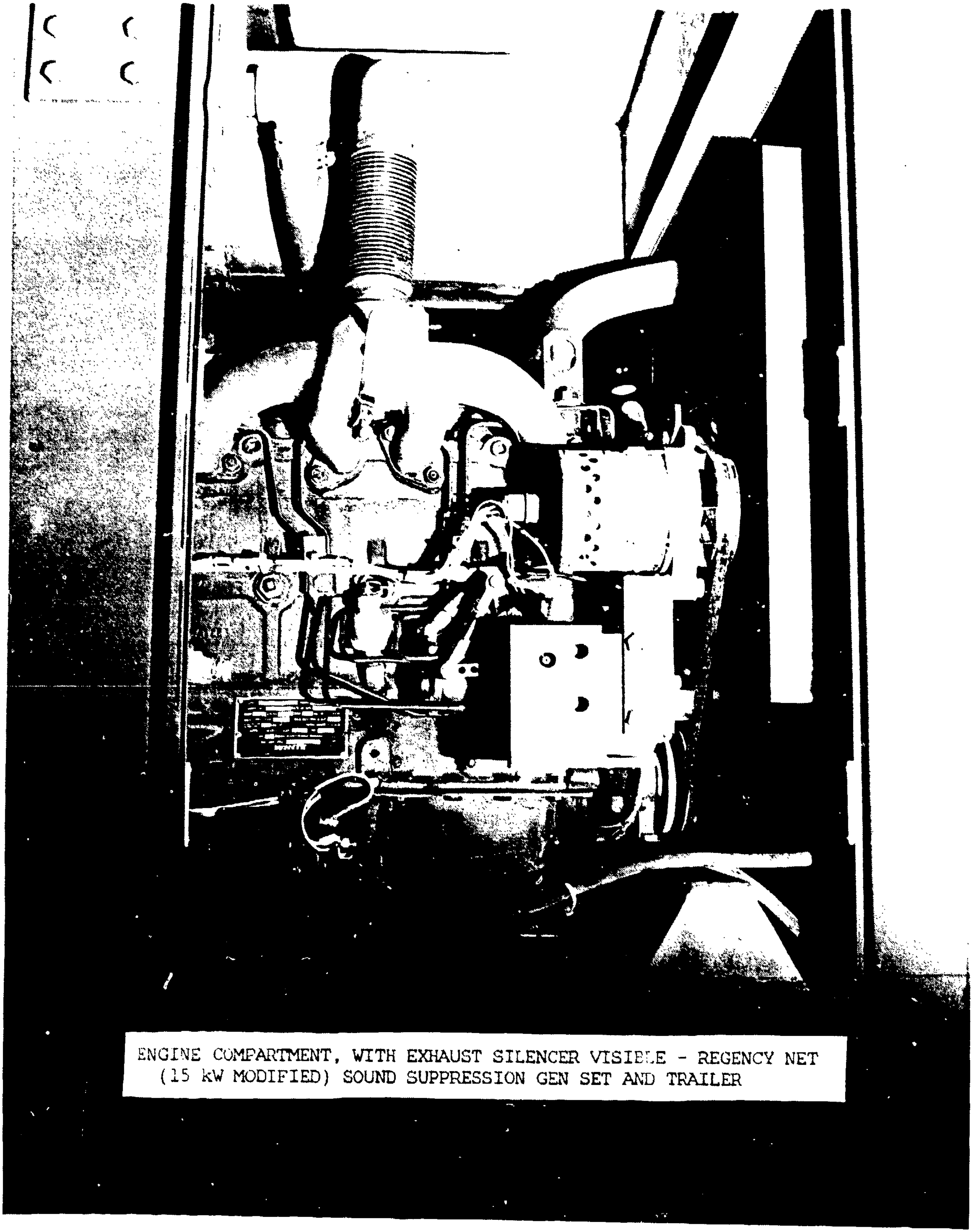
COOLING AIR INTAKE END - REGENCY NET (15 kW MODIFIED) SOUND SUPPRESSION GEN SET AND TRAILER



COOLING AIR DISCHARGE END - REGENCY NET (15 kW MODIFIED) SOUND SUPPRESSED GEN SET AND TRAILER



SOUND ABSORPTION PANELS RAISED - REGENCY NET (15 kW MODIFIED) SOUND SUPPRESSION GEN SET AND TRAILER



ENGINE COMPARTMENT, WITH EXHAUST SILENCER VISIBLE - REGENCY NET
(15 kW MODIFIED) SOUND SUPPRESSION GEN SET AND TRAILER

Appendix N
Battery Charger for EMU-30 Generator Set

U.S. ARMY

MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT COMMAND

FORT BELVOIR, VIRGINIA

BATTERY CHARGER

for

EMU-30 GENERATOR SET

Modifications for Compatibility With Lead Acid Batteries

Contract No. DAAK70-78-D-0080
TASK ORDER 0001.053

Prepared December 7, 1979

by

VSE Corporation

2550 Huntington Avenue

Alexandria, Virginia 22303

BATTERY CHARGER

FOR

EMU-30 GENERATOR SET

MODIFICATIONS FOR COMPATIBILITY WITH LEAD ACID BATTERIES

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EMU-30 BATTERY CHARGER, MODIFICATION OF

1.0 BACKGROUND

The subject battery charger is identified as Teledyne Inet model number 35D0044, part number 68E22793. It was originally designed to charge a Nickel Cadmium battery manufactured in accordance with Military Specification MS 24498-1. A complete description of the charger prior to modification is contained in Technical Manuals (T. O. 35C2-3-436 series). Information from these manuals is repeated herein only when it is directly applicable to a circuit modification, or necessary to clarify the discussion.

During the spring and summer of 1979, a modified version of the battery charger was developed to charge two lead acid batteries connected in series, type MS 35000 BB-249/U 2HN. The modification was incorporated into EMU/EA Generator Sets utilized in the Patriot Missile System during the fall of 1979.

This report describes the development and testing of the modified charger.

2.0 CONFIGURATION PRIOR TO MODIFICATION

2.1 Baseline Schematic

A schematic diagram of the unmodified battery charger circuitry is shown in Figure 1. It is extracted from pages 4-59 of T.O. 35C2-3-436-1 and is included to provide an overview of all circuitry within the charger.

Attention is directed to the lower right hand corner of the schematic, where VR2 is erroneously identified as a 9.7 Volt Zener diode. The illustrated parts breakdown in T.O. 35C2-3-436-4 identifies this diode as a 1N936A, which has a specified operating voltage of 9.0 Volts ± 5%. This was verified by inspection of battery charger components during the modification program.

2.2 Internal Power Conversion

The battery charger obtains DC power from an internal transformer-rectifier and a switching voltage converter or chopper as shown in Figure 2. EMU-30 line voltage (208V, 400Hz, 3 phase AC) is applied through 1.5 Ampere fuses to Transformer T1. The secondary output from T1 (approx. 31 Vrms) passes through a three phase full wave rectifier (rectifier bridges CR1 plus 1/2 CR2) to filter capacitor C1 and a power chopper circuit on power module A2. The chopper is switched at a rate of 2000 to 3000 Hz by the pulse width modulator circuitry (IC2 and Q1) on control module A3. Positive and negative transients from the chopper and choke which exceed the voltage across C1 are clipped by two diodes on bridge CR2. Filter choke L1 then converts the resulting square wave to its average DC voltage level. This DC power then passes through fuse F4 to the battery and other auxiliary loads.

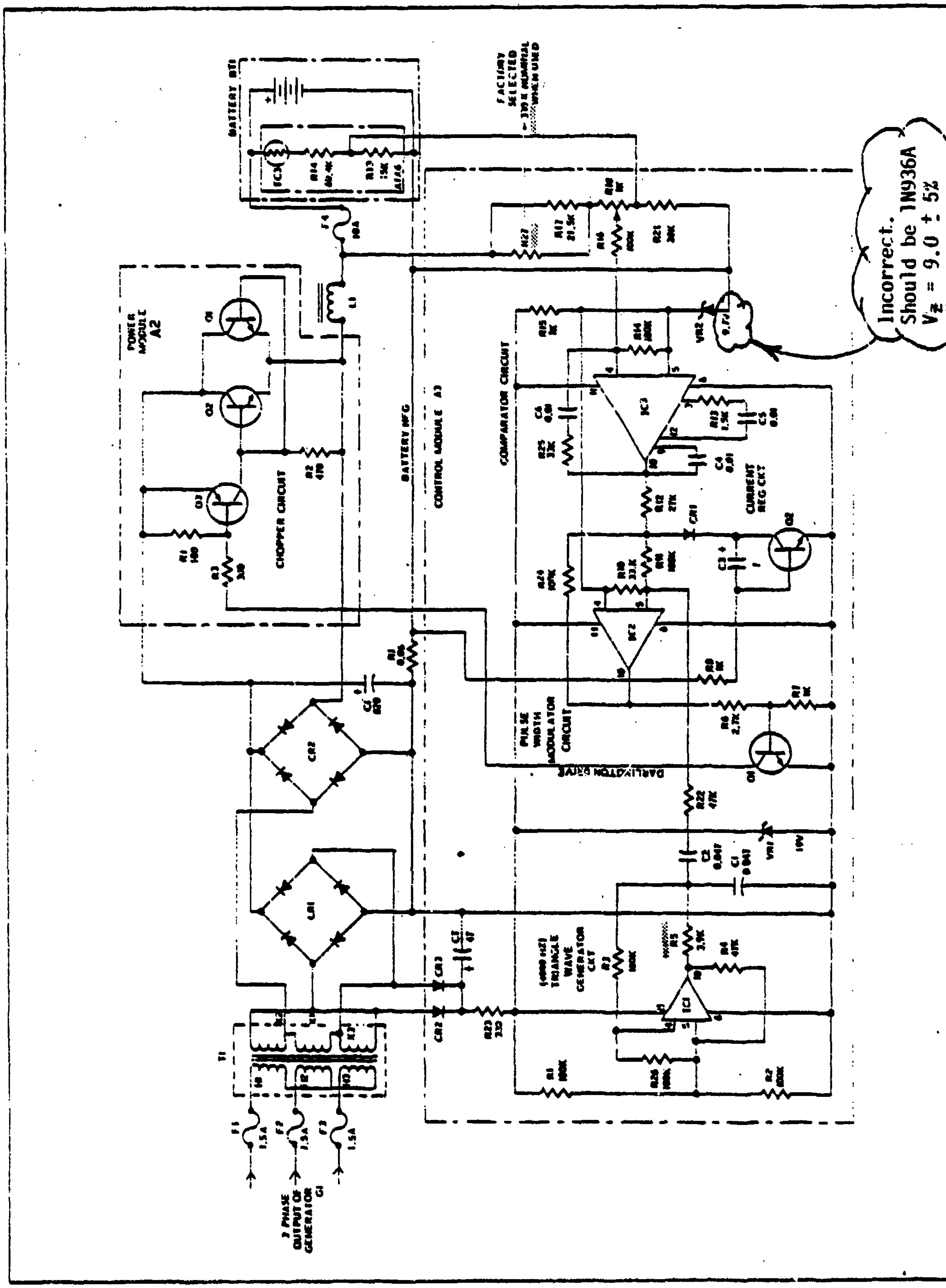


Figure 1. Battery Charger B2, Schematic, Prior to Modification

4-59

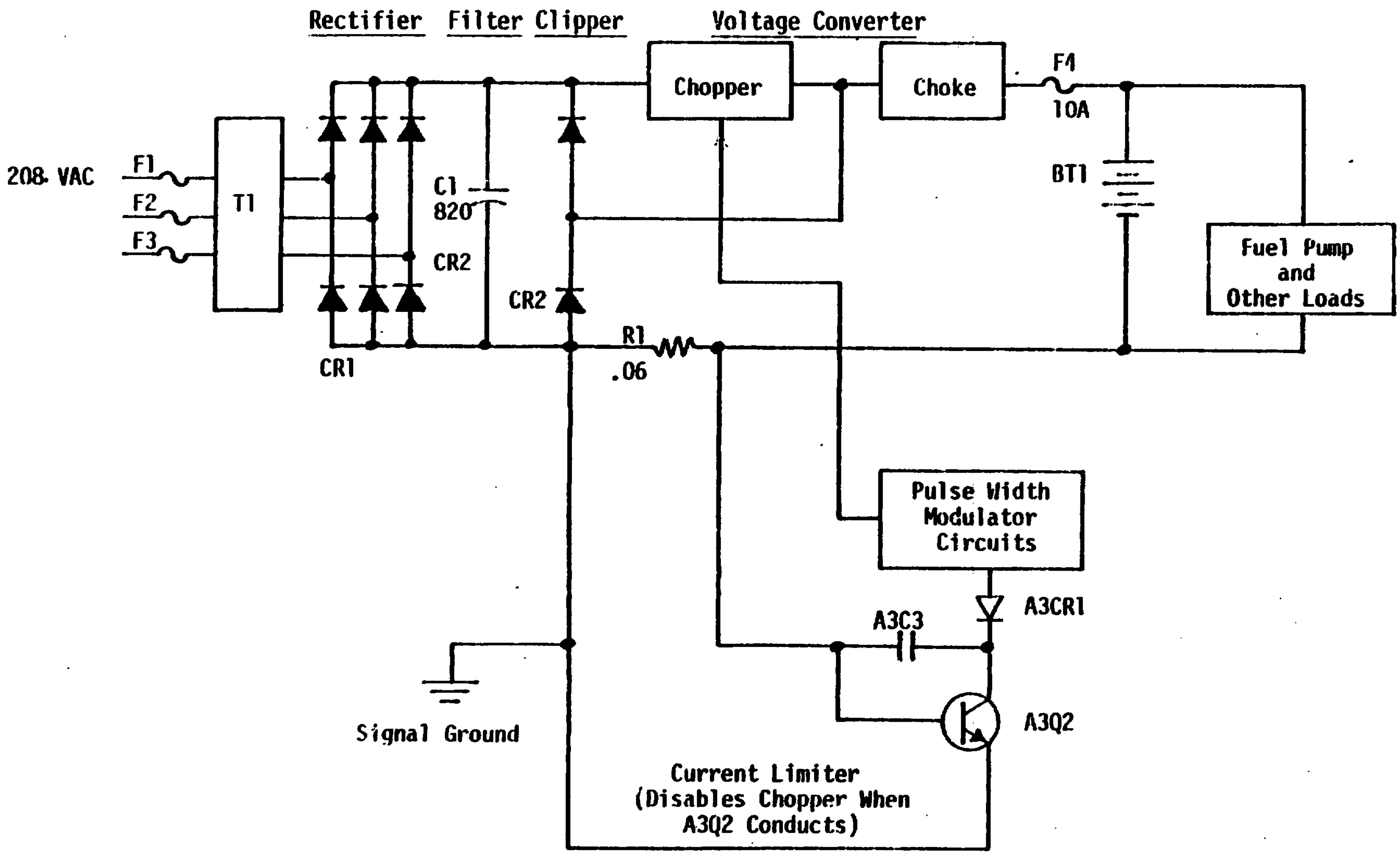


Figure 2. DC Power Circuits and Current Limiter

2.3 Voltage Control Loop

A resistive voltage divider network and a voltage comparator provide the feed-back signal necessary for closed loop operation of the regulator. A block diagram of the voltage control loop is shown in Figure 3A, and a schematic diagram of the resistive network and comparator is shown in Figure 3B.

The output voltage is sensed by a resistive network consisting of sensor module TC3 and resistors R17, R18 and R21 on control module A3. Temperature compensation is provided by a thermistor in module TC3, and voltage adjustment is provided by a 1000 OHM potentiometer. For a given temperature and a given setting of the potentiometer, the output from the resistive network (Vn) is directly proportional to the output from the regulator (Vo). Therefore:

$$Vn = K\ Vo \text{ (at 25°C, K is approximately 1/3)}$$

Vn is applied to a voltage comparator, where it is compared to a fixed 9.0 Volt reference obtained from Zener diode VR2. The comparator produces signals which indirectly adjust the regulator output voltage so that Vn is always equal (within one half of a millivolt) to the 9.0 Volt reference. For example, if the resistive constant K is equal to 1/3 as previously assumed, the feedback signal through the comparator will continuously adjust the regulator output voltage to a value of 3 times the 9.0 Volt reference signal from Zener diode VR2.

2.4 Current Limiting

Current limiting is accomplished by a circuit which bypasses the output of A3IC3 to ground, thereby overriding the normal operation of the

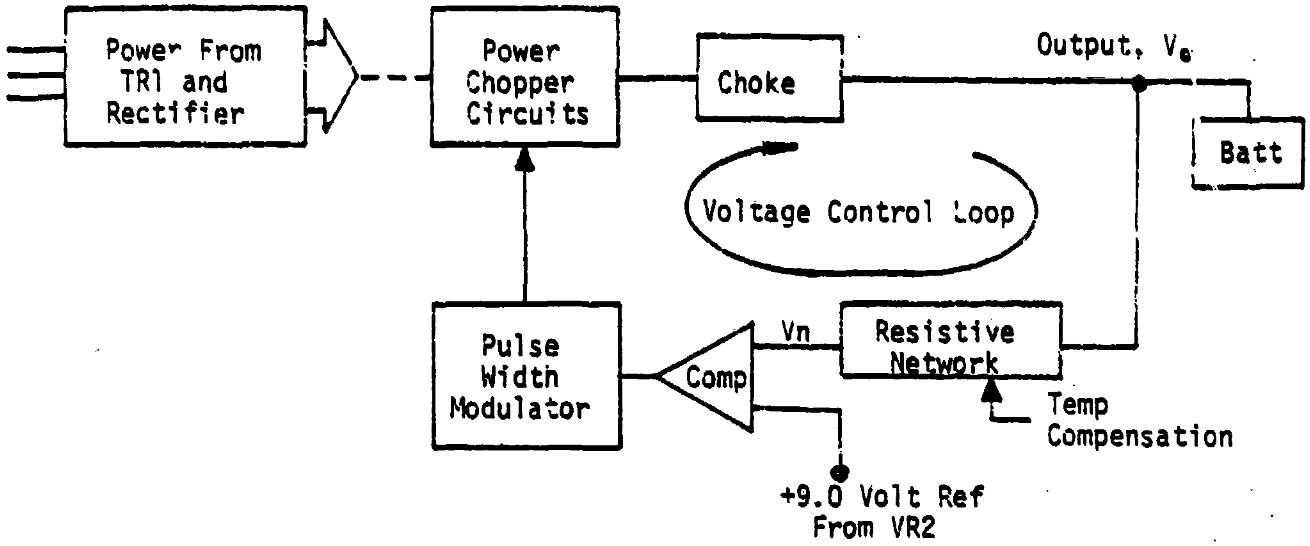


Figure 3A. Voltage Control Loop

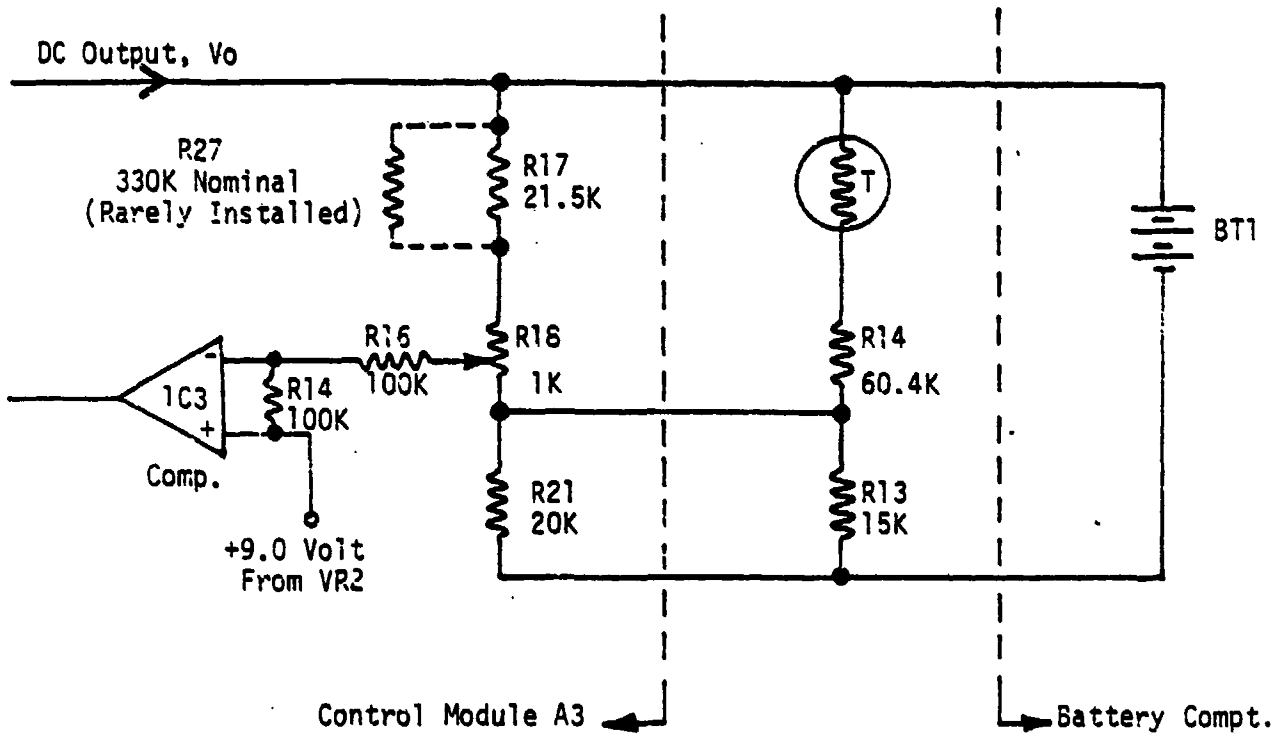


Figure 3B. Resistive Network and Comparator pulse width modulator A3IC2. As shown in Figure 2, current through the battery is sensed by current shunt R1. The voltage drop across R1 is applied to the emitter to base junction of A3Q2, which conducts when its junction threshold of 0.6 to 0.7 Volts is approached. Because of output ripple and noise at the millivolt level, current limiting begins at 8.5 to 9.0 Amperes, which is somewhat less than one would expect from the .06 OHM current sensor.

2.5 Adjustment Procedures

Adjustment and test of the battery charger is specified in drawing A 735020, and also on pages 6-209 of T.O. 35C2-3-436-1. The test set-up calls for an output voltage of 27.5 Volts with a current drain of only 1.1 Ampere. These values are not realistic, because the charger must supply an auxiliary servicing current of 4.4 Amperes (for operation of the fuel boost pump and other devices) as well as the charging current for the battery. Therefore, the optimum "end of charge" or float voltage for the battery should be set with a charger output current of at least 4.4 Amperes.

2.6 Regulation

The regulation curve for the unmodified charger is shown in Figure 4.

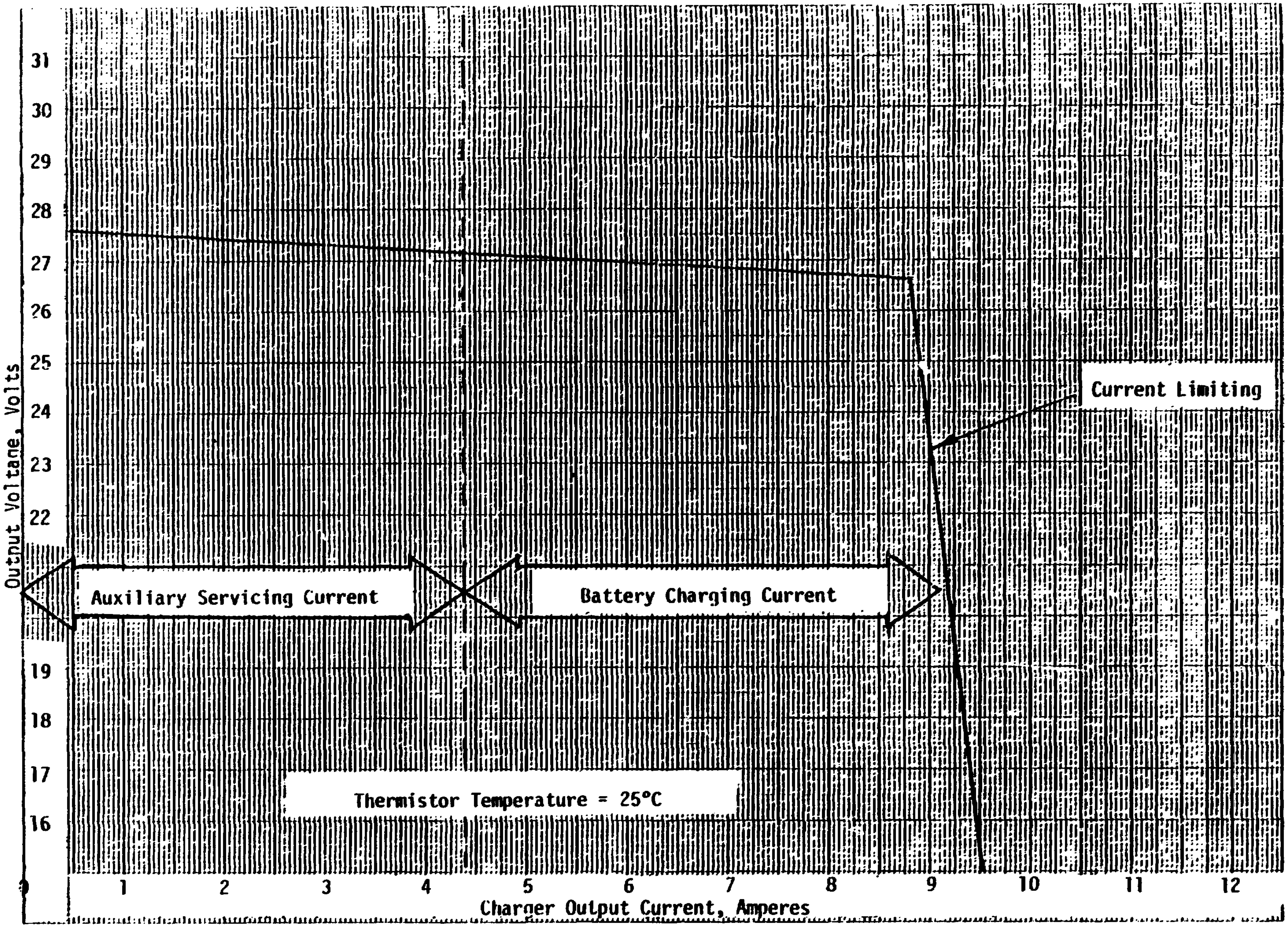
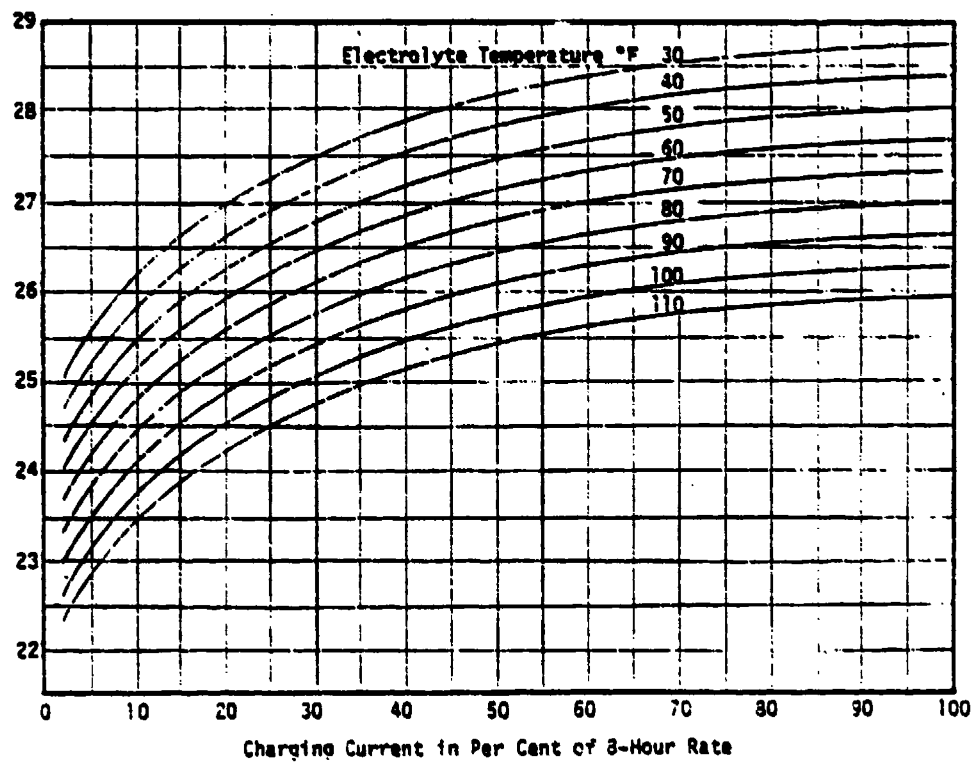


Figure 4. Regulation of Unmodified Charger

3.0 LEAD ACID BATTERY CHARGING REQUIREMENTS

A study was made of available literature and reference material, and findings were discussed with military users and manufacturers of the MS 35000 BB-249/U 2 HN battery. Generally, as the voltage of a storage battery rises during charge, the final or maximum value reached at the completion of charge depends on several factors. Among the major factors are (1) charging current, (2) temperature, (3) concentration of electrolyte, and (4) composition and structure of the cells.

Figure 5 shows the variation of final voltage with temperature and rate of charge for lead acid cells. Although this figure applies to a different type of battery, it closely approximates the characteristics of the MS 35000 BB-249/U 2HN and illustrates the basic nature of changes involved.



Final charging voltages at various rates and temperatures, lead-acid batteries.
The interval between curves is 0.0035 volt per °F.

Figure 5.

3.1 Charger Output Voltage

The choice of a nominal output voltage for a single step, voltage regulating charger depends on the above factors, and in addition entails a rather arbitrary trade-off between two objectives. The first objective is to insure that the battery is restored to a fully charged condition within a reasonable length of time. This inevitably dictates "over-charging" the battery at the end of the charging cycle with a voltage that is several volts higher than the quiescent open circuit voltage of the battery. The second objective is to avoid excessive loss of water (due to electrolysis) during prolonged operating periods of the system. This trade-off must, of course, be based on the anticipated operating schedule of the system.

A practical formula for the quiescent open circuit voltage of a lead acid battery is given in the Standard Handbook for Electrical Engineers by Fink and Carroll as follows:

$$V_{oc} \text{ in Volts per cell} = \text{Specific gravity} + 0.84.$$

Hence, for the MS 35000 battery with a specific gravity of 1.280, the open circuit voltage will be 25.44 Volts.

It was decided that a voltage level of 30.50 Volts (at 25° C) is a suitable choice for the "end of charge" or maximum voltage which the charger will apply to the battery.

3.2 Temperature Compensation

With regard to the variation of charging voltage with temperature, it was concluded that the voltage should decrease with increasing temperature at a constant rate of 0.0063 Volts/cell/degree Celsius over an operating range of -15°C to +52°C (+5°F to +125°F). Over this temperature range, the charger output voltage would vary from roughly 33.5 to 28.5 Volts. No attempt was made to extend the range of temperature compensation down to -54°C (-65°F) for the following reasons:

- All vendors stated that it was impractical to charge the MS 35000 BB-249/U 2HN battery at these very low temperatures, citing extreme viscosity of the electrolyte, and very low charging rates as almost insurmountable problems.
- Voltages in excess of 34 Volts would be applied to the fuel boost pump and other DC accessories as well as the batteries.
- Military users generally remove the batteries during sub zero temperatures, store them in a heated space, and replace them as required for use. Therefore, a capability for charging at the specified lower limit of -54°C is unnecessary. In fact, because of inherent limitations in the temperature sensing hardware, this capability would entail a risk of dangerous overcharging at a voltage of more than 36 Volts if service personnel were to start a cold soaked EMU 30 shortly after installing a warm battery.

4.0 SUMMARY OF DESIGN OBJECTIVES

A redesign of the battery charger was undertaken with the following objectives.

a. Retain basic circuit configuration insofar as practicable.

b. Provide an end of charge voltage of 30.50 Volts at 25°C.

c. Provide negative temperature compensation in the amount of 0.0063 Volts/cell/degree Celsius over a temperature range of -15°C to +52°C.

d. Provide additional current capability to accommodate the auxiliary servicing current of 4.4 Amperes as well as a maximum battery charging current of at least 6.0 Amperes.

5.0 MODIFICATIONS AND SUPPORT DATA

5.1 Control Module A3

In order to achieve the new voltage and temperature characteristics, the following changes were made:

- Zener diode VR2 was changed from 1N936A (9.0 Volts ± 5%) to 1N2622A (9.3 Volts ± 4.3%).
- Potentiometer R18 was changed from 1K OHM to 2K OHM.
- Nominal resistor R27 was removed.
- Resistor R17 was changed from 21.5K OHM to 28K OHM.
- Resistor R21 was changed from 20K OHM to 28K OHM.

The new values for VR2 and R18 eliminated the need for nominal resistor R27. Increasing the value of R18 increased the temperature coefficient but decreased the output voltage. The decrease in output voltage was restored by higher values for VR2 and R21.

A plot of the voltage versus temperature characteristic of the modified system is shown in Figure 6. Generally the temperature characteristic conforms to the vendor's recommended rate of 0.0063 Volt/cell/°C over the temperature range of -15°C to +52°C. At lower temperatures, the output voltage approaches an ultimate limit of 34.1 Volts.

Figure 7 is a regulation curve of the battery charger with the

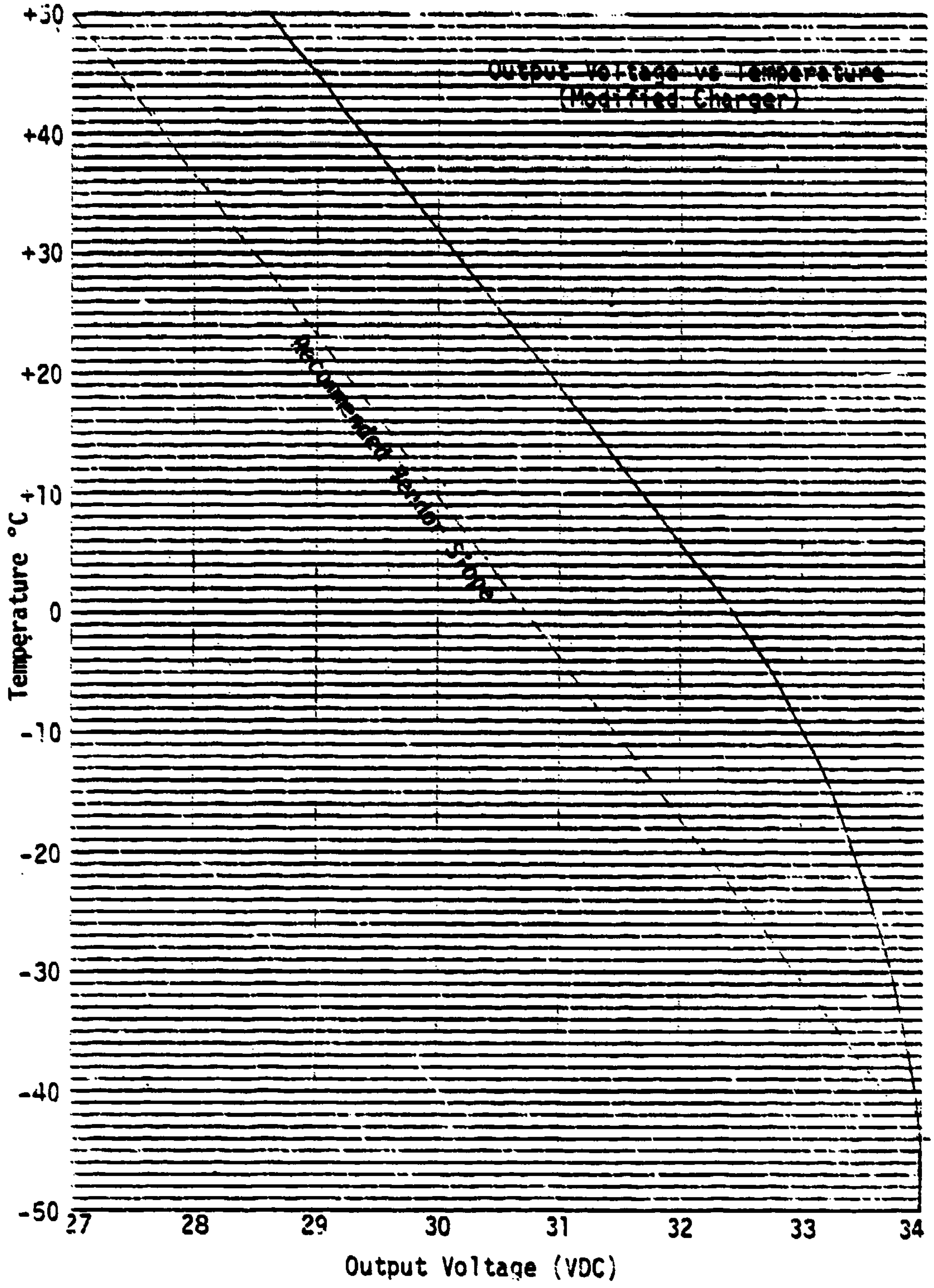


Figure 6. Output Voltage vs Temperature
(Modified Charger)

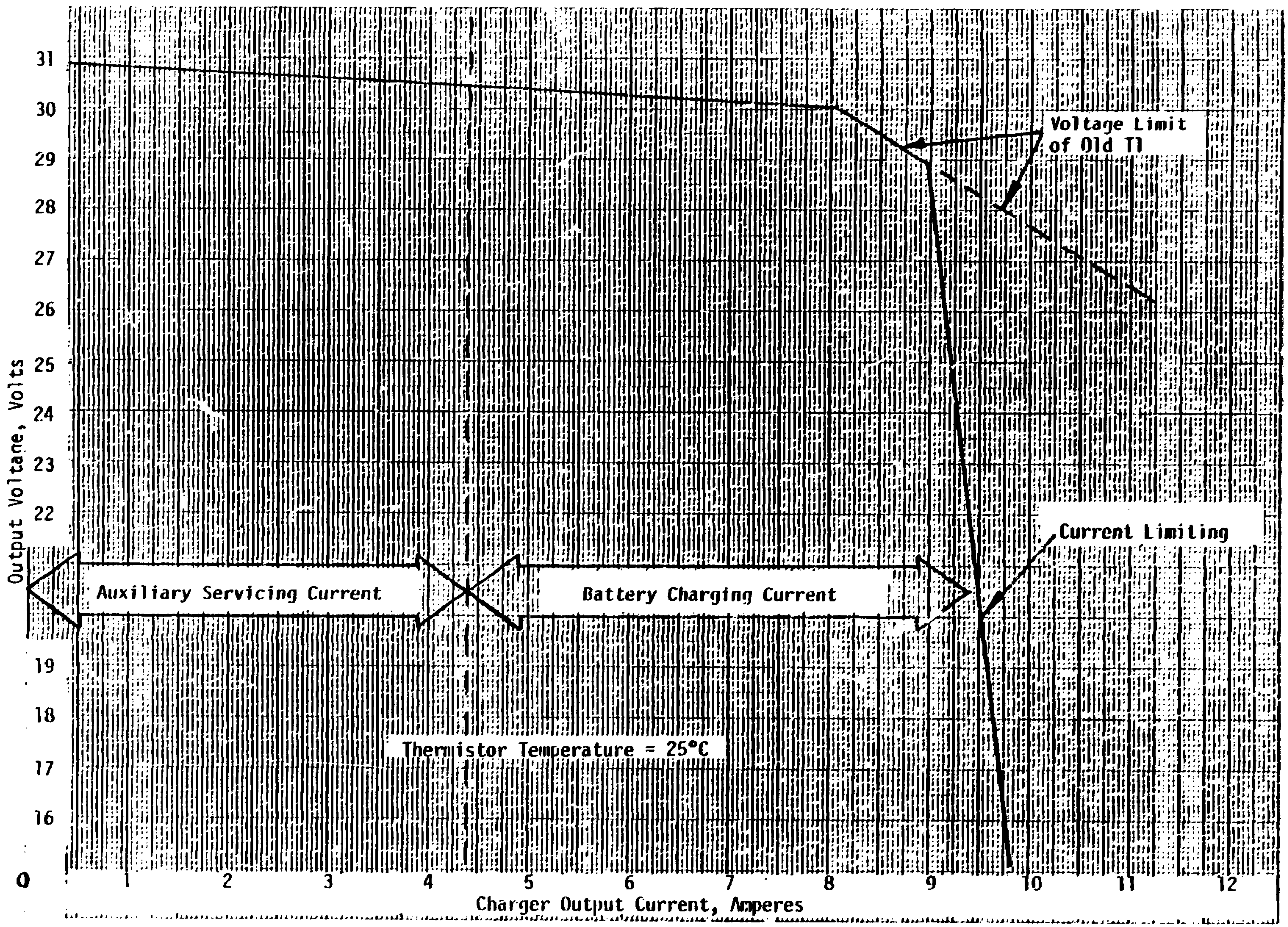


Figure 7. Regulation With Modified A3 Board, Old R1 and Old T1

modified A3 board installed. The limitations caused by Transformer T1 and current sensing resistor R1 are shown. T1 causes excessive voltage droop and R1 causes premature current limiting.

5.2 Current Sensing Resistor R1

As previously explained, this resistor controls the current limiting action of the regulator. Its value was changed from 0.06 OHM to 0.045 OHM. This change shifts the onset of current limiting from 8.7 Amperes to 11.5 Amperes.

Figure 8 shows the regulation curve of a battery charger unit configured as follows:

- New A3 board
- New R1 = 0.045 OHM
- Old Transformer T1

This curve shows that the performance of the charger is seriously degraded by the characteristics of the old transformer. It also shows the effect of a ten volt variation in the AC input voltage to the charger. The limitations of the old transformer would be particularly critical at low operating temperatures, where charging voltages of up to 34 Volts are required.

5.3 Transformer T1

A new transformer was designed to provide the required output voltage throughout the operating range of the charger. The voltage versus current regulation of the old and new transformer are shown in Figure 9. This figure also shows the test circuit used for these measurements.

The new transformer provides a substantial improvement in regulation and superior temperature characteristics. The temperature rise

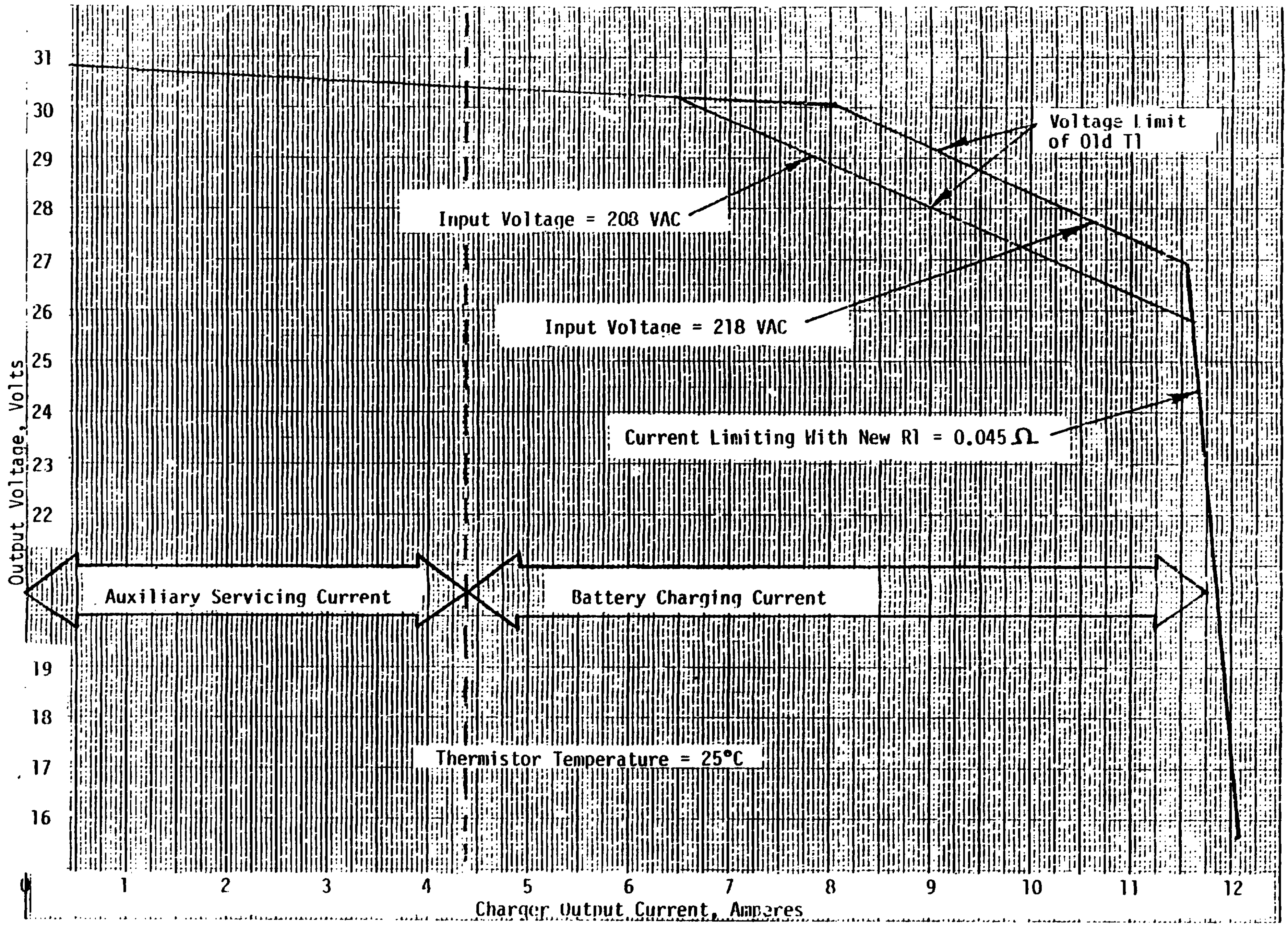


Figure 8. Regulation With Modified A3 Board, New R1 and Old T1

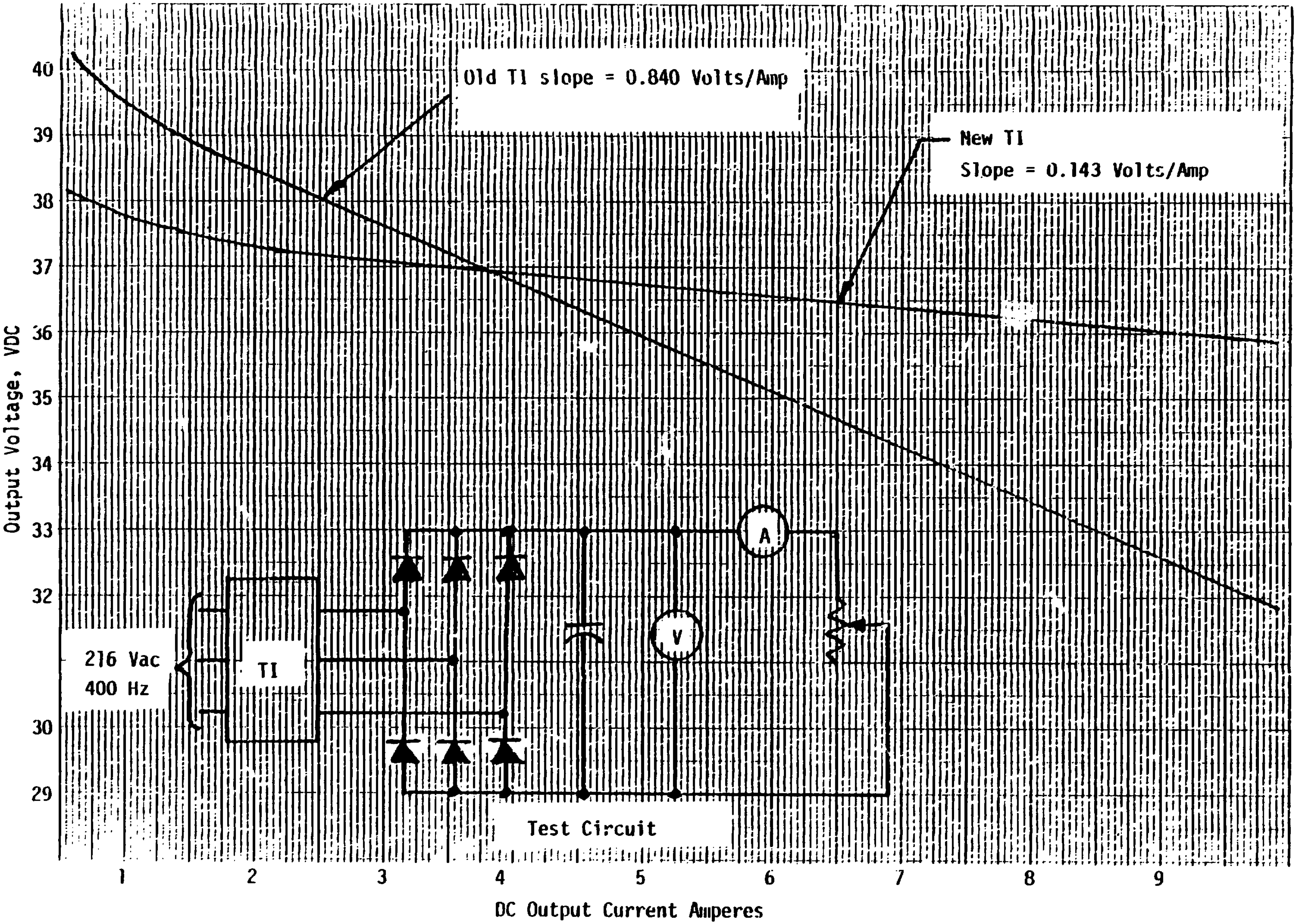


Figure 9. Voltage/Current Regulation of New TI and Old TI

of the new transformer over a 30 minute period in a charger providing a continuous output of 5 Amperes was measured at 20°F. The temperature rise of the old transformer under similar conditions was measured at 40°F.

5.4 Fuses and Maximum Current Tests

Fuses F1, F2 and F3 were changed from 1.5 Ampere to 2.0 Ampere ratings. Fuse F4 was changed from a 10.0 Ampere to a 15 Ampere rating.

Short circuit tests were conducted on a completely modified unit to verify current limiting action. This was done by shorting the DC output lines for a period of 10 seconds. The maximum short circuit current, measured with a conventional D'Arsonval DC Ammeter (Simpson model 375) was measured at 13.25 Amperes.

The short circuit current waveform was determined by measuring the voltage drop across resistor R1 with an oscilloscope. The waveform was found to be a saw-tooth ranging from 11.1 Amperes to 16.5 Amperes, with a calculated average value of 13.8 Amperes. These values are well within the specified ratings of components used in the power switching circuitry.

5.5 Location of Sensor Module TC3

Since the thermistor can control the output voltage of the charger, the location of this sensor module is critical. It has been found that changes in the location of the module within the battery compartment can alter the output voltage by as much as 1.5 Volts.

During the modification of units in the field, the sensor module was mounted as shown in Figure 10. The metal attaching flange of the sensor module was sandwiched between the upper and lower sections of the

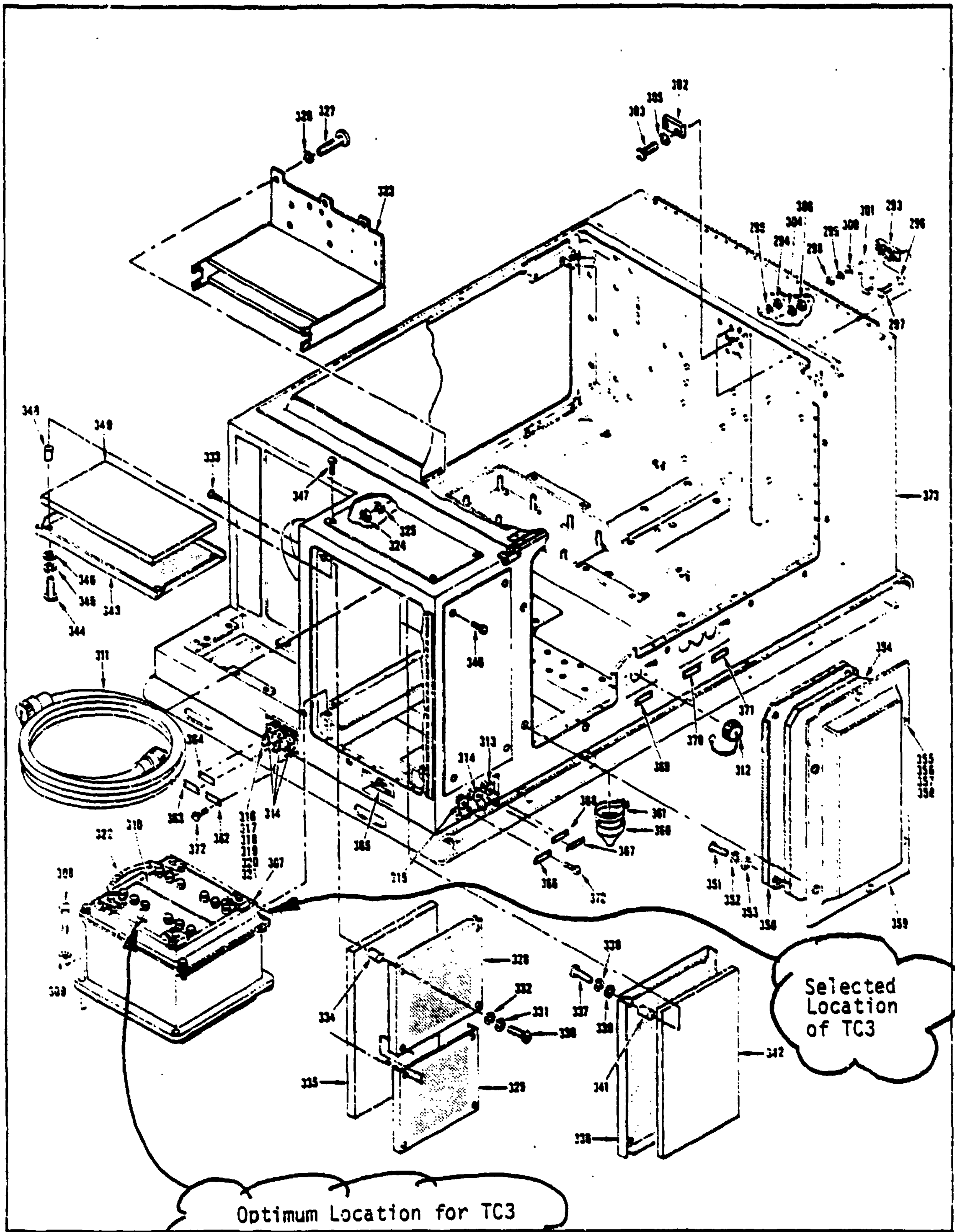


Figure 10. Location of Sensor Module TC3

battery container assembly. When the length of adjoining wire permitted, it was secured in place by passing the battery container bolt through the eye of the attaching flange of the sensor module.

This mounting arrangement is not considered optimum, but was necessary to conform to the installation schedule. See paragraph 7 for further comments and recommendations.

5.6 Output Characteristics of Completely Modified Charger

The regulation curve of the completely modified charger for a battery temperature of 25°C is shown in Figure 11.

Nominal characteristics of the modified charger are tabulated below:

Output current	11.5 Amperes
Voltage regulation	0.1 Volts/Ampere
Calibration at 25°C	30.4 Volts at 5.0 Amperes
Short circuit current	13.25 Amperes
Temperature compensation	-0.0063 Volts/cell/°C
Maximum obtainable output voltage at -54°C	34.1 Volts

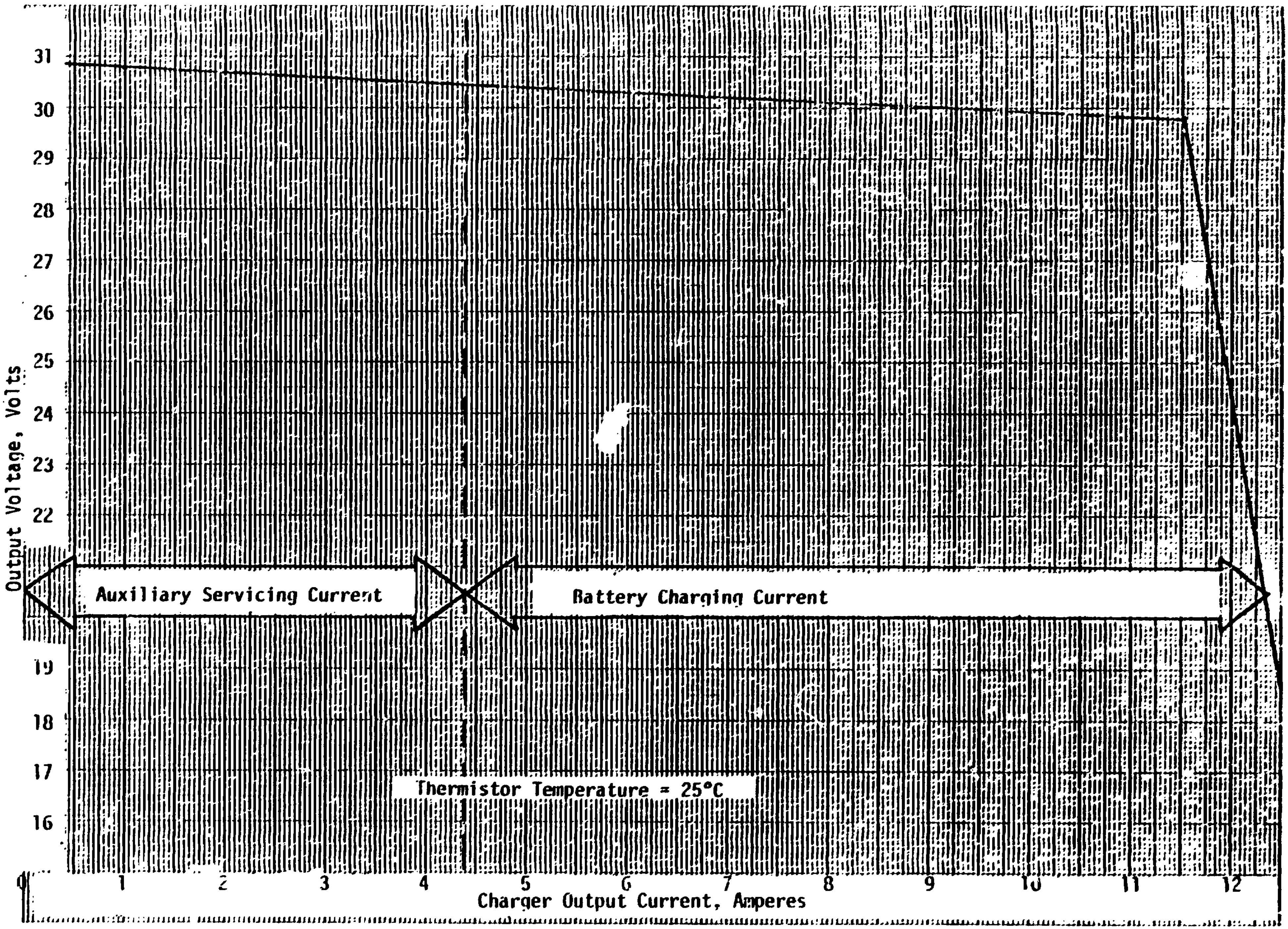


Figure 11. Regulation of Completely Modified Charger

6.0 SYSTEM TESTS WITH EMU 30 GENERATOR SET

An eight hour test run was conducted to determine the effect of continuous charging for prolonged periods on the battery. Immediately prior to the run, the charger was bench tested and calibrated to a 25°C setting of 30.4 Volts at 5.0 Amperes. The condition of the battery electrolyte before and after the run is tabulated below.

ELECTROLYTE	START	FINISH
Temperature	66.5°F	97.0°F
Specific Gravity	1.245	1.230

After four hours of running, the charger output had stabilized to a level of 30.3 Volts, with an output current of 1.6 Amperes for the battery and 4.4 Amperes for auxiliary loads. For the remainder of the run, there was no discernible change in the charger output, and moderate gassing of the electrolyte was noted. At the end of the run, there was no significant change in the level of the electrolyte.

Several test trials were conducted to determine the charging time required to replace the 0.6 Ampere hours which is consumed in starting the EMU-30 turbine at normal ambient temperatures. The tests indicated a recovery time of six to nine minutes depending upon the condition of the battery.

7.0 RECOMMENDATION

Because of the control the thermistor has on the output voltage of the charger, it is important that the thermistor be mounted in the same thermal environment as the battery to provide proper charging voltage. As it is physically impractical to submerge the thermistor into the battery electrolyte and still maintain ease of battery service, it is recommended that the existing thermistor be mounted on the battery hold down frame, away from the turbine exhaust area, using the existing hardware and lengthening the thermistor wiring. This recommendation is based on the assumption that the battery hold down frame will provide fairly good thermal contact with the battery case, and that the installation will cause no major problems during inspection and routine maintenance.

For optimum temperature sensing it is recommended that the thermistor be packaged in a thermally conductive material and mounted directly on the battery case. See Figure 12.

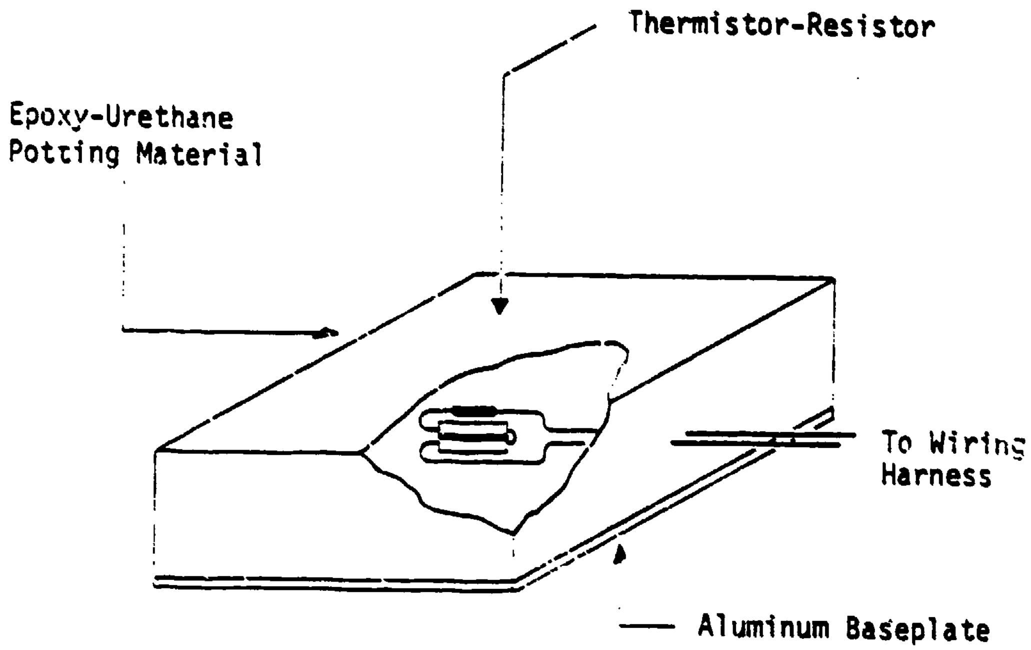


Figure 12.

REFERENCED DOCUMENTS

I. REFERENCED DOCUMENTS

1.1 Government Documents. The documents listed below were used in the preparation of this report.

SPECIFICATIONS

MIL-G-52884	Generator Sets, Diesel Engine Driven, 15 thru 200 kilowatts, 50/60 and 400 (Tactical),
Hertz,	General Specification For
MIL-G-52889	Generator Sets, Diesel Engine Driven, 5 kw, 60 Hertz and 10 kw, 60 and 400 Hertz Tactical, Utility, General Specification For

STANDARDS

MIL-STD-209	Slinging & tie down provisions for lifting & trying down military equipment.
MIL-STD-454	Standard General Requirements for Electronic Equipment
MIL-STD-461	Electromagnetic Emission and
Susceptibility	Requirements for the Control of Electromagnetic Interference
MIL-STD-633	Mobile Electric Power Engine Generator Set Family Characteristic Data Sheets
MIL-STD-705	Generator Sets, Engine Driven Methods of Tests and Instructions.
MIL-STD-882	System Safety Program Requirements
MIL-STD-1332	Definitions of Tactical, Prime Precise and Utility Terminologies for Classification of the DOD Mobile Electric Power Engine Generator Set Family
MS53028	Chasis, Trailer: 3/4 Ton, 2 Wheel, Military Design, M116A1
MS53029(AT)	Trailer, Chassis 1 1/2 Ton, 2 Wheel,
M103A3 &	M103A4
MS53030(AT)	Chassis, Trailer: Generator, 2 1/2 Ton,
2	Wheel, Military Design, M200A1
MS53031	Chassis, Trailer: 2 Wheel, 3 1/2 Ton,
M353	

ARMY REGULATIONS

AR-70-38	Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions
AR-70-71	Nuclear, Biological, & Chemical Contamination Survivability of Army Materiel

MISCELLANEOUS

Evaluation of Development Test III of 100 kW, 50/60 Hz Generator Set, DED, TECOM Project No. 7-EG-335-100-007,dtd 23 September 1974

ABBREVIATION and ACRONYMS

BITE	Built In Test Equipment
CARC	Chemical Agent Resistant Coating
CGSA	Commercial Generator Set and Assemblages
dBA	Decibel Adjusted
DCA	Diagnostic Connector Assembly
DED	Diesel Engine Driven
DISE	Distribution/Illumination System Electrical
DOD	Department of Defense
EIR	Equipment Improvement Report
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
F	Fahrenheit
Ft	Feet
FY	Fiscal Year
GED	Gasoline Engine Driven
GFD	Government Furnished Data
GTED	Gas Turbine Engine Driven
Hz	Hertz
IAW	In Accordance With
IPECS	Integrated Power and Environmental Control Systems
IR	Infrared
KW	Kilo Watt
LBS	Pounds
LEH	Load-Sensing Electric Hydraulic
Ma	Milliamperes
MACI	Military Adaptation of Commercial Items
MEP	Mobile Electric Power
MEPG	Mobile Electric Power Generator
MEPGS	Mobile Electric Power Generating System
MIL-SPEC	Military Specification
MIL-STD	Military Standard
MOPP	Mission Operational Protective Procedures
MTBF	Mean Time Between Failure
MTBOMF	Mean Time Between Operational Mission Failures
NBC	Nuclear, Biological, Chemical
NDI	Non Developmental Item
OMF	Operational Mission Failures
QDR	Quality Deficiency Report
RAM-D	Reliability, Availability, Maintainability, Durability
RFI	Radio Frequency Interference
ROC	Required Operational Capability
SDC	Sample Data Collection
Secs	Seconds
SSDED	Signature-Suppressed Diesel Engine Driven
STE/ICE	System Test Equipment/Internal Combustion Engine
TACOM	Tank Automotive Command

ABBREVIATIONS and ACRONYMS

TAMMS	The Army Maintenance Management System
TM	Technical Manual
Vdc	Voltage direct current