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Matériel Test Procedure 9-2-166
General Equipment Test Activity

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

AIR COMPRESSOR

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1. OBJECTIVE*

This document provides test methodology and test techniques necessary to determine the technical performance and safety characteristics of air compressors and associated tools and equipment as described in Qualitative Materiel Requirements (QMR's), Small Development Requirements (SDR's), and Technical Characteristics (TC's), and to determine the item's suitability for service tests.

2. BACKGROUND

Portable air compressors furnish compressed air through a hose system to pneumatically-operated construction tools such as saws, pumps, paving breakers, rock drills, clay diggers, concrete vibrators and back fill tampers. For such applications the usual air pressure is 100 psig, nominal, and the usual air delivery rate ranges from 85 c.f.m. to 600 c.f.m.

The major items comprising a compressor unit are the drive motor, the compressor, the air reservoir or receiver, the cooling and regulating systems, and the control panel. These are usually contained within a sheet metal housing equipped with hinged side access panels. The entire unit, including the appropriate essential accessories, is generally supported on an integral metal framework, which may be mounted on a truck or on skids, or it may be equipped with wheels and a tow bar to make it a trailer-mounted device.

The compressed air output from the compressor unit is taken from the air receiver, which is usually equipped with an air service manifold having two or more individually-controlled service outlets, each of which can be shut off at will. Each service outlet is equipped with a suitable coupling to which a flexible air hose can be attached. The compressed air may be conveyed to the pneumatic tool by means of a continuous length of 3/4-inch diameter flexible hose. However, when the air line length to the tools exceeds 200 feet, such a hose may introduce too much pressure drop in the air line. To remedy this, an external manifold system may be installed, consisting of a 2-1/2 inch, or larger, diameter metal pipe to convey the compressed air to a point near the work site. A short length of small diameter flexible hose is then used to connect the pneumatic tool to the nearest point on this pipe. The smaller-sized compressor units are frequently supplied with one or two externally-mounted hose reels, each holding a 50 or 100 foot length of flexible air hose. A fire extinguisher, mounted on the compressor unit, is a recommended safety feature.

*This MTP is intended to be used as a basic guide in preparing actual test plans for the subject equipment. Specific criteria and test procedures must be determined only after careful appraisal of pertinent QMR's, SDR's, TC's, and any other applicable documents.

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The "size" of the compressor unit is identified by the maximum quantity of air it can deliver at the rated p.s.i. gauge pressure. In practically all cases, the compressor inlet air is at atmospheric pressure. When a variable speed drive motor is used, the output c.f.m. can be reduced by reducing the speed of the compressor drive motor. An automatic pressure regulator is generally used to maintain the discharge pressure substantially constant as the air demand is reduced from maximum to zero.

Various kinds of prime movers are used to drive the compressor. These include electric motors, gas turbines, and reciprocating internal combustion engines (gasoline or diesel.) Portable compressor units require the use of a gasoline or diesel engine drive at present, but there is a possibility that a newly-developed multiple fuel engine, operating on either diesel fuel oil, gasoline or kerosene, will become available in the near future.

There are six basic types of air compressors: thermal, centrifugal, axial flow, reciprocating piston, rotary sliding vane, and cycloidal screw. The most frequently-used portable types, at present, are the rotary sliding vane, and the cycloidal screw types. These types are smaller in size than a reciprocating piston type of the same rating, and their maintenance costs are less because they have no valves to wear out and replace, no clutch to adjust and repair, and no pistons, rings or rods to cause air pulsations and unbalanced reciprocating forces.

For each 1000 feet above sea level, the performance of 125 to 600 c.f.m. rotary sliding vane and cycloidal screw type compressors changes approximately as follows, using the same fuel: (1) Capacity decreases 0.5%, (2) power input requirement decreases 1%, and (3) engine power output decreases 2.7%.

3. REQUIRED EQUIPMENT

One or more of the following items and/or facilities will be required to obtain data during the various evaluations:

- a. Tape Measure.
- b. Still Camera, Film, Flashbulbs.
- c. Motion Picture Camera and Film.
- d. Weighing Scales.
- e. Ship Simulator for roll and pitch tests.
- f. Environmental Test Facility.
- g. Drop Test Facility
- h. Reference Standards for Instrument Calibration, including a dead weight pressure gauge to calibrate Bourdon pressure gauges.
- i. Calibrated Thermocouples for temperature measurement.
- j. Sound Level Meter per ASA Standard Z24.3.
- k. Octave-band Filter Set per ASA Standard Z24.10.
- l. The following instruments meeting the ASME Power Test Code Supplements on Instruments and Apparatus (hereinafter called I & A):

- 1) Barometer, Part 2, Chapters 1 and 6.
- 2) Thermocouples and associated instruments, Part 3, Chapters 1,

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3, and 6.

- 3) Pressure Gauges, Part 2, Chapters 1, 2, 4, 5, and 6.
- 4) Differential Gauges, Part 2, Chapters 2, 5, and 6.
- 5) Standardized Flow Nozzles, Part 5, Chapter 4.
- 6) Revolution Counters, Part 13.
- 7) Appropriate Electrical Instruments for electric motor cradle dynamometer, Part 6, (when used).

m. Psychrometer (dew point measuring apparatus).

n. Fuel Measuring Apparatus for internal combustion engine driver.

o. Flow Nozzle arrangement per Figure 2"A" of ASME Power Test Code PTC-9 (hereinafter called PTC-9) and sections 4-10 through 4-15 and 4-29 of PTC-9.

p. Long Radius, Low Ratio Flow Nozzle described in I & A, Part 5, Chapter 4, and meeting the following requirements of PTC-9 for the air capacity being measured, with the inlet air at 68°F and 14.7 p.s.i.a., having a relative humidity of 36 percent.

1) Figure 2"A"

2) Figure 6.

q. Fortin type mercurial barometer fitted with a vernier suitable for reading the nearest 0.002 part of an inch, and equipped with an attached thermometer for indicating the instrument temperature.

r. D.C. Voltmeter and Ammeter.

s. Radio Frequency Measuring Equipment meeting the requirements specified in paragraph 4J and 400.

t. Means to vent the exhaust fumes of gasoline or diesel engines to outdoors.

u. Wrenches, Pliers, Screwdrivers.

v. Fuel-contaminating foreign matter consisting of not less than 68 percent SiO₂ and having a particle size analysis as follows:-

<u>Particle Size, microns</u>	<u>Percent of Total by Weight</u>
0 - 5	39 ± 2
5 - 10	18 ± 3
10 - 20	16 ± 3
20 - 40	18 ± 3
Over 40	9 ± 3
Through a 200-mesh screen	100

w. Lubricating Oil for compressor per MIL-L-17672, symbol 2110TH.

x. Diesel Engine Fuel Oil per VV-F-800.

y. Gasoline Fuel per MIL-G-3056.

z. Anti-freeze Compound per G-A-548.

aa. Gasoline Engine Lubricating Oil per MIL-L-2104 and MIL-L-10295.

bb. Tire Pressure Gauge.

cc. Forklift Truck.

dd. Stop Watch.

ee. Tension Dynamometer and associated steel cable or chain.

ff. Greases per MIL-G-23827 and MIL-G-10924.

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- gg. Automatic device to shut off compressor air flow for 1 minute during a 5 minute ON-OFF cycle.
- hh. Nylon straps, chains or wire ropes for sling rigging tests.
- ii. Broad band audio frequency amplifier, with substantially flat response between 37 and 9600 cps, and associated microphone and sound level recorder.

4. REFERENCES

- A. Army Regulations AR 70-38, Operation of Materiel Under Extreme Conditions of Environment.
- B. AMCP 706-134, Maintenance Guide for Design.
- C. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
- D. USATECOM Regulation 70-23, Equipment Performance Report (EPR's).
- E. USATECOM Regulation 700-1, Value Engineering.
- F. USAGETA (HEDGE) Document, Human Factors Evaluation Data for General Equipment.
- G. American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels.
- H. American Society of Mechanical Engineers, Power Test Code, Displacement Compressors, Vacuum Pumps, and Blowers. (PTC 9-1954) (Referred to hereinafter as PTC-9).
- I. US Department of Commerce Publication No. 235, Weather Bureau Psychometric Tables.
- J. Human Engineering Laboratories (HEL) Standard S-1-63B, Maximum Noise Level for Army Materiel Command Equipment.
- K. Human Engineering Laboratories (HEL) Technical Memorandum 13-67, Criteria for Assessing Hearing Damage Risk from Impulse-Noise Exposure.
- L. MIL-C-00555, Compressors, Reciprocating and Rotary, Air: Diesel-Engine-Driven.
- M. MIL-C-26805, Compressor Units, Air, General Requirements for.
- N. MIL-C-3600, Compressor, Rotary, Power-Driven; and Compressor, Reciprocating, Power-Driven: Air and Gas (Except Oxygen and Refrigerant), Packaging of.
- O. MIL-C-4851, Compressor, Air, Gas Turbine Driven; Trailer Mounted, 150 Air HP, Type MA-1A.
- P. MIL-C-82086, Compressors, Rotary, Power Driven: Diesel Engine, Commercial.
- Q. MIL-E-11275, Engine, Gasoline, Industrial Type, General Specification for.
- R. MIL-E-11276, Engines, Diesel: Industrial, Medium and High Speed, General Specification for.
- S. MIL-G-10924, Grease, Automotive and Artillery.
- T. MIL-G-23827, Grease, Aircraft and Instrument, Gear and Actuator Screw.
- U. MIL-G-3056, Gasoline, Automotive, Combat.
- V. MIL-L-10295, Lubricating Oil, Internal Combustion Engine, Sub-Zero.
- W. MIL-L-17672, Lubricating Oil, Hydraulic and Light Turbine, Non-

- Corrosive.
- X. MIL-L-2104, Lubricating Oil, Internal Combustion Engine, Heavy Duty.
 - Y. MIL-P-116, Preservation, Methods of.
 - Z. Federal Test Method Standard No. 101b, Preservation, Packaging, and Packing Materials; Test Procedures.
 - AA. O-A-548, Antifreeze, Ethylene Glycol, Inhibited.
 - AB. VV-F-800, Fuel Oil, Diesel.
 - AC. TM 55-450-8, Exterior Transport Procedures.
 - AD. TM 55-450-9, Internal Transport Procedure.
 - AE. MIL-STD-129, Marking for Shipment and Storage.
 - AF. MIL-STD-130, Identification Marking of US Military Property.
 - AG. MIL-STD-209, Slinging Eyes and Attachments for Lifting and Tying Down Military Equipment.
 - AH. MIL-STD-281, Automobiles, Trucks, Truck-Tractors, Trailers and Trailer Dollies, Preservation and Packaging of.
 - AI. MIL-STD-461, Electromagnetic Interference Characteristics, Requirements for Equipment.
 - AJ. MIL-STD-810, Environmental Test Methods.
 - AK. MIL-STD-1186, Cushioning, Anchoring, Bracing, Blocking and Waterproofing; with Appropriate Test Methods.
 - AL. MIL-STD-1400, Engines, Gasoline or Diesel, Methods of Test.
 - AM. MTP 2-2-520, Logistics-Over-The-Shore (LOTS) (Vehicles).
 - AN. MTP 2-2-613, Broadband Radio Interference Tests of Vehicles and Electronic Equip-Noncom.
 - AO. MTP 2-2-800, Center of Gravity.
 - AP. MTP 7-2-515, Air Transport, Internal (Suitability of Equipment for).
 - AQ. MTP 9-2-503, Durability.
 - AR. MTP 10-2-500, Physical Characteristics.
 - AS. MTP 10-2-501, Operator Training and Familiarization.
 - AT. MTP 10-2-503, Surface Transportability (General Supplies and Equipment).
 - AU. MTP 10-2-505, Human Factors Evaluation.
 - AV. MTP 10-2-507, Maintenance Evaluation.
 - AW. MTP 10-2-508, Safety.
 - AX. MTP 10-2-511, Quality Assurance.
 - AY. MTP 10-2-512, Reliability.

5. SCOPE

5.1 SUMMARY

This procedure describes the preparation for, and methods of evaluating the technical characteristics of air compressors and their suitability for service testing. The required tests are summarized as follows:

- a. Preparation for Test - A determination of the condition and physical characteristics of the test item, operator training and familiarization procedures, and pre-test requirements.
- b. Functional Performance - An evaluation to determine the following characteristics:

- 1) Rated capacity
- 2) Automatic regulation
- 3) Tilted position test
- 4) Endurance test
- 5) Cycling Test
- 6) Fuel contamination test.

c. Radio Interference Characteristics - An evaluation of the amount of conducted, induced, or radiated electrical disturbance generated by the test item during operation.

d. Environmental Tests - An evaluation of the ability of the test item to withstand temperature extremes, high altitude, shock, salt fog, and dust.

e. Transportability - An evaluation to determine the ability of the test item and its accessories to be transported by land, sea and air without damage.

f. Maintenance - An evaluation to determine and appraise the test item's maintenance characteristics and requirements, a verification and appraisal of its malfunctions, an evaluation of the test item's associated publications and other common and special support elements (maintenance test package), an appraisal of the test item's design for maintainability (AMCP 706-134: Accessibility, ease of maintenance, standardization, and interchangeability), an evaluation of component and system durability and reliability, and the calculation of indicators which express the effects of appropriate preceding aspects.

g. Safety - An evaluation to determine the test item compliance with safety requirements and to confirm the test item's safety characteristics during conduct of all tests.

h. Human Factors - An evaluation of the man-item relationship during operation, maintenance and transport of the test item, including the noise level generated, and design deficiencies which affect operability.

i. Value Analysis - An evaluation to determine whether the test item contains unnecessary, costly, or "nice-to-have" features which could be eliminated without affecting technical performance or safety.

j. Quality Assurance - A review to determine and evaluate defects in material and workmanship.

5.2 LIMITATIONS

None

6. PROCEDURES

NOTE: The techniques used in the installation, fueling, lubrication, adjustment, operation and maintenance of the test item will be those described in the applicable manufacturer's instruction manual, or draft technical manual. Any change or deviation from these techniques will be recorded in the test item log book.

6.1 PREPARATION FOR TEST

6.1.1 Initial Inspection

Upon receipt of the test item at the test site, the test item shall be subjected to the following:

- a. Visually inspect the test item packaging and record the following:
 - 1) Evidence of packaging damage or deterioration.
 - 2) Identification markings, including:
 - a) Name of contractor
 - b) Date of manufacture
 - c) Other markings pertaining to the test item.
- b. Weigh and measure the individual package(s) of the test item and its accessories and record the following:
 - 1) For each shipping package
 - a) Contents
 - b) Weight
 - c) Length, width and height
 - d) Cubage
 - 2) For the entire test item:
 - a) Weight
 - b) Cubage
- c. Unpack the test item, visually inspect it, and record the following, as applicable:
 - 1) Evidence of defects in:
 - a) Manufacturing
 - b) Material
 - c) Workmanship
 - 2) Evidence of damage, especially behind any sheet metal dents.
 - 3) Evidence of wear, especially on the back and front side walls of trailer tires.
 - 4) Evidence of lubricant leakage.

NOTE: Make use of photographs, diagrams, and narration to indicate the condition of the test item and its accessories, as applicable.
- d. Note and record the presence of identification and instruction plates, and their adequacy, including:
 - 1) Identification, name and serial number.

- 2) Caution instructions.
- 3) Installation and service instructions, including lubrication and fueling.
- 4) ASME Code for Unfired Pressure Vessels stamping on the air receiver.
- 5) Engine make, model and serial number.
- 6) Compressor make, model and serial number.
- 7) Air delivery rating in c.f.m. and air pressure in p.s.i.

e. Note and record the presence of descriptive technical, installation and maintenance literature, and any shortage in repair parts, accessories, tools or kits.

f. Submit an Equipment Performance Report (EPR) for each noted shortage or discrepancy.

g. Note and record the following:

- 1) The condition of all test unit controls and indicators.
- 2) Freedom of rotation of the compressor drive shaft.

6.1.2 Physical Characteristics

Determine the physical characteristics of the test item in conformity with MTP 10-2-500. Measure and record the following data:

- a. Test item length (less drawbar).
- b. Overall silhouette width and height.
- c. Ground clearance.
- d. Wheel base.
- e. Drawbar pull.
- f. Center of gravity per MTP 2-2-800 or TM 55-450-9, appendix II, as applicable.
- g. Gross weight.

6.1.3 Operator Training and Familiarization

Test personnel shall receive training and familiarization in accordance with applicable procedures of MTP 10-2-501 and the following:

a. Instruct all test personnel in test item operation and maintenance. Stress safety precautions to be observed when operating, maintaining, or repairing the test item and associated equipment.

b. Copies of the draft or preliminary technical manual, and written safety instructions, will be issued to each test team member.

c. Familiarize the test team concerning the purpose and methods required to test the air compressor (and the trailer, when applicable) and familiarize team members with trade terms and unique state-of-the-art terminology not otherwise defined in the supplied instructions.

d. Test personnel will read and be familiar with all operations indicated in the manuals.

6.1.4 Pre-Test Requirements and Qualifications

a. Proper testing of air compressors requires that competent personnel do the work, that all necessary testing equipment and facilities be provided, and that testers have a practical knowledge of fueling, lubricating, maintaining and adjusting gasoline or diesel engines. When an internal combustion engine maintenance group is available, personnel from this group should perform these tests, as well as any maintenance of the compressor system that may be necessary.

b. Before starting the air compressor unit, perform all of the checks and adjustments specified in the draft technical manual.

c. Determine and record whether military greases were used as lubricants in the test item. If not, clean the bearings and lubricate them with the following greases, unless otherwise specified: -

- 1) MIL-G-23827 - Instruments and sealed bearings.
- 2) MIL-G-10924 - Bearings where operating temperatures do not exceed 175° F.
- 3) Record that each component has been identified in a conspicuous place to indicate which military grease has been used.

d. Verify and record that the following requirements have been met, unless otherwise specified: -

<u>Component</u>	<u>Specification</u>
Compressor lubricating oil (for ambient temperatures from 120°F. to minus 25°F.)	MIL-L-17672, symbol 2110TH
Diesel engine fuel	VV-F-800
Gasoline engine fuel	MIL-G-3056, type II
Diesel or gasoline engine lubricant for 0°F. and higher ambient temps.	MIL-L-2104
Diesel or gasoline engine lubricant for subzero ambient temps.	MIL-L-10295, OES Grade
Antifreeze for water cooling system	O-A-548
Gasoline engine	MIL-E-11275
Diesel engine	MIL-E-11276

e. Verify and record that the diesel or gasoline engine lubrication system is completely drained when changing lubricating oils, and that the specified amount of antifreeze compound is added to the water cooling system

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when the ambient temperature is 32° F. or lower.

f. Verify and record that all Bourdon pressure gauges, and all manometers, are calibrated on a dead-weight tester.

g. Verify and record that the air receiver meets the requirements of the ASME Unfired Pressure Vessel Code.

6.2 TEST CONDUCT

NOTE: Report all equipment failures in accordance with USATECOM Regulation 70-23.

6.2.1 Functional Performance

6.2.1.1 Preparations

a. Remove any air intake pipe ahead of the air intake filter.

b. Verify and record that the test item is mounted on a surface having an inclination of not more than 5 degrees from the horizontal, unless otherwise specified.

c. Verify and record that all procedures specified by the manufacturer have been complied with before starting the compressor unit.

d. Install the flow nozzle sized for the rated capacity and described under items o and p of Section 3, "REQUIRED EQUIPMENT".

6.2.1.2 Rated Capacity Test

a. Start the unit and run it for 8 hours at an ambient temperature not less than 68° F. and not greater than 90° F.

b. During the last hour, measure and record the following:

- 1) T_1 , the average absolute temperature, in ° K., at compressor air intake. This shall be the average of three readings taken at 3 points, at the engine crankshaft height, 3 to 5 feet from the compressor.
- 2) P_a , the absolute pressure at the compressor intake, p.s.i.a.
- 3) P_b , the barometric pressure, (inches of mercury, corrected).
- 4) P , the differential pressure across the nozzle, inches of water column.
- 5) T_2 , the absolute temperature, upstream of the nozzle, ° F.
- 6) The compressor air receiver pressure, p.s.i.g.

c. Record the air discharge pressure, and the compressor shaft r.p.m.

6.2.1.3 Automatic Regulation

a. Install a 50% capacity flow nozzle in the compressor air discharge. See items in paragraph 30 and 3P

b. Start the unit and run it for 30 minutes at an ambient temperature not less than 68° F. and not greater than 90° F.

c. During this interval, measure and record the readings described under para. 6.2.1.2b.

- d. Record the air discharge pressure and the compressor shaft r.p.m.
- e. Repeat steps b and c with the compressor air discharge completely shut off.

6.2.1.4 Tilted Position Test

NOTE: Perform this test in four different tilted positions, each of which shall be 15 degrees from the horizontal plane about the compressor transverse and longitudinal axes. These tests shall be performed in a sequence whereby the compressor is operated first in the tilted position least likely to adversely affect the lubrication or fuel systems, and lastly in that tilted position most likely to adversely affect these systems.

- a. Install a 100% capacity flow nozzle in the compressor air discharge. See paragraph 30 and 3P.
- b. With the unit in its least adverse tilted position, start and run it for one hour. During this interval, record the readings described under para. 6.2.1.2.
- c. Repeat step b and the 3 remaining tilted positions in the order of increasing severity.
- d. Upon the completion of the fourth or last tilted position test, stop the engine, and allow the compressor to stand in this position for 4 hours, after which period, start and run the compressor in this position for 30 minutes. During this interval, record the readings described under para. 6.2.1.2.
- e. Note and record any evidence of compressor air or lubricant leaks, or any other malfunction.

6.2.1.5 Endurance Test

- a. With a 100% capacity flow nozzle installed in the compressor air discharge, and with the test item mounted on a surface inclined not more than 5 degrees from the horizontal, start the test item, and run it for a total of 640 hours. At the start of the test, and at the end of each 8-hour interval during this period, record the test data described in para. 6.2.1.2.
- b. Record the following downtime data:

- 1) Date.
- 2) Start time.
- 3) Stop time.
- 4) Downtime, hours and minutes.
- 5) Total accumulated operating hours.
- 6) Reason for each stop, such as:
 - a) Normal services such as replenishing fuel, adding or changing lubricant, adding radiator coolant, cleaning or changing filters, etc.
 - b) Kind of adjustments made.
 - c) Nature and cause of malfunction.
 - d) Part replacements.

7) Quantities and kinds of lubricants added or changed (quarts).

6.2.1.6 Cycling Test

a. Install an automatic cycling device to completely shut off the air flow from the 100% capacity flow nozzle for 1 minute during a 5 minute ON-OFF cycle, and then start and run the test item for a total of 180 hours. During this interval, record the air pressure on the upstream side of the flow nozzle, and the compressor rpm, during one ON-OFF cycle, at every 10-hour interval.

b. At the end of 180 hours of cycling, remove the automatic cycling device from the flow nozzle, and run the test item at 100% capacity for 1 hour. At the end of this 1-hour period, record the test data described in para. 6.2.1.2.

c. Repeat the cycling test described under 6.2.1.6 a for another 180 hours, followed by the 1-hour full load test described under 6.2.1.6 b, and record all readings and calculations.

d. Record the downtime data described under 6.2.1.5 b, as applicable.

6.2.1.7 Fuel Contamination Test

a. Drain the fuel from the gasoline or diesel engine fuel tank(s) and replace it with fuel contaminated, to the extent of 8 grams per 1000 gallons, with foreign matter described in para. 3v.

b. With a 100% capacity flow nozzle installed in the compressor air discharge, start and run the test item for a total of 10 hours. At the end of this period, inspect and record the condition of the gasoline or diesel engine fuel filter.

6.2.2 Radio Interference Characteristics

Perform the applicable portions of MTP 2-2-613 (A) and MIL-STD-461, and record all test results.

6.2.3 Environmental Tests

6.2.3.1 High Temperature

a. Perform the high temperature test, method 501, Procedure I, of MIL-STD-810 B with a 100% capacity flow nozzle installed in the compressor air discharge.

b. Run the test item for not less than 8 hours with only the housing covers that are hinged, open. No adjusting or replacement of the engine, or the compressor components, shall be permitted after the first hour of operation.

c. Record the following data at 30-minute intervals during the remaining 7 hours of test:

- 1) Engine coolant liquid temperature.
- 2) Engine lubricating oil temperature.
- 3) Compressor lubricating oil temperature.
- 4) The data described under item b in para. 6.2.1.2 "Rated

Capacity Test".

6.2.3.2 Low Temperature

a. Perform the low temperature test, method 502, Procedure I, of MIL-STD-810 B with a 100% capacity flow nozzle installed in the compressor air discharge, and with the following additional requirements:

- 1) Subject the test item to a temperature of minus 25° F. for a period of not less than 24 hours.
- 2) Start up the test item twice, but do not run it.
- 3) Start the test item a third time, and allow it to run only long enough to establish steady operation. Then adjust the test item controls for compressor cyclic operation, and allow it to operate until the engine and compressor coolant and lubricating oils have stabilized.

b. Record all test results.

6.2.3.3 Salt Fog

Perform the salt fog test, method 509, of MIL-STD-810 B, and record all test results.

6.2.3.4 Dust Test

Perform the dust test, method 410, of MIL-STD-810 B, and record all test results.

6.2.3.5 Altitude

Perform the altitude test, method 500, of MIL-STD-810 B, Procedure I, in conformity with the procedures specified in para. 6.2.3.2, with the pressure in the altitude chamber held at 20.6 inches of mercury (corresponding to an altitude of 10,000 feet), and record all test results.

6.2.4 Drop Test

NOTE: Perform this test only on test items which are protected against mechanical damage during shipment by being partly or wholly encased in a protective shipping structure or container.

a. Visually inspect the test item for defects prior to testing. Record the findings of this inspection.

b. Pack the test item for shipment as specified in MIL-C-3600 and MIL-STD-281, as applicable.

c. Perform the drop test (free fall), methods 5007 and 5018, of FED. TEST METHOD STD. NO. 101 b, except that in no case shall a dummy load be used as a substitute for the test item itself.

d. Upon completion of the test, the test item shall be inspected

visually for damage, and will be operated under normal conditions to determine if there has been any change in performance. Record the results of the visual inspection, and evidence of any change in test item operational performance.

6.2.5 Slinging, Towing and Tiedown Eyes

a. Using a tension dynamometer and suitable steel wire rope or steel chain, apply the following static stress loads to each attachment, (where the value of G is the total shipping weight of the test item), and record the results.

- 1) Lifting - 2 1/2 G's.
- 2) Pulling - 3 G's (for towing a skid-mounted item).
- 3) Tiedown - 8 G's (forward or rearward), 2 1/4 G's (upward or sideward).

b. Determine and record conformance to MIL-STD-209.

c. When the overall dimensions of the test items are such as to require the use of several sling legs to lift and transport it as an external sling load, attach appropriate sling legs, or their equivalent, to the test item lifting eyes (see TM 55-450-8 for rigging instructions), and determine whether the sling legs will converge not more than 19 feet above the lowest extremity of the test item, and clear all exterior parts of the test item by not less than 1 inch. Record all test results.

6.2.6 Transportability

6.2.6.1 Surface Transportability

Determine the following as described in the applicable sections of MFP 10-2-503.

a. Rail transportability, including railroad in operation and rail humping.

b. Highway transportability, including carrier operation and emergency stopping.

c. Marine tests

- 1) Load the test item aboard a suitable ship-simulating facility capable of simulating actual ship loading conditions, hold and deck space, and ship's pitch and roll, using normal materials handling equipment, and record the following:

- a) Ship type simulated
- b) Equipment used for loading
- c) Location of storage
- d) Difficulties encountered during loading
- e) Materials used for securing.

- 2) Apply a roll of 30°, with a period of 30 seconds, and a pitch of 5° with a period of 30 seconds, and a pitch of 5° with a

period of 20 seconds, for a minimum of 1 hour, and record the following:

- a) Pitch and roll period
- b) Accelerometer recording readings
- c) Damage to test item or bracing

6.2.6.2 Air Transportability Tests

NOTE: The conduct of air transportability testing shall be coordinated with the appropriate unit conducting the air transportability tests.

Determine and record the internal and external air transportability of the test item as described in MTP 7-2-515 and MTP 7-2-516, respectively.

6.2.6.3 Logistics-Over-The-Shore (LOTS)

NOTE: Perform this test only on test items which are trailer-mounted, or which form an integral part of a self-propelled vehicle.

Perform the applicable tests specified in MTP 2-2-520, and record all test results.

6.2.7 Maintenance

Evaluate the maintenance-related factors of the test item as described in MTP 10-2-507 and MTP 10-2-512 with emphasis on the following:

- a. Organizational (O), Direct Support (F), and General Support (H) Maintenance Requirements.
- b. Operator through General Support Maintenance Literature.
- c. Repair parts
- d. Tools
- e. Test and handling equipment
- f. Calibration and maintenance facilities
- g. Personnel skill requirements
- h. Maintainability
- i. Reliability
- j. Availability

6.2.8 Safety

Provide a safety release statement in accordance with USATECOM Regulation 385-6, and observe all the safety precautions specified by the manufacturer governing the operation of the test item and test equipment. Perform applicable procedures of MTP 10-2-508. Record data required by that MTP and the following:

- a. Any dangerous or unsafe condition, or any condition that might

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present a safety hazard, including the cause of the hazard.

b. Record the following:

- 1) The steps taken to alleviate any safety hazard
- 2) The safety features incorporated into test item design
- 3) Adequacy of warning instructions and markings
- 4) Suggestions to improve the existing safety precautions

6.2.9 Human Factors Evaluation

6.2.9.1 General Evaluation

Throughout the test, evaluate the effectiveness and characteristics of the man-item interaction as related to human factors by performing the applicable sections of MTP 10-2-505 and the following:

a. Prepare checklists to evaluate the human factor characteristic using Human Factors Evaluation Data for General Equipment (HEDGE) for the class III C equipment, including the following:

- 1) Operability
 - a) Controls and indicators - location, visibility of markings sufficient for proper control of the test item.
 - b) Installation and attachment of external lines.
- 2) Maintainability
 - a) Ease of locating malfunctions and determination of cause
 - b) Access to defective component
 - c) Ease of replacement and/or repair of malfunction
- 3) Transportability
 - a) Test item supplied with handles or other lifting attachments for moving.
 - b) Removal of internal or external components for transport.
 - c) Breakdown and reinstallation of the test item.

6.2.9.2 Noise Evaluation

6.2.9.2.1 Preparation for Test

a. Install a 100% capacity flow nozzle in the compressor air discharge with the test item located in a room which is large enough to eliminate any reverberation noise.

b. Determine the measuring locations for the microphone around the test item, using the following criteria:

- 1) The test item shall be in its normal operating position.
- 2) There should be no obstructions between the measuring microphone and the test item.
- 3) Measuring locations for the microphone shall be approximately

every 20° along a circular path whose radius is approximately ten feet from the approximate geometric center of the test item.

- 4) No measurements should be taken at plus or minus 30° with respect to the normal leading to an open inlet or outlet.

c. Encase the microphone in a sound absorbing enclosure which will be open only on the side facing the test item to minimize indirect reflections.

6.2.9.2.2 Test Conduct

a. Calibrate the Sound Level Meter and set the weighting network switch to the "flat response" or C position.

b. Determine the highest sound pressure level in each band over all the bands at each location (Table I, HEL Standard S-1-63B) with the test item operating at a normal level.

c. During Compressor blowdown use a broadband audio frequency amplifier which has a substantially constant amplification over the frequency band of 37 to 9600 hertz and a suitable microphone and sound level recorder to measure and record the positive peak sound pressure level in decibels, and its duration.

NOTE: Blowdown occurs shortly after the compressor unit is shut down.

d. With the test item inoperative, determine the ambient noise level for the point of highest sound pressure in each band.

6.2.10 Value Analysis

Throughout all tests, the test item shall be examined for any unnecessary, costly, "nice-to-have" features as described in USATECOM Regulation 700-1. Perform the following:

a. During operation of the test item, observe for features which could be eliminated without compromising performance, reliability, durability, or safety.

b. Question test personnel regarding features of the test item which could be eliminated without decreasing the functional value of the test item, or decreasing man-item effectiveness.

c. Record the following:

- 1) Non-functional, costly, or "nice-to-have" features of the test item.
- 2) Test personnel comments and opinions regarding features to be eliminated.

6.2.11 Quality Assurance

Determine the quality of the test item as described in the applicable section of MTP 10-2-511.

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6.3 TEST DATA

6.3.1 Preparation for Test

6.3.1.1 Initial Inspection

Record the following:

- a. Evidence of packaging damage or deterioration
- b. Identification markings, including the following:
 - 1) Name of contractor
 - 2) Date of manufacture
 - 3) Other markings pertaining to the test item
- c. For each shipping package:
 - 1) Contents
 - 2) Weight
 - 3) Length, width and height
 - 4) Cubage
- d. For the entire test item:
 - 1) Weight
 - 2) Cubage
- e. For the unpacked test item:
 - 1) Evidence of defects in:
 - a) Manufacturing
 - b) Material
 - c) Workmanship
 - 2) Evidence of damage to the following:
 - a) Behind any sheet metal dents
 - b) The back and front side walls of trailer tires
 - c) Lubricant leaks
- f. For identification and instruction plates
 - 1) Adequacy of plates
 - 2) Identification, name, and serial number
 - 3) Caution instructions
 - 4) Installation and service instruction
 - 5) Engine make, model, and serial number
 - 6) Compressor make, model and serial number
 - 7) Air delivery rate in c.f.m.
 - 8) Air pressure in p.s.i.

- g. Descriptive technical, installation and maintenance literature.
- h. Shortage in repair parts, accessories, tools or kits.
- i. The condition of all test unit controls and indicators.
- j. Freedom of rotation of the compressor drive shaft.

6.3.1.2 Physical Characteristics

Record the following:

- a. The test item length
- b. Overall silhouette width and length
- c. Ground clearance, when applicable
- d. Wheelbase, when applicable
- e. Drawbar pull, when applicable
- f. Center of gravity
- g. Gross weight

6.3.2 Operator Training and Familiarization

a. Record the following for personnel requiring retraining:

- 1) Name and rank
- 2) Past experience
- 3) Degree of re-training required

b. Record the following for test team personnel

- 1) Name and rank
- 2) Unit
- 3) Experience
- 4) Previous training

c. Record adequacy of technical manual(s).

6.3.3 Pre-Test Requirements and Qualifications

Record the following:

- a. The checks and adjustments made.
- b. The greases used as lubricants, and whether any cleaning of bearings was performed.
- c. The fuel, lubricating oil, and antifreeze used.
- d. Whether the gasoline engine meets MIL-E-11275, or the diesel engine meets MIL-E-11276.
- e. Whether the air receiver meets the requirements of the ASME Unfired Pressure Vessel Code.
- f. Whether all pressure gauges and manometers are calibrated on a deadweight tester.

6.3.4 Test Conduct

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Record the following general information on the test item:

- a. Mounting surface inclination (not to exceed 5° from horizontal).
- b. Procedures specified by the manufacturer

6.3.4.1 Functional Performance

6.3.4.1.1 Preparations -

Record the following:

- a. Removal of any air intake pipe
- b. Installation of proper-sized flow nozzle

6.3.4.1.2 Rated Capacity Test -

Record the following:

- a. Average absolute temperature in °K (Kelvin)
- b. The absolute pressure at the compressor intake (p.s.i.a.)
- c. The barometric pressure (inches of mercury)
- d. The differential pressure across the nozzle (inches of water)
- e. The absolute temperature upstream of the nozzle
- f. The compressor air receiver pressure (p.s.i.g.)
- g. The air discharge pressure
- h. Compressor shaft r.p.m.

6.3.4.1.3 Automatic Regulation -

Record the data of paragraph 6.3.4.1.2

6.3.4.1.4 Tilted Position Test -

Record the data of paragraph 6.3.4.1.2 and the following.

- a. Any evidence of compressor air or lubricant leaks
- b. Any other malfunction

6.3.4.1.5 Endurance Test -

Record the data of paragraph 6.3.4.1.2 and the following:

- a. Downtime
 - 1) Date
 - 2) Start time
 - 3) Stop time
 - 4) Downtime, hours and minutes
 - 5) Total accumulated operating hours
- b. Reasons for each stop

- 1) Normal services such as replenishing fuel, adding or changing lubricant, adding radiator coolant, cleaning or changing filters, etc.
- 2) Kind of adjustments made.
- 3) Nature and cause of malfunction.
- 4) Part replacements.

c. Quantities and kinds of lubricants added or changed (quarts).

6.3.4.1.6 Cycling Test -

a. Record the following at every 10 hour interval:

- 1) Air pressure on the upstream side of the flow nozzle
- 2) Compressor rpm

b. Record the following at the end of each 180 hour cycling operation:

- 1) Data as described in paragraph 6.3.4.1.2
- 2) Appropriate downtime information

6.3.4.2 Radio Interference Characteristics

Record test results of applicable sections of MTP 2-2-613 and MIL-STD-461.

6.3.4.3 Environmental Tests

Record the appropriate data as outlined in MIL-STD-810B for the following tests:

- a. High temperature
- b. Low temperature
- c. Salt fog
- d. Dust
- e. Altitude

6.3.4.4 Drop Test

Record the following:

- a. Evidence of any damage prior to the test
- b. Evidence of any damage after the test

6.3.4.5 Slings, Towing and Tiedown Eyes

Record the following:

- a. The results of the lifting, pulling and tiedown stresses applied to the test item.

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- b. Conformance to MIL-STD-209.
- c. Points of convergence of multiple slings and clearance of exterior parts.

6.3.4.6 Transportability

6.3.4.6.1 Surface Transportability -

Record the effects of rail, highway and marine transporting and, in particular, the following for marine:

- a. Ship type simulated
- b. Equipment used for loading
- c. Location of storage
- d. Difficulties encountered during loading
- e. Materials used for securing
- f. Pitch and roll period
- g. Accelerometer readings
- h. Damage to test item or bracing

6.3.4.6.2 Air Transportability -

Record the internal and external transportability of the test item as described in MTP 7-2-515 and MTP 7-2-516.

6.3.4.6.3 Logistics-Over-The-Shore (LOTS)

Record the results of the applicable sections of MTP 2-2-520.

6.3.4.7 Maintenance

Record data collected as described in the applicable section of MTP 10-2-507.

6.3.4.8 Safety

Record data required by MTP 10-2-508 and the following:

- a. Any dangerous or unsafe condition, or any condition that might present a safety hazard, including the cause of the hazard.
- b. The safety features incorporated into test item design.
- c. Adequacy of warning instructions and markings.
- d. Suggestions to improve the existing safety precautions.

6.3.4.9 Human Factors Evaluation

6.3.4.9.1 General Evaluation -

- a. Record data collected as described in the applicable sections of MTP 10-2-505.
- b. Retain completed checklists.

6.3.4.9.2 Noise Evaluation -

Record the following:

- a. A diagrammatic layout of the compressor site showing the locations at which measurements were taken.
- b. The highest noise level in each band over all bands at each measuring location and the corresponding ambient noise levels at each of these frequencies with the test item inoperative.
- c. A list of "out of tolerance" readings where they exist for each band.

6.3.4.10 Value Analysis

Record all non-functional, costly or "nice-to-have" features, and test personnel comments and opinions.

6.3.4.11 Quality Assurance

Record the data collected as described in the applicable section of MTP 10-2-511.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Rated Capacity

Calculate the volumetric rate of flow using the following equation:

$$Q_a = \frac{2.552 C D_n^2 T_1}{P_a} \sqrt{\frac{P_b P}{T_2}}$$

where

- A_a = volumetric rate of flow (cubic feet per minute)
- T_1 = Absolute temperature at compressor intake ($^{\circ}\text{C.} + 273.16$)
(average temperature taken at three points at the engine crankshaft height, 3 to 5 feet from the compressor)
- P_a = Absolute pressure at compressor intake, pounds per square inch absolute (p.s.i.a.)
- C = Nozzle coefficient of discharge
- D_n = Nozzle throat diameter (inches)
- P_b = Barometric pressure, corrected (inches of mercury)
- T_2 = Absolute temperature, upstream of the nozzle ($^{\circ}\text{C.} + 273.16$)
- P = Differential pressure across the nozzle (inches of water column)

6.4.2 Safety

A Safety Release Recommendation shall be submitted in accordance with USATECOM Regulation 385-6 based on the data collected related to safety.

6.4.3 Human Factors

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Present an analysis of human factors design features which do not conform to recognized human factors design criteria; including steady state noise and blowdown noise, when applicable.

GLOSSARY

Absolute pressure	The pressure measured from absolute zero, i.e., from an absolute vacuum. It is the algebraic sum of the atmospheric pressure and the gauge pressure.
Absolute temperature	The temperature above absolute zero. It is equal to the degrees Centigrade plus 273.16.
Atmospheric pressure	The pressure of the atmosphere. It is commonly designated by the height of the mercury column it supports in a mercury barometer, the value of 76.00 cm at sea level and at 32° F. being taken as standard.
Blowdown	The air discharge which occurs when the air pressure in the compressor unit is relieved to atmosphere. "Blowdown" occurs automatically each time the compressor unit is shut down.
c.f.m.	Cubic feet per minute.
Gauge pressure	The pressure excess above atmospheric pressure.
p.s.i.	Pounds per square inch. Unless otherwise specified, gauge pressure is implied.
p.s.i.a.	Absolute pressure in pounds per square inch.
p.s.i.g	Gauge pressure in pounds per square inch.

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