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AD 720580
Materiel Test Procedure 6-2-184
Electronic Proving Ground

3818 U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

METEOROLOGICAL EQUIPMENT INFLATION, TETHERING, AND LAUNCHING EQUIPMENT

1. OBJECTIVE

The objective of this materiel test procedure (MTP) is to determine the technical performance under controlled conditions of inflating, tethering, and launching equipment. The tests also determine the engineering adequacy and safety characteristics of the test item.

2. BACKGROUND

Military Characteristics (MC's) approved by Department of the Army in 1958 for a Meteorological Balloon System, Fast Rising included a gas generator (hydrogen) and ground components for inflating and sheltering the lineup balloon on the ground prior to launch.

Combat Developments Objectives Guide, paragraph 438e(15) was deleted in 1961 and reinstated with Priority II in December 1964 with a separate Qualitative Materiel Requirement (QMR).

Exploratory development models were procured and tested in 1961. From these tests a decision was made to secure advanced developmental models which were received in late 1962. Faults inherent in the configuration used led to a new design produced by proving ground agencies.

Difficulties in hydrogen generation and measurement during inflation led to use of bottled hydrogen for test, in conjunction with a modified residential type gas meter.

Signal Corps Technical Requirements (SCTR's) specify performance characteristics for a Meteorological Balloon Inflation-Launching Device. The balloons must be sheltered from wind and protected from puncture during inflation and ground handling before launch. Use of a special-purpose test to provide shelter and protection for the balloon is awkward and time-consuming. A close-fitting shroud has been found to be of dubious value in winds above 20 knots. A safety hazard has existed with these types of shelters because neither the tent nor the shroud has been effectively grounded.

3. REQUIRED EQUIPMENT

- a. Gas meter (volume)
- b. Gas meter (pressure)
- c. Electrostatic voltmeter (electroscope)
- d. Voltmeter
- e. Thermometers
- f. Humidity devices
- g. Bottled gas
- h. Thermocouples
- i. Simulated loads (radiosonde)

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- j. Standard sounding balloons
- k. Standard weight units for weigh-off

4. REFERENCES

- A. Compendium of Meteorology, American Meteorological Society, 1951
- B. Meteorological Instruments, Middleton and Spilhaus, 1960.
- C. Combat Development Objectives Guide, paragraph 439e, (15)
- D. Qualitative Materiel Requirements 1539, 1966.
- E. Signal Corps Technical Requirements, SCL-5749A, 1960.
- F. FM 6-15, Artillery Meteorology, 1962.
- G. Engineering Report, Inflation Shelter, and Launching Device, Raven Industries, 1962.
- H. Ltr, Hq CONRAC, Report of Service Test of MET Balloon, 1960.
- I. RDT&E Task Card, Atmospheric Sounding and Plotting
- J. MTP 6-2-210, Power Supply, Electrical
- K. MTP 6-2-514, Electrical Power Requirements
- L. MTP 6-2-185, Meteorological Sounding Systems
- M. TM 11-2405, Meteorological Balloons, Inflation and Launching Accessories.
- N. AR 700-68, Safe Handling, Storing, Shipping, Use and Disposal of Compressed Gas Cylinders.
- O. AMCR 385-12, Safety Verification of Army Materiel
- P. USATECOM Reg. 385-6, Safety Release
- Q. USATECOM Reg. 385-12, Safety Statments

5. SCOPE

5.1 SUMMARY

a. Hydrogen Generator Test - The objective of this subtest is to determine capacity, operational characteristics, and technical performance of the gas delivery unit and of its component parts.

b. Inflation and Launch Devices - The objective of this subtest is to determine adequacy of the protective holding system and efficiency of the release mechanism for quick release of the balloon and flight train.

c. Volume Weigh-Off Test - The objective of this subtest is to determine capability of the volume meter to measure gas volume delivered to the balloon in quantity exactly equalling that required in the weigh-off method of exact inflation. Concurrently, the nomograph from which the volume is taken shall be checked for accuracy.

d. Engineering Evaluation of Manuals - The objective of this subtest is to determine technical adequacy of descriptive and operational manuals supplied.

5.2 LIMITATIONS

This MTP is limited in scope to the testing of catalytic gas generators producing pure hydrogen from inexpensive expendables.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Visual Inspection

Carefully inspect the system for damage, missing parts, compatibility of common junctions, and evidence of misuse.

6.1.2 Gas Generator

Provide bottled gas (hydrogen or helium) when the catalytic generator has not been supplied or is inoperative.

6.1.3 Volume Meter

Provide a gas volume-measuring meter for comparison as a standard and for use in absence of the generating component and its auxiliary equipment.

6.1.4 Personnel

Ensure that test personnel are familiar with the test item, its operation and test objective.

6.1.5 Records and Forms

Prepare necessary forms and a schedule for conduct and completion of engineering test.

6.1.6 Safety

Obtain a safety statement and ascertain that appropriate actions are taken on any actions therein.

6.2 TEST CONDUCT

6.2.1 Hydrogen Generator Test

Subtest of the generator components shall be conducted simultaneously where possible and tests of a safety nature shall be conducted first.

6.2.1.1 Volume Measurement Component

a. When available, a calibrated gas volume meter shall be used for comparison.

b. In other cases, a commercial design, residential gas meter, suitably modified for connection in the test item system shall be procured or prepared locally and calibrated.

c. Connect the comparison meter to the gas delivery port.

d. Place the gas generating system in operation and observe reading of the system gas volume meter (product gas totalizer). Simultaneously observe the reading of the comparison meter. Continue the delivery of gas to a total of approximately 5000 cubic feet.

e. Repeat the above procedure at intervals during the test to ensure that the volume readings are consistent.

6.2.1.2 Starter Mechanism

a. Check the operational characteristics of the starter electrical system.

b. Start the generator following "manual" or "automatic" procedures, as appropriate. If both capabilities are provided, each should be tested separately.

c. Observe and record the operational characteristics of the fuel control, and safety valves on the fuel lines.

d. Start the generator when cold (not used for 24 hours). After the generator is fully operational, close it down according to instruction, wait 15 minutes, and start it again.

NOTE: If instructions caution against restarting when hot, this portion of the test should not be conducted.

e. If electrical controls, including electrical ignition, are used, the operating voltage range shall be checked by starting the generator at the normal high and low voltage values indicated in the specifications.

6.2.1.3 Fuel Usage Rate

a. Completely drain the entire fuel supply and burner system -

b. Introduce a measured quantity (e.g., five gallons) of fuel in a gravity feed connection, bypassing the tank supply (disconnect tank line; connect measured supply).

c. Start the generator and operate it at maximum gas output while actually inflating balloons. The balloons will provide normal backpressure. Time the operation, obtaining the time from start to initial gas output and the time the gas generation stops for lack of fuel.

d. Repeat test with each type of permissible fuel available.

6.2.1.4 Fuel Usage Versus Gas Output

a. Supply a measure amount of fuel as in usage rate test above.

b. Record the gas meter reading; operate the generator at maximum output as in the fuel usage test until the fuel is consumed, and record the final reading of the gas meter. Time the entire operation. Repeat at intervals during the project to determine effect of usage and effect of other climatic conditions. The temperature and gas pressure gages shall be read every 15 minutes during the test.

6.2.1.5 Standby Condition

a. If the generator has a standby mode, this feature shall be tested following a normal gas generating period of at least 30 minutes.

- b. At the change to standby, the fuel system shall be switched to a measured amount of fuel to determine the rate of fuel consumption. (See para. 6.2.1.3)
- c. The temperature and gas pressure gages on the generator shall be read while the generator is producing gas just prior to change over to standby and every 15 minutes while in the standby mode.
- d. The generator shall be operated in the standby mode for two hours or less if instructions caution against this time period.

6.2.1.6 Gages and Controls

- a. The pressure gage shall be removed and tested in a laboratory by comparison with a standard gage which has an equivalent range. Pressure shall be compared at three or more points evenly spaced throughout the operating pressure range.
- b. The temperature gage shall be removed and compared with a laboratory standard at a minimum of four points evenly spaced throughout the operating range.
- c. The fuel gage shall be checked by adding known amounts of fuel as the tank is filled from empty to full.
- d. The water gage shall be checked by adding known amounts of water as the tank is filled from empty to full.
- e. If catalyst gages and controls are provided, these shall be checked for accuracy and adequacy of control by a means appropriate to the type of catalyst.

6.2.1.7 Moisture Content of Gas

- a. Obtain a small humidity (moisture) measuring device and recorder from the Meteorological Support Activity. Insert the device into the neck of a balloon which is to be inflated, or into a suitable housing through which the gas can flow to a balloon, and connect the device to its recorder (or gage).
- b. Obtain moisture readings from the initial flow of gas to completion of inflation of a radiosonde balloon.

6.2.1.8 Effect of Environmental Changes

- a. All of the above generator operating tests shall be repeated, if possible, at the lowest and highest elevation points available at the test site.
- b. The operational tests shall also be repeated at the lowest and highest temperature extremes available during the test period.
- c. Ambient temperature and air pressure readings will be obtained every 30 minutes at each site during operation.

6.2.9 Inflation and Launch Devices

- a. Determine the weight, configuration, and special handling requirements of the radiosonde equipment to be accommodated and the size, free lift, and other characteristics of the balloon to be inflated and launched by the test item.

b. Check the engineering adequacy of inflation nozzles, tie-off devices, release mechanisms, balloon holding provisions, and balloon train and radiosonde supports by weighing, stressing, and operating the items. If a time sequencing of operations is required, the synchronization of actions shall be checked for effectiveness.

c. The above components shall be tested in chambers under environmental extremes, within the size limitations of the chambers.

6.2.10 Static Electricity

The safety officer shall observe all readings of the following test:

a. Procedures for conduct of the test shall be coordinated with the installation Safety Division.

b. Obtain indications of build-up of static charges by using an electrostatic voltmeter probe to touch appropriate areas of the balloon and the holding components during inflation. Ground wires, wire mesh covers, and static retardant materials should prevent the build-up of dangerous charges.

6.2.11 Volume Weigh-Off

The required lift of the balloon depends upon the weight of the items to be carried and the rate of ascent desired. The "free lift" determines the rate of ascent.

a. Contact the Meteorological Support Activity and obtain the lift needed for the type of balloon in use to carry standard types of radiosonde trains at the normal ascent rates.

b. Consult the nomograph supplied with the test item to determine the volume of gas to give the required lift and inflate the balloon with the indicated volume of gas. Repeat for other lift values available.

c. Disengage the balloon from the inflation nozzle and other holding devices and tie the neck. Balance the lift of the balloon with radiosonde balloon inflation weights or measure the lift with a spring scale and convert to grams. (one pound equals 453 grams).

d. Perform an approximate check of the nomograph accuracy for the lift values as follows:

$$\text{Density of dry air} = \frac{0.001293}{1 + 0.00367t} \times \frac{H}{76} \text{ grams/cubic cm.}$$

t = ambient temperature in degrees Fahrenheit

H = pressure of air in centimeters of mercury

$$\text{Density of dry hydrogen} = \frac{0.0000805}{1 + 0.00376t} \times \frac{H}{76}$$

$$\text{The difference is } \frac{0.001213}{1 + 0.00376t} \times \frac{H}{76}$$

6.2.12 Evaluation of Manuals

The manuals supplied with the test item shall be examined during testing for technical adequacy and accuracy.

6.3 TEST DATA

6.3.1 Hydrogen Generator Test

6.3.1.1 Volume Measurement Data

a. Description and method of use shall be recorded when nonstandard meter modification has been necessary.

b. Record readings of the comparison meter versus indicated gas volume (on generator) showing whether separate, consecutive, or cumulative.

c. At each test interval, record total operating time and state any variations from normal conditions.

6.3.1.2 Starter Mechanism

Record the following:

a. Operational characteristics

b. Observations under "manual" or "automatic" as appropriate to the test item

c. All variations from prescribed limits in the start-up procedures. This shall be done for each operation (i.e., "cold" and at expiration of 15 minute waiting period).

d. Starter reaction, failure or hesitation that may occur at each of the specified normal, high, and low voltages specified.

6.3.1.3 Fuel Usage Rate

Record the following:

a. Amount of fuel used for the trial

b. Time of start-up

c. Time of initial gas output

d. Time of cessation of gas generation

e. Any evidence that combustion in the generator continues after generation stops

f. The same data for each fuel used for test

6.3.1.4 Fuel Usage Versus Gas Output

Record the following:

a. Measured quantity of fuel

b. Gas-volume meter reading (initial)

c. Time of start-up

d. Time of stoppage

- e. Temperature and pressure each 15 minutes
- f. Repeat the above recordings for each test run .
- g. Repeat the above recordings for each fuel used.

6.3.1.5 Standby Condition

Record the following:

- a. Temperature and pressure while at full operating rate
- b. Temperature and pressure every 15 minutes during the standby period (maximum determined in criteria)
- c. Amount of fuel
- d. Time of switchover
- e. Time of stoppage

6.3.1.6 Gauges and Controls

- a. Record pressure readings of the test item and of the laboratory standard.
- b. Repeat above at each part of the range tested.
- c. Record temperatures shown by the test item gauge and by the laboratory standard.
- d. Repeat at each temperature of the test.
- e. Record fuel gauge readings and total of increments of fuel as they are added.
- f. Record water gauge readings and total of increments of water as they are added.
- g. Record observations of other gauges and controls by comparison with a standard or with a calibrated device of the same kind.

6.3.1.7 Moisture Content of Gas

Record the following:

- a. Moisture readings taken at start of inflation and at the end of inflation
- b. Total moisture in the gas delivered to the balloon

6.3.1.8 Effect of Environmental Changes

- a. Record all data previously indicated for all tests specified for repetition at different altitudes and temperatures.
- b. In addition to other requirements, record air temperature and barometric pressures every 30 minutes during the tests.

6.3.2 Inflation and Launch Devices

Record the following:

- a. Physical characteristics of the radiosonde to be lifted from the test item, including:

- 1) Dimensions
- 2) Weight
- 3) General shape of configuration
- 4) Special handling

b. Physical characteristics of the balloon (or balloons) to be inflated:

- 1) Size (dimensions and volume)
- 2) Free lift
- 3) Other

c. Results of application of weight, and stresses as described in paragraph 6.2.9.

d. Timed sequences

6.3.3 Static Electricity

Record all voltmeter readings and indicate points of measurement on the test time.

6.3.4 Volume Versus Weigh-Off

- a. Record free lift of each balloon used.
- b. Record total required lift (each balloon).
- c. Record gas volume shown on nomograph provided, for the desired lift (each balloon).
- d. Record actual lift of inflated balloon.
- e. Compute and compare required volume versus nomograph volume values.

6.3.6 Evaluation of Manuals

Record by page number, paragraph, and line, all errors, omissions, or other technical inadequacies.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Hydrogen Generator Test

6.4.1.1 Volume-Measurement Component

- a. Present a brief narrative description of the comparison meter and actions taken to ensure accuracy.

b. Tabulate and present comparative values taken from the comparison volume meter and from the product gas totalizer of the test generator.

Table I. Volume of Gas Produced

Readings Taken	1	2	3	4	-----
Times of reading					
Comparison Meter					
Test Item Meter					
Differences					

c. The tabulation shall be repeated for each test made.

d. Small and generally random differences shall not be emphasized but large and/or erratic differences shall be presented by means of graphical plots of the tabulated data.

e. The data variations shall be reduced to show a measure of central tendency.

6.4.1.2 Starter Mechanism

a. Describe unusual or unexpected characteristics of the device.

b. Note the record of observations in paragraph 6.3.1.2.

c. Tabulate under normal, low-limit, and high-limit voltage values the results of the prescribed procedure when cold and at 15 minute intervals after shut-down.

Table II. Starter Mechanism Performance

Voltage used	Normal	Low Limit	High Limit
Start Results "Cold"			
Start Results after 15 Minutes.			

6.4.1.3 Fuel Usage Rate

- a. Compute time of operation.
- b. Divide fuel provided by elapsed time .
- c. Present time rate of fuel used.
- d. Repeat for each fuel used.
- e. Present a bar graph comparing fuel usage rates .

6.4.1.4 Fuel Usage versus Gas Output

- a. Determine elapsed time of gas production .
- b. Determine total gas volume produced .
- c. Divide fuel used by volume of gas produced and present result
as volume of gas per unit of fuel.

Table III. Gas Production Rate

	Test 1	Test 2	Test 3	etc.
Time start				
Time end				
Elapsed time				
Volume Meter Start				
Volume Meter End				
Volume per fuel unit				

Table IV. Temperature-Pressure Record

Time or Observation	Temp.	Atmospheric Pressure
0		
15 min		
30 min		
and each 15 min to end of test		

- d. Repeat for each test made and for each fuel type.

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6.4.1.5 Standby Condition

Tabulate temperature and pressure indicated on test item gauges.

Table V. Temperature-Pressure During Standby

Time	Temperature	Pressure	Quantity Fuel
0			
15 min			
30 min			
Each 15 min during test			

6.4.1.6 Gauges and Controls

a. Tabulate comparative readings and include as a presentation:

Table VI. Pressure Gauge

Reading	Test Item	Laboratory
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Midscale

Low

High

Temperature Gauge

Midscale

Low

High

Fuel Gauge

Zero

Quarter scale

Half

Three-quarter

Full

Water Gauge

Zero

Quarter scale

Half

Three Quarter

Full

b. Gauges and controls pertaining to the catalyst shall be described briefly and results of any test presented as may be required in the manual of instruction.

6.4.1.7 Moisture Content of Gas

a. Determine by computation the total weight of moisture in the gas volume used for inflation.

1) Measurement of the dew point temperature permits tabular determination of the weight of water per unit volume.

2) Measurement of relative humidity permits the same determination by multiplication of the relative humidity in percent by the saturation moisture content from the table at the gas sample temperature.

3) Chemical absorption gives weight of moisture by direct weighing.

b. The moisture content is presented as an absolute figure. It may however, be an average of two or more determinations.

6.4.1.8 Effect of Environmental Changes

a. No reduction of these data will be made.

b. For each tested component all data taken in separate tests under different conditions of temperature and pressure (altitude) shall be compared by plotting comparable data on rectangular coordinates. Expand the scale sufficiently to aid accurate point plotting and magnify differences.

6.4.2 Inflation and Launch Devices

a. Present a narrative account of the engineering data taken, noting structural defects, failures, or malfunctions.

b. Discuss performance of combined release action in terms of smoothness, quickness, and efficiency.

c. Present a statement of the estimated efficiency as a one-man operated device.

6.4.3. Static Electricity

Present a list of static voltages.

6.4.4. Volume versus Weigh-Off

Tabulate all data taken to compare lift as determined from the nomograph.

Table VII. Volume - Weigh-Off Comparison

Free Lift Required	Gas Volume (nomograph)	Gas Volume (computed)	Measured lift
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Compare data for all inflations.

6.4.5. Evaluation of Manuals

Present a narrative evaluation, conclusion, and recommendation covering the technical adequacy of manuals provided.