TEST METHOD 101

TEMPERATURE RISE TEST

(GENERATOR ONLY)

101.1 General. Temperature rise tests are used by design engineers to assure each operating component is operating well within its rated temperature range and serve as a check on the manufacturing processes.

101.2 Apparatus. Instrumentation for measuring load conditions, generator and exciter field voltage and current, generator and ambient temperatures, and coil resistance's shall be as described in EGSA 107T . In addition an electrical prime mover capable of driving the generator at rated output conditions shall be required.

101.3 Procedure.

101.3.1 Preparation for test.

a. Refer to the contract to determine which components have maximum temperature rises specified.

b. Attach the necessary thermal instrumentation for these components and the ambient temperature in accordance with EGSA 107T , Test Method 20 and make necessary winding resistance measurements in accordance with EGSA 107T , Test Method 40.

c. Mechanically connect the generator to the prime mover. Be sure to shield the generator from air currents caused by the prime mover, adjacent machinery, belts or pulleys.

d. Connect the load and field instrumentation for a voltage connection and frequency specified in the contract.

101.3.2 Test.

a. Start and operate the prime mover so that the generator is operating at rated voltage and rated frequency (speed) while under control of the voltage regulator. Apply rated load and allow the generator to stabilize at rated load, rated voltage and rated frequency. During this period record all instrument readings including thermal instrumentation at minimum intervals of 10 minutes. If necessary adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and frequency. Adjustments to the voltage shall be limited to those adjustments that would normally be available to the operator when the generator is installed in the set configuration, specifically adjustments to the voltage adjust devices. No other adjustments to the voltage control system shall be make unless permitted by the contract. Adjustments to

load, voltage or frequency controls shall be recorded on the data sheet at the time of adjustment. Unless otherwise specified in the contract, stabilization shall be considered to have occurred when:

1. Three consecutive voltage and current readings of the field(s) remain unchanged after the last load, voltage and frequency adjustments has been made and,
2. The average ambient temperature has not been changed by more than 5 F° (2.73 C°) for the final six data readings.

b. After stabilization has occurred shut down the equipment so that temperatures of rotating components and windings may be taken. For application of contact method to rotating parts, or the resistance method to the armature coils (see EGSA 107T , Test Method 10and Test Method 20), a quick shutdown is mandatory.

CAUTION: Do not connect bridges, meters of temperature measuring equipment for measuring resistance or temperature to circuits which may still be energized, e.g., during the time that the generator is coming to a stop.

c. Immediately after the shutdown, start to record the resistance bridge readings of the coils and the temperature of the components where the contact method of measuring temperature rise is used. Readings of resistance measurements shall be recorded in accordance with instructions given in EGSA 107T , Test Method 10.

The first reading shall be taken and recorded within 30 seconds after shutdown and additional readings taken and recorded at approximately 30 second intervals until one reading has been recorded after the temperature has begun to decrease, or three minutes has elapsed since the generator shutdown, whichever is longer, being certain that the maximum temperature reached by each component has been recorded. Continuous or multipoint temperature recorder(s) may be used to record component temperatures as long as the above time requirements are met.

d. Repeat steps a thru c above for each of the coils specified in the contract.

e. Repeat steps a thru d above at each additional specified voltage connection, frequency, stabilization voltage, and load condition.

101.4 Results.

a. From the data obtained, compute the temperature rise of each specified component, in accordance with instructions given in EGSA 107T , Test Method 10.

NOTE: To compute the temperature rise of a component, subtract the average ambient temperature of the air (immediately preceding shutdown) from the maximum temperature reached by each component.

b. Compare the temperature rise of every component, with the maximum temperature rise specified, for that component, in the contract.

101.5 Contract requirements. The following items must be specified in the individual contract:

a. Maximum allowable temperature rise allowed for each component and class of insulation, for the method of measurement.

b. The voltage connection(s) and frequency(ies) at which this method is to be performed.

c. The stabilization voltage(s), if other than rated, at which this method is to be performed.

d. The load condition(s), if other than rated, at which this method is to be performed.

TEST METHOD 102

TEMPERATURE RISE TEST
(ALTERNATE LOADING METHOD)

102.1 General. Temperature rise tests are used by design engineers to assure each component is operating well within its rated temperature range and serve as a check on the manufacturing process.

102.2 Apparatus. Instrumentation for measuring load conditions, generator and exciter field voltage and current, generator and ambient temperatures, and coil resistance's shall be as described in EGSA 107T . In addition, an electrical prime mover capable of driving the generator at the conditions specified herein shall be required.

102.3 Procedure.

102.3.1 Preparation for test.

a. Refer to the contract to determine which components have maximum temperature rises specified.

b. Attach the necessary thermal instrumentation in accordance with EGSA 107T , Test Method 23. Be sure to include the generator frame and bearing(s). Make the necessary winding resistance measurements in accordance with EGSA 107T , Test Method 27.

c. Mechanically connect the generator to the prime mover. Be sure to shield the generator from air currents caused by the prime mover, adjacent machinery, belts or pulleys.

d. Connect the load and field instrumentation in accordance with the applicable figure of this method.

e. From Test Method 33, the Open Circuit Core Loss Test, determine the generator field current necessary to create a core loss equal to twice the rated voltage full load core loss of the generator.

f. Determine the value of the current that is to flow in the armature windings during the short-circuit period. The following formula shall be used:

$$I_t = 2I_a$$

Where: I_t is the short-circuit current in the armature during this method.

I_a is the rated armature current.

This current will create twice the full-load copper loss in the armature.

102.3.2 Test.

a. Start and operate the prime mover such that the generator is at rated frequency (speed) with the field adjusted to the value determined in 102.3.1 e and at no load for 30 minutes.

b. Decrease the field current to approximately zero and immediately apply the short-circuit and adjust the field current such that the armature current will be of the value determined in 77.3.1 f above (I_t).
Operate under the short-circuit conditions for 30 minutes.

c. During steps a and b above read and record all instrument readings at 15 minute intervals (see figure 102-I).

d. Repeat steps a through c above until the temperature becomes stabilized as evidenced by frame and bearing temperatures remaining unchanged over a 1-hour period.

e. Repeat steps a and b above except that operating cycles shall be reduced to 15 minutes, until frame and bearing temperatures remain unchanged for 30 minutes. Record all instrument readings prior to each adjustment.

f. Repeat steps a and b above except that operating cycles shall be reduced to 5-minute periods, until frame and bearing temperatures remain unchanged for 30 minutes. Record all instrument readings prior to each adjustment.

g. After these procedures have been accomplished, the generator shall then be considered as having achieved temperature stabilization, provided the ambient temperature has not changed more than 5 F° (2.73 C ^{o}) during the last 30 minutes of operation.

h. As soon as the generator is considered stable, immediately shut down the equipment so that temperatures of rotating components and windings may be taken. For application of the contact method to rotating parts, or the resistance method to the armature coils (see EGSA 107T Test Methods 10 and 12), a quick shutdown is mandatory.

CAUTION: Do not connect bridges, meters or temperature measuring equipment for measuring resistance or temperature to circuits which may still be energized, e.g., during the time that the generator is coming to a stop.

i. Immediately after the shutdown, start to record the resistance bridge readings of the coils and the temperature of the components where the contact method of measuring temperature rise is used. Readings of resistance measurements shall be recorded in accordance with instructions given in EGSA 107T Test Method 4.

The first thermocouple reading shall be taken and recorded within 30 seconds after shutdown and additional readings taken and recorded at approximately 30 second intervals until one reading has been recorded after the temperature has begun to decrease, or three minutes has elapsed since generator shutdown, whichever is longer, being certain that the maximum temperature reached by each component has been recorded. Continuous or multipoint temperature recorder(s) may be used to record component temperatures as long as the above time requirements are met.

j. Repeat steps a thru i above for each of the coils specified in the contract.

k. Repeat steps a thru j above for each additional specified voltage connection and frequency specified in the contract.

102.4 Results.

a. From the data obtained, compute the temperature rise of each specified component, in accordance with instructions given in EGSA 107T ,

NOTE: To compute the temperature rise of a component, subtract the average ambient temperature of the air (immediately preceding shutdown) from the maximum temperature reached by each component.

b. Compare the temperature rise of every component with the maximum temperature rise specified, for the component, in the contract.

102.5 Contract requirements. The following items must be specified in the individual contract:

a. Maximum allowable temperature rise allowed for each component and class of insulation, for the method of measurement

b. The voltage connection(s) and frequency(ies) at which this method is to be performed.

TEST METHOD 103

ENDURANCE TEST

103.1 General. The endurance run approximates, under controlled conditions, the wear and deterioration a generator set receives in field service. The endurance run consists of operating the set for a specified period of time and adhering to a specified schedule of maintenance. Prior to, during, and after the endurance run, certain performance checks are made.

103.2 Apparatus. Instrumentation of measuring load conditions, field voltage and current, pressures, and temperatures shall be as described in EGSA 107T . In addition, test recording equipment(s), as described in EGSA 107T Test Methods 1 and 4 (unless otherwise specified in the contract) for recording voltage and frequency, and an elapsed time meter will be required.

103.3 Procedure.

103.3.1 Preparation for test.

a. Unless otherwise specified in the contract, the generator set shall be placed outdoors such that it is completely exposed to the weather on all sides; and placed directly on a level, solid reinforced concrete surface at least 3 inches thick and having a total weight at equal to the weight (wet) of the set. The generator set should not be restrained in any manner. If the generator set must be restrained to prevent "walking", the test results shall so indicate.

b. Connect the load and instrumentation for the voltage and frequency condition specified in the contract. Unless otherwise specified, connect the signal input of the test recording equipment(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage sensing input to the voltage regulator. Connect the exciter field instrumentation and generator field instrumentation, if applicable. For generator sets having more than one power output system (e.g., high voltage ac and low voltage dc, set battery charging system not included, or two ac systems of different frequencies), separate loads and instrumentation are required for each system. The elapsed time meter for monitoring set operating hours shall be relay operated from commercial power with the relay coil being energized from the convenience receptacle or the generator side of the set circuit interrupter.

c. Install appropriate thermocouples to measure the following temperatures. (NOTE: Not all sets will require instrumentation of all of the listed items. The list contains items normally instrumented, however, additional thermal instrumentation may be required for the specified performance checks.):

1. Engine coolant (inlet and outlet).

2. Spark plug(s).
3. Exhaust gas (combined exhaust gases in exhaust manifold or turbine tailpipe).
4. Lubricating oil sump.
5. Engine combustion air in (located at the inlet of the intake manifold).
6. Control panel cubicle "ambient air, inside).
7. Ambient temperature (in accordance with Test Method 23, paragraph 4).
8. Generator stator frame (top and bottom, outside).
9. Generator cooling air (inlet and outlet).
10. Air entering generator set.

d. Install appropriate pressure instrumentation to measure the ambient barometric pressure.

103.3.2 Test.

103.3.2.1 Pre-Endurance. Within 8 hours of the start of the endurance run the following test methods shall be performed.

a. Test Method 94, Commutation Test (AC Units) and Test Method 95, Commutation Test (DC Units). These methods are not applicable for brushless machines.

b. Additional performance checks, if specified in the contract.

103.3.2.2 Performance evaluation. During the first 8 hours of the endurance run, the following test methods shall be performed.

(**NOTE**: All operating time during this paragraph shall be included as reliability-creditable hours.):

a. Test Method 77, Frequency and Voltage Regulation Stability and Transient Response Test (Short Term).

b. Test Method 90, Maximum Power Test (for Gasoline and Diesel Generator Sets)

c. Test Method 100, Fuel Consumption Test. Perform this method for a minimum of 2 hours at rated load only. Do not compute tank capacity or operating hours on a full fuel tank.

NOTE: No adjustments, other than those permitted in the maintenance and service schedule of thecontract, shall be made after the above performance checks except as required in subsequent performance checks.

103.3.2.3 Endurance. Start and operate the set at the specified voltage connection and frequency using the applicable fuel and lubricating oil(s) specified in the contract. Doors, shrouds, access panels, etc., shall be properly positioned in accordance with the instructions on the set or in the technical manual. The first 50 hours of testing under this method shall be performed utilizing

the set fuel tank, if provided. If an auxiliary fuel supply is used for the remainder of testing under this method, the set fuel tank(s), if provided, shall be three-quarters full at all times and the static head from the auxiliary fuel supply shall not exceed 4 feet above the set base. The set shall be loaded in accordance with the cyclic load schedule of Table I, unless otherwise specified in the contract. The one hundred hour cycle shall be repeated as required to complete the endurance time specified in the contract.

For a set with more than one power output system, each system shall be loaded in accordance with the cyclic load schedule of Table I. Throughout the entire endurance test, the set shall be operated continuously without shutdown except for the required scheduled maintenance and servicing as permitted by the contract.

a. All external thermal, load, electrical (including elapsed time meter) and pressure instrumentation shall be read and the readings recorded maximum time intervals of one hour. The minimum required thermal and pressure data is given in paragraphs 640.1.3.1 c and d. All generator set panel instruments, including the engine gauges, shall be read and the readings recorded at maximum time intervals of four hours. When reading the set panel instrumentation, the set shall be visually inspected for leaks, excessive vibration, loose bolts, etc., note findings and repairs made if applicable.

b. The voltage and frequency shall be recorded continuously throughout the duration of this method. If using recording meter(s), the minimum chart speed shall be 6 inches per hour except as otherwise specified in the individual performance tests. At the time of each instrumentation reading the voltage and frequency recording equipment(s) shall be marked with the time of day, elapsed hours of endurance, corresponding data reading number. Any indications of abnormal or unusual set performance, with explanations, shall be recorded.

c. The long-term voltage and frequency stability bandwidths as specified in the requirement document shall be used for the criteria during reliability operation, i.e., if either the voltage or frequency exceeds these bandwidths by spikes, shifts, etc., they shall be considered a chargeable failure.

d. Within 12 hours prior to each scheduled maintenance and servicing of any item specified in the contract, perform method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term), for rated load only omitting stabilization requirements. All operating time during the performance of this paragraph shall be included as reliability-creditable hours.

(**NOTE**: In the event service is performed more frequently than at 100-hour intervals, the minimum time between the performance of method 608.1 shall be 100 hours.)

e. In addition to the data recorded above, a separate log book identified by set nomenclature and serial number shall be maintained throughout the endurance run. Log entries shall be made every 4 hours. The log book shall contain, as a minimum, the following information:

1. Date, shift hours, elapsed endurance hours and a brief statement on the prevailing weather conditions.
2. All adjustments, if made, as permitted by the contract.
3. Information regarding scheduled maintenance performed. This shall include the time and number of persons to perform each service or maintenance operation.

4. Title, method number and data sheet numbers for all performance checks.
5. All shutdowns, with explanations.
6. Results of periodic visual inspection of the set.
7. In a separate section of the log book, all parts replacement, repairs, and oil consumption between oil changes shall be tabulated. These entries shall also include elapsed endurance hours, total set hours (set hour meter reading) and date.

TABLE I - Cyclic load schedule

Run Number	Percent of Rated Load	Number of hours at Each Condition
1	50	24
2	0	4
3	75	24
4	25	24
5	100	24

103.3.4 Endurance conclusion.

a. Within 24 hours prior to the completion of the Reliability Test and prior to any maintenance and servicing of the set, repeat the performance checks listed in 690.1.3.2.2b and c.

b. Within 12 hours prior to the completion of the Reliability Test and prior to any maintenance and servicing of the set, repeat the performance checks listed in 103.3.2.2a.

(**NOTE**: All operating time during this paragraph shall be included as reliability-creditable hours.)

103.3.2.5 Post-Endurance.

a. Immediately after completing the endurance run and prior to any maintenance or servicing of the set, repeat the performance checks listed in 103.3.2.1.

b. Perform the scheduled maintenance and servicing but do not overhaul the set.

c. For first article sets, after performance of the final scheduled maintenance and servicing (and after any additional tests required to be performed after the endurance run as specified in the contract), disassemble the generator set sufficiently for the inspection of the
combustion chambers, pistons, piston rings, valves, manifolds, and all parts and passages in the engine block, bearings, crankshaft, connecting rods, and cylinder head. Inspect the rotor, stator and exciter surfaces for any indication of rubbing. Inspect the drive system for warpage, cracks and other deterioration. Clean and inspect the fuel system and governor. Ferromagnetic parts, such as connecting rods, piston pins, camshaft, springs,

bolts, pistons, and crankshaft, shall be subjected to inspection for cracks and defects. Carefully examine all nonferrous parts to detect cracks, checks, blowholes, sand, or any weakening effects. Record all defects or abnormalities contract.

103.4 Results. The results of this test shall include all recorded data, recording charts, data from all performance checks, the log book, disassembly data and a summary. The summary shall briefly analyze the results of this test, in 100 hour segments, including any abnormalities of the operation of the set.

103.5 Contract requirements. The following items must be specified in the individual contract:

a. Length of endurance run.

b. Cyclic load schedule, if different from Table I.

c. Additional instrumentation requirements, if any.

d. Additional performance checks required, if any, and the elapsed hours during the endurance at which they are to be performed or if other than those specified in EGSA 107T .

e. Scheduled service and maintenance required and the hours of operation at which they are to be performed.

f. Reassembly or reconditioning instructions, if applicable.

g. Fuel(s) and lubricant(s) to be used during the performance of this method.

h. Performance requirements to satisfy the tests in 103.3.2.1 and 103.3.2.2.

TEST METHOD 104

RELIABILITY TEST

104.1 General. The reliability test is designed to measure the probability that a generator set will perform as intended. While this test method is called "Reliability Test", the actual parameter developed will be the Mean-Time-Between Failure (MTBF). This method may be used for a time-terminated reliability test or a probability ratio sequential reliability test as required by the contract.

104.2 Apparatus. Instrumentation for measuring load conditions and temperatures shall be as described in EGSA 107T . In addition, the test recording equipment(s) as described in EGSA 107T , methods 101.1 and 104.1 (unless otherwise specified in the contract) for recording voltage and frequency, and an elapsed-time meter will be required.

104.3 Procedure.

104.3.1 Preparation of test.

a. Unless otherwise specified in the contract, the generator set shall be placed outdoors such that it is completely exposed to the weather on all sides, and shall be placed directly on a level, solid reinforced concrete surface at least 3 inches thick and having a total weight at least equal to the weight (wet) of the generator set. The generator set should not be restrained in any manner. If the generator set must be restrained to prevent “walking", the test results shall so indicate.

b. Connect the load instrumentation for the voltage and frequency condition specified in the contract. Unless otherwise specified, connect the signal input of the recording equipment(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage-sensing input to the voltage regulator. For generator sets having more than one power output system (e.g., high voltage ac and low voltage dc, set battery charging system not included, or two ac systems or different frequencies), separate loads and instrumentation are required for each system. The elapsed-time meter for monitoring set operating hours shall be relay operated for commercial power with the relay coil being energized from the set convenience receptacle or the generator side of the coil of the circuit interrupter.

c. Install appropriate thermocouples to measure critical operating temperatures. The thermal instrumentation shall be installed in accordance with the instructions in EGSA 107T , Test Method 23.

104.3.2 Failure definition. The contracting officer shall have final determination of all failure classifications. The failure definition below shall be used unless otherwise specified in the contract:

a. A reliability-chargeable failure shall be defined as an event other than scheduled maintenance in which malfunction occurs, resulting in the replacement of the malfunctioning item (part, component, subassembly, or assembly) by a like item, except as provided in the servicing and adjustment schedule in the contract; and also resulting in the removal, adjustments or repair of the malfunctioning item or any adjustment or repair required because of faulty workmanship (as defined explicitly or quantitatively in the contract) in manufacture or assembly.

b. Additionally, any impending malfunction detected which constitutes a safety hazard to operating personnel or would cause serious damage to the equipment if continued in operation shall be considered a chargeable failure.

c. Those malfunctions occurring as dependent or secondary failure or as a result of improper maintenance procedures or operator error shall be excluded from considerations as chargeable failure, as are those resulting in proven design modification, applicable to all production items, that satisfies the contracting officer as to its effectiveness.

104.3.3 Test.

104.3.3.1 Performance evaluation. During the first 8 hours of the reliability test, the following test methods shall be performed. (NOTE: All operating time during this paragraph shall be included as reliability-creditable hours.):

a. Method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term).

b. Test Method 90, Maximum Power Test (for Gasoline and Diesel Generator Sets).

c. Test Method 100, Fuel Consumption Test. Perform this method for a minimum of 2 hours at rated load only. Do not compute tank capacity or operating hours on a full fuel tank.

104.3.3.2 Reliability operation. Start and operate the set at the specified voltage connection and frequency using the applicable fuel, coolant and lubricating oil(s) specified in the contract. Doors, shrouds, access panels, etc., shall be properly positioned in accordance with the instructions on the set or in the technical manual. The first 50 hours of testing under this method shall be performed utilizing the set fuel tank, if provided. If an auxiliary fuel supply is used for the remainder of testing under this method, the set fuel tank(s), if provided, shall be at least three-quarters full at all times and the static head from the auxiliary fuel supply shall not exceed 4 feet above the set base. The set shall be operated at the loads specified in Table I unless otherwise specified in the contract. For sets with more than one power output system, each system shall be loaded as specified in Table I. Throughout the entire duration of this method, the set shall be operated continuously without shutdown except for the required scheduled maintenance and servicing as permitted by the contract and as provided in Test Method 104.3.3.3.

a. All external thermal, load, electrical and elapsed-time meter shall be read and the reading recorded at maximum time intervals of one hour. All generator set panel instrumentation shall be read and the readings recorded at least once each 4 hours. When reading the set panel instrumentation, the set shall be visually inspected for leaks, excessive vibration, loose bolts, etc., note findings and repairs made if applicable.

b. The voltage and frequency shall be recorded continuously throughout the duration of this method. If using recording meter(s), the minimum chart speed shall be 6 inches per hour except as otherwise specified in the individual performance tests. At the time of each instrumentation reading the voltage and frequency test recording equipment(s) shall be marked with the time of day, elapsed hours of test and corresponding data reading number. Any indications of abnormal or unusual set performance, with explanations, shall be recorded.

c. The long-term voltage and frequency stability bandwidths as specified in the requirement document shall be used for the criteria during reliability operation, i.e., if either the voltage or frequency exceeds these bandwidths by spikes, shifts, etc., they shall be considered a chargeable failure.

d. Within 12 hours prior to each scheduled maintenance and servicing of any item specified in the contract, perform method 608.1, Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term), for rated load only omitting stabilization requirements. All operating time during the performance of this paragraph shall be included as reliability-creditable hours.

(**NOTE**: In the event service is performed more frequently than at 100-hour intervals, the minimum time between the performance of Test Method 77 shall be 100 hours.)

e. In addition to the data recorded above, a separate log book identified by set nomenclature and serial number shall be maintained throughout the reliability evaluation. Log entries shall be made every 4 hours. The log book shall contain, as a minimum, the following information:

1. Date, shift hours, elapsed reliability hours and brief statement on the prevailing weather conditions.
2. All adjustments, if made, as permitted by the contract and man-hours expended.
3. Information regarding scheduled and unscheduled maintenance performed. This shall include clock hours, man-hours, and number of persons to perform each service or maintenance operation.
4. Title, method number, and data sheet numbers for all performance checks.
5. All shutdowns, with explanation.
6. Results of periodic visual inspection of the set.
7. In a separate section of the log book, all replacement or repair of parts and oil consumption between oil changes shall be tabulated. These entries shall also include elapsed reliability hours, total set hours (set hour meter reading) and date.

f. In addition to the data recorded above, failure analysis sheets shall be prepared for each incident and shall be reported on forms similar to that in figure 104-I.

TABLE I
Cyclic load schedule

Run Number	Percent of Rated Load	Number of hours at Each Condition
1	50	24
2	0	4
3	75	24
4	25	24
5	100	24

104.3.3.3 Reliability duration. The duration of this method shall be in accordance with MIL-STD-781, test plan III, unless otherwise specified in the contract. If a time-terminated test is specified, the duration of this method shall be 500 hours unless otherwise specified in the contract. The cyclic load schedule in Table I shall be repeated as required to fulfill these requirements. After 1200 hours of operation under this method and every 1000 hours thereafter, the set shall be shut down at other than scheduled maintenance shutdowns for at least 72 hours but not more than 120 hours. During this period of shutdown no servicing, maintenance or adjusting of the set shall be permitted. This shutdown period is to determine the ability of the set to start after prolonged shutdown.

104.3.4 Reliability conclusion.

a. Within 24 hours prior to the completion of the Reliability Test and prior to any maintenance and servicing of the set, repeat the performance checks listed in 104.3.3.1b and c.

b. Within 12 hours prior to the completion of the Reliability Test and prior to any maintenance and servicing of the set, repeat the performance checks listed in 104.3.3.1a.

(**NOTE**: All operating time during this paragraph shall be included as reliability-creditable hours.)

104.4 Results.

a. The results of this test shall include all recorded data, recording charts, data from all performance checks, the log book, failure reports, and a summary. The summary shall briefly analyze the results of this test including any abnormalities of the operation of the set and shall include, but not be limited to, the following:

1. Elapsed time meter reading when failure occurred.
2. Description of failed components.
3. Cause of each failure.
4. Man-hours to isolate and repair each failure.
5. Corrective action taken to correct each failure.

b. The results from step a above, shall be used for determination of the MTBF and the Maintenance Ratio (MR) with the following formulas used for these calculations:

$$\frac{\text{Total Operational Hours}}{\text{Number of Failures}} = \text{MTBF (Observed)}$$

$$\frac{\text{Total Man-hours for Preventative and Corrective Maintenance}}{\text{Total Operational Hours}} = \text{MR}$$

104.5 Contract requirements. The following items must be specified in the individual contract:

a. Test termination criteria, if other than specified herein.

b. Accept/reject criteria if other than test plan III of MIL-STD-781 as specified herein.

c. Number of sets to be subjected to this method.

d. Load schedule if different from that in table I.

e. Additional performance checks required, if any, and the elapsed hours when they shall be performed.

f. Scheduled maintenance and service required and the hours of operation at which they shall be performed.

g. Fuels and lubricants to be used for the performance of this method.

h. Voltage connections and frequency at which this method shall be performed.

i. Minimum acceptable value of "specified" value for MTBF.

j. Maximum allowable Maintenance Ratio (MR), if specified.

k. Performance requirements to satisfy the tests in 104.3.3.1.

1. Failure definition if other than as specified herein.

EGSA 107T

RELIABILITY PROGRAM
FAILURE REPORT

TEST: Method 695.1 ETM HRS:_____ END HRS:_____
UNIT:_____kW,_____Hz DATE:_____
MFGR:_____ TIME:_____
SET S/N:_____ WEATHER:_____
LOAD:_____FUEL:_____ VOLTAGE:_____
FAULT INDICATORS:_____
SET PANEL INDICATORS:_____
FAULT INDICATORS:_____
SET PANEL INDICATORS:_____
FAILURE:

HOW FAILURE DETECTED:_____

FAILED ITEM:_____
REPAIR ACTION:_____

SPECIAL TOOLS: NO_____ YES_____
TYPE:___
FIND PROB AREA FINE PROB ITEM
W/O TEST EQUIP W/TEST EQUIP DISASSEMBLE OR REPAIR REASSEMBLE ADJUSTMENT CHECKOUT
HR MIN HR MIN HR MIN HR MIN HR MIN HR MIN HR MIN HR MIN
MEN MEN MEN MEN MEN MEN MEN

TOTAL HOURS FOR ALL PHASES OF REPAIR:_____
REMARKS:_____
RECORDER:_____
CONTRACTING OFFICER FAILURE CLASSIFICATION:_____

Figure 104-I

TEST METHOD 105

STARTING AND OPERATING TEST (EXTREME COLD, BATTERY START)

105.1 General. The generator set must satisfactorily start and operate in extreme low temperature environments.

105.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient and set temperatures shall be as described in EGSA 107T . In addition, test recording equipment(s) for recording voltage and frequency (speed) shall be required. The test recording equipment(s) shall be as described in EGSA 107T Test Method 1 and 4 (unless otherwise specified in the contract).

A controlled temperature room shall be used having sufficient capacity to maintain the specified low temperature with the set operating at rated load for the duration of this test. This controlled temperature room shall be as described in EGSA 107T Test Method 14

105.3 Procedure.

105.3.1 Preparation for test.

a. Install appropriate thermocouples to measure the following temperatures. (**NOTE**: Not all sets will require instrumentation of all of the listed items. This list contains items normally instrumented, however, some sets may require additional thermal instrumentation). The thermal instrumentation shall be installed in accordance with the instructions in EGSA 107T , Test Method 23.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s) (gasoline engines).
4. Exhaust gases (The exhaust manifold(s) of reciprocating engines shall be drilled and tapped as close as possible to the combustion chamber(s). For gas turbine engines, thermocouples shall be located in the tailpipe approximately one turbine wheel diameter downstream from the last turbine stage).
5. Lubricating oil sump and gallery for preproduction sets and sets and sump only for production sets.
6. Oil cooler (inlet and outlet).
7. Hydraulic oil sump.
8. Storage battery electrolyte (thermocouple(s) shall be so located that the electrolyte temperature at the center of the electrolyte is measured).
9. Engine combustion air in (located at the inlet of the intake manifold).
10. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
11. Generator cooling air (inlet and outlet).
12. Generator stator frame (top and bottom, outside).
13. Generator exciter (stator housing for rotation exciters, transformers for static exciters).

14. Generator voltage regulator (ambient air, inside).
15. Control panel cubicle (ambient air, inside).
16. Relay and control boxes (ambient air, inside).
17. Average ambient air temperature (EGSA 107T , Test Method 23).
18. Air entering generator set for housed sets.
19. Heater coolant (air or liquid-into and out of the heater).
20. Heater exhaust.

b. 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, heater, and all coolant lines. Be sure that the set is completely drained. Fill the coolant system with the proper solution of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

c. Drain the fuel from all fuel tanks, lines, strainer, pumps and filters. Flush tanks with low temperature fuel using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets an strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuels of the proper grade (low temperature fuel specified in the contract). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

d. Drain the lubricating oil from the engine, filters, strainer and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubrication oil. Fill a small container with a sample (approximately 8 ounces) of the oil used.

e. Operate the winterization and ether systems as applicable. See that all controls work properly. It may be necessary to temporarily bypass some controls if the ambient temperature is too high. Do not operate the heater for longer than necessary to perform the checkout.

f. Operate any fuel priming pumps on the set with the discharge lines open to clear lines of normal ambient fuel.

g. On all units, as applicable, check the spark plugs, magneto, distributor, valve clearances, injector timing, etc. 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 lubricant 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 all set fuel tanks as well as the oil from the air cleaners. Fill set fuel tanks, except for sets with gasoline engines. Refill the air cleaner oil reservoirs with the proper grade of lubricating oil. Fill the air cleaner oil reservoirs with the proper grade of lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of fuel and oil used.

i. If a storage battery is part of the set, fill it with electrolyte having the specific gravity recommended for arctic operation. Determine that the batteries have been cycled and completely charged (see EGSA 107T , Test Method 22) before placing them in the cold room.

j. Place containers of fuel, lubricant, and coolant in the cold room.

k. Place the generator set in the cold room. If the set is equipped with a three-way valve for an auxiliary fuel supply, connect the fuel supply to the engine thru the three-way valve using the auxiliary fuel hoses (length and size of hoses are specified in the contract) supplied with the generator set. The auxiliary fuel supply must have sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. This auxiliary fuel supply shall be in the cold room. Set fuel supply valve in the auxiliary fuel position.

l. Connect the load and field instrumentation for the voltage connection and frequency specified in the contract. Unless otherwise specified, connect the signal input of the test recording equipment(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage sensing input to the voltage regulator. (Power the test recording equipment(s) from the commercial utility.)

m. Where temperature measurements are made by means of thermocouples, the thermocouple leads shall be brought out of the cold room 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 cold. In addition to step l above, provisions shall be made for measuring the voltage on the generator side of the circuit breaker with instruments located outside the cold room.

105.3.2 Test.

a. For sets with gasoline engines, decrease the temperature in the cold room and when the ambient temperature has reached approximately 0 °F (-17.7 ➡C) open the auxiliary fuel container and fill the set tank. (Note: The volatility of arctic fuel at temperatures above 0 °F (-17.7 °C) necessitates storing the fuel in sealed containers. Fill and label a small container with a sample of the fuel used. Place this sample along side samples of fuel, lubrication oil, and coolant taken previously, in preparation for test, in a location in the cold chamber where they may be observed.

b. For sets with gasoline engines, start and operate the set for approximately 15 minutes at no load to allow the fuel to thoroughly circulate. Then shut down the set.

NOTE: Applied rated load during this period of operation to assure the setting of the load bank for the operation portion of this method.

c. Expose the complete generator set (including all fuels, lubricants, coolants and hydraulic oils to be used during this method) to the specified low temperature until such time as all components are at the specified low temperature or until 24 hours have elapsed, whichever comes later.

During all steps of this test, all of the eight ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the contracts. Prepare the set for extreme cold start by explicitly following the operating instructions on the set. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet.

d. By following the operating instructions, place the heater switch in the "ON " position, if applicable. Record the time the switch was placed in the "ON" position and the elapsed time required for the ignition of the fuel. Warm up the test recording equipment(s) by placing the switch in the standby operation position, if applicable.

e. Record the readings of temperature devices continuously during the period that the winterization equipment is in operation. (See figure 105-I).

f. The heater shall be operated a minimum of 50 minutes and a maximum of 55 minutes (unless otherwise specified in the contract). The heater shall be turned off and the time of operation recorded. After the heater is turned off, perform the two required cranking cycles with the set inactive (to preclude starting). (**WARNING**: Care must be taken in cranking the engine. Excessive cranking can damage the starter. See the instructions on the set or the technical manual for the maximum cranking time.)

g. Turn on the test recording equipment(s) and leave the equipment(s) on until the entire method 701.1 is completed. Then start the engine. The set must be operating at rated voltage and rated frequency without further use of any type of starting aids or winterization equipment within 1 hour from the time the heater switch was first turned on. After the engine starts, allow the engine to warm up at no load, rated voltage and rated frequency for a period of 15 minutes.

NOTE: If using recording meter(s), the chart speed shall be operated at a minimum speed of 12 inches per hour during the portions of the test where steady-state loading conditions exist and shall be operated at a minimum speed of 12 inches per minutes at least 30 seconds before, during, and after a load change.

h. Just before applying rated load, reset the frequency to the rated value and record the amount the frequency had drifted from the time of set start.

i. Within 16 minutes after the engine starts, apply rated load in one step with the circuit interrupter, starting with the interrupter in the off position. Leave rated load on the set for 30 seconds, then drop the load to no load in one step using the circuit interrupter. Operate at no load for 30 seconds. Again, using the circuit interrupter, apply and drop rated load two more times with 30 seconds of operation in each load condition. Next apply rated load and operate for 5 minutes.

j. After 5 minutes of rated load operation, drop the load to no load in one step and operate the set at no load, rated voltage and rated frequency until temperature stabilization of the engine occurs. During this period readings of all instrumentation including thermal instrumentation

shall be recorded at minimum intervals of 10 minutes. If necessary, adjustments to the voltage and frequency may be made to maintain operation at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage and frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the contract. Adjustments to the voltage or frequency controls shall be recorded on both the data sheet and the test recording equipment(s). Unless otherwise specified in the contract, engine temperature stabilization will be considered to have occurred when two consecutive recorded readings of the engine coolant and oil temperatures remain unchanged.

k. Apply rated load in one step and allow the generator set to stabilize at rated load, rated voltage, and rated frequency. During this period, readings of all instrumentation including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. When the generator set under test is diesel driven, remove the auxiliary fuel hose from the auxiliary fuel supply for 5 minutes during the time the set is operating at rated load from the auxiliary fuel supply, then replace the hose and continue operation from the auxiliary fuel supply for at least 10 minutes. Change the fuel transfer valve to the set tank position and continue the test using the set fuel tank. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the contract. Adjustments to the load, voltage or frequency controls shall be recorded on both the data sheet and test recording equipment(s).
Unless otherwise specified in the contract, stabilization will be considered to have occurred when four consecutive voltage and frequency recorded readings of the generator line output either remain unchanged within plus or minus one-half the long-term stability bandwidth with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

l. After stabilization has occurred, unless otherwise specified in the contract, operate the generator set in accordance with the instructions an the set or in the technical manual and perform the following methods at the specified low temperature, voltage connection and frequency:

1. Method 58, Rheostat Range Test.
2. Method 59, Regulator Range Test.
3. Method 64, Indicating Instrument Test (Electrical).
4. Method 77, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term). In addition to the required data, all thermal instrumentation as specified in 105.3.1 shall be read and recorded at the same time for the stabilization portion of this test.

NOTE: The above methods are listed in numerical order; however they need not be performed in this order. Test Method 58 shall only be performed on sets so equipped.

m. If the total operating time between the start of the no load stabilization run (step i) and the completion of the tests listed in step k above is less than 8 hours, then continue to run the set at no load, rated voltage and rated frequency until the accumulated operating time is at least 8 hours.

105.4 Results. Results shall be as specified in the methods listed in paragraph 105.3.2(k). Compare the manner in which the generator set functioned, as denoted by the instrument and temperature readings, with the requirements of the contract.

105.5 Contract requirements. The following details must be specified in the individual contract:

a. Temperature at which method is to be performed.

b. Type of fuel, lubricating oil, and coolant to be used.

c. Additional tests to be performed not listed in 105.3.2(k) of this method.

d. Voltage connection and frequency at which this method is to be performed.

e. Allowable starting time if different than specified in 105.3.2(f) of this method.

f. Requirements for auxiliary fuel supply system.

g. Maximum and minimum voltage values between which the generator set shall perform.

h. The maximum allowable voltage regulation.

i. The accuracy requirements of the panel instruments.

j. Maximum allowable short-term frequency stability bandwidth or deviation in percent of rated frequency.

k. Maximum allowable frequency recovery time after a load change.

l. Maximum allowable frequency overshoot or undershoot during a load change.

m. Maximum allowable frequency regulation (droop).

n. Maximum allowable short-term voltage stability bandwidth or deviation in percent of rated voltage.

o. Maximum allowable voltage recovery time after a load change.

p. Maximum allowable voltage overshoot or undershoot during a load change.

q. Engine temperature requirements.

r. Requirements for checking devices in 105.3.2(c).

TEST METHOD 106

STARTING AND OPERATING TEST (MODERATE COLD, BATTERY START)

106.1 General. The generator set must satisfactorily start and operate in moderate low temperature environments without the use of any winterization equipment.

106.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient and set temperatures shall be as described in EGSA 107T . In addition, test recording equipment(s) for recording voltage and frequency (speed) shall be required. The test recording equipment(s) shall be as described in EGSA 107T Test Method 1 and 4 (unless otherwise specified in the contract).

A controlled temperature room shall be used having sufficient capacity to maintain the specified low temperature with the set operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in EGSA 107T Test Method 14.

106.3 Procedure. If this method is performed immediately following Test Method 105 or Test Method 109, omit 106.3.1 and steps a and b of 106.3.2 except that the tester may change batteries.

106.3.1 Preparation for test.

a. Install appropriate thermocouples to measure the following temperatures. (**NOTE**: Not all sets will require instrumentation of all of the listed items. This list contains items normally instrumented, however, some sets may require additional thermal instrumentation). The thermal instrumentation shall be installed in accordance with the instructions in EGSA 107T , Test Method 17.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s) (gasoline engines).
4. Exhaust gases (The exhaust manifold(s) of reciprocating engines shall be drilled and tapped as close as possible to the combustion chamber(s). For gas turbine engines, thermocouples shall be located in the tailpipe approximately one turbine wheel diameter downstream from the last turbine stage).
5. Lubricating oil sump and gallery for preproduction sets and sets and sump only for production sets.
6. Oil cooler (inlet and outlet).
7. Hydraulic oil sump.
8. Storage battery electrolyte (thermocouple(s) shall be so located that the electrolyte temperature at the center of the electrolyte is measured).
9. Engine combustion air in (located at the inlet of the intake manifold).
10. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
11. Generator cooling air (inlet and outlet).

12. Generator stator frame (top and bottom, outside).
13. Generator exciter (stator housing for rotation exciters, transformers for static exciters).
14. Generator voltage regulator (ambient air, inside).
15. Control panel cubicle (ambient air, inside).
16. Relay and control boxes (ambient air, inside).
17. Average ambient air temperature (Test Method 23).
18. Air entering generator set for housed sets.

b. 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, heater, and all coolant lines. Be sure that the set is completely drained. Fill the coolant system with the proper solution of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

c. Drain the fuel from all fuel tanks, lines, strainer, pumps and filters. Flush tanks with low temperature fuel using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets an strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuels of the proper grade (low temperature fuel specified in the contract). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

d. Drain the lubricating oil from the engine, filters, strainer and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubrication oil. Fill a small container with a sample (approximately 8 ounces) of the oil used.

e. Operate any fuel priming pumps on the set with the discharge lines open to clear lines of normal ambient fuel.

f. On all units, as applicable, check the spark plugs, magneto, distributor, valve clearances, injector timing, etc. Check instruction manual or operating and servicing instructions to see that all set requirements or recommendations have been performed.

g. Start and operate the generator set for approximately 15 minutes at no load to allow the fuels and lubricant 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 all set fuel tanks as well as the oil from the air cleaners. Fill set fuel tanks, except for sets with gasoline engines. Refill the air cleaner oil reservoirs with the proper grade of lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of fuel and oil used.

h. If a storage battery is part of the set, fill it with electrolyte having the specific gravity recommended mended for arctic operation. Determine that the batteries have been cycled and completely charged (see Test Method 22) before placing them in the cold room.

i. Place containers of fuel, lubricant, and coolant in the cold room.

j. Place the generator set in the cold room. If the set is equipped with a three-way valve for an auxiliary fuel supply, connect the fuel supply to the engine thru the three-way valve using the auxiliary fuel hoses (length and size of hoses are specified in the contract) supplied with the generator set. The auxiliary fuel supply must have sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. This auxiliary fuel supply shall be in the cold room. Set fuel supply valve in the auxiliary fuel position.

k. Connect the load and field instrumentation for the voltage connection and frequency specified in the contract. Unless otherwise specified, connect the signal input of the test recording equipment(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage sensing input to the voltage regulator. (Power the test recording equipment(s) from the commercial utility.)

l. Where temperature measurements are made by means of thermocouples, the thermocouple leads shall be brought out of the cold room 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 cold room. In addition to step k above, provisions shall be made for measuring the voltage on the generator side of the circuit breaker with instruments located outside the cold room.

106.3.2 Test.

a. For sets with gasoline engine, decrease the temperature in the cold room and when the ambient temperature has reached approximately 0 °F (-17.7 ➡C) open the auxiliary fuel container and fill the set tank. (Note: The volatility of arctic fuel at temperatures above 0 °F (-17.7 °C) necessitates storing the fuel in sealed containers. Fill and label a small container with a sample of the fuel used. Place this sample along side samples of fuel, lubrication oil, and coolant taken previously, in preparation for test, in a location in the cold chamber where they may be observed.

b. For sets with gasoline engines, start and operate the set for approximately 15 minutes at no load to allow the fuel to thoroughly circulate. Then shut down the set.

NOTE: Applied rated load during this period of operation to assure the setting of the load bank for the operation portion of this method.

c. Expose the complete generator set (including all fuels, lubricants, coolants and hydraulic oils to be used during this method) to the specified low temperature until such time as all components are at the specified low temperature or until 24 hours have elapsed, whichever comes later. During all steps of this test, all of the eight ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the contracts. Prepare the set for extreme cold start by explicitly following the operating instructions on the set. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet.

d. Turn on the test recording equipment(s) and leave the meter(s) on until the entire method 106 is completed.

NOTE: If using recording meter(s), the chart speed shall be operated at a minimum of 12 inches per hour during the portions of the test where steady-state loading conditions exist and shall be operated at a minimum speed of 12 inches per minutes at least 30 seconds before, during, and after a load change.

e. By following the operating instructions on the set or in the technical manual, start the generator set. Prior to the first attempt to start, but within the allotted 5 minutes, complete two required cranking cycles with the set inactive (to preclude starting). Record the time when cranking is started. Record the time when the set starts. See figure 106-I.

WARNING: Care must be taken in cranking the engine. Excessive cranking may damage the starter. See the instructions on the set or the technical manual for the maximum cranking time

f. Allow the engine to warm up at no-load, rated voltage and rated frequency for a period of 15 minutes.

g. Just before applying rated load, reset the frequency to the rated value and record the amount the frequency had drifted from the time of set start.

h. Within 16 minutes after the engine starts, apply rated load in one step with the circuit interrupter, starting with the interrupter in the off position. Leave rated load on the set for 30 seconds, then drop the load to no load in one step using the circuit interrupter. Operate at no load for 30 seconds. Again, using the circuit interrupter, apply and drop rated load two more times with 30 seconds of operation in each load condition. Next apply rated load and operate for 5 minutes.

i. After 5 minutes of rated load operation, drop the load to no load in one step and operate the set at no load, rated voltage and rated frequency until temperature stabilization of the engine occurs. During this period readings of all instrumentation including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. If necessary, adjustments to the voltage and frequency may be made to maintain operation at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage and frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the contract. Adjustments to the voltage or frequency controls shall be recorded on both the data sheet and the recording chart(s). Unless otherwise specified in the contract, engine temperature stabilization will be considered to have occurred when two consecutive recorded readings of the engine coolant and oil temperatures remain unchanged.

j. Apply rated load in one step and allow the generator set to stabilize at rated load, rated voltage, and rated frequency. During this period, readings of all instrumentation including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. When the generator set under test is diesel driven, remove the auxiliary fuel hose from the auxiliary fuel supply for 5 minutes during the time the set is operating at rated load from the auxiliary fuel supply, then replace the hose and continue operation from the auxiliary fuel supply for at least 10 minutes. Change the fuel transfer valve to the set tank position and continue the test using the set fuel tank. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the contract. Adjustments to the load, voltage or frequency controls shall be recorded on both the data sheet and recording chart(s). Unless otherwise specified in the contract, stabilization will be considered to have occurred when four consecutive voltage and frequency recorded readings of the generator line output either remain unchanged or have only minor variations within plus or minus one-half the long-term stability bandwidth with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

k. After stabilization has occurred, unless otherwise specified in the contract, operate the generator set in accordance with the instructions an the set or in the technical manual and perform the following methods at the specified low temperature, voltage connection and frequency:

1. Test Method 58, Rheostat Range Test.
2. Test Method 59, Regulator Range Test.
3. Test Method 64, Indicating Instrument Test (Electrical).
4. Test Method 77, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term). In addition to the required data, all thermal instrumentation as specified in Test Method 6 shall be read and recorded at the same time for the stabilization portion of this test.

NOTE: The above methods are listed in numerical order; however they need not be performed in this order. Test Method 58 shall only be performed on sets so equipped.

l. If the total operating time between the start of the no load stabilization run (step i) and the completion of the tests listed in step k above is less than 8 hours, then continue to run the set at no load, rated voltage and rated frequency until the accumulated operating time is at least 8 hours.

106.4 Results. Results shall be as specified in the methods listed in paragraph 106.3.2(k). Compare the manner in which the generator set functioned, as denoted by the instrument and temperature readings, with the requirements of the contract.

106.5 Contract requirements. The following details must be specified in the individual contract:

a. Temperature at which method is to be performed.

b. Type of fuel, lubricating oil, and coolant to be used.

c. Additional tests to be performed not listed in 106.3.2(k) of this method.

d. Voltage connection and frequency at which this method is to be performed.

e. Allowable heating and starting time if different than specified in 105.3.2(f) of this method.

f. Duration of cranking cycle (see 106.3.2(e)).

g. Requirements for auxiliary fuel supply system.

h. Maximum and minimum voltage values.

i. Maximum and minimum voltage values between which the generator set shall perform.

j. The maximum allowable voltage regulation.

k. The accuracy requirements of the panel instruments.

l. Maximum allowable short-term frequency stability bandwidth or deviation in percent of rated frequency.

m. Maximum allowable frequency recovery time after a load change.

n. Maximum allowable frequency overshoot or undershoot during a load change.

o. Maximum allowable frequency regulation (droop).

p. Maximum allowable short-term voltage stability bandwidth or deviation in percent of rated voltage.

q. Maximum allowable voltage recovery time after a load change.

r. Maximum allowable voltage overshoot or undershoot during a load change.

s. Minimum allowable engine temperatures after 1 hour of operation at rated load.

TEST METHOD 107

STARTING AND OPERATING TEST
(EXTREME COLD, MANUAL CRANK)

107.1 General. The generator set must satisfactorily start and operate under extreme low temperature environments.

107.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient and set temperatures shall be as described in EGSA 107T . In addition, test recording equipment(s) for recording voltage and frequency (speed) shall be required. The test recording equipment(s) shall be as described in EGSA 107T Test Method 1 and 4 (unless otherwise specified in the contract).

A controlled temperature room shall be used having sufficient capacity to maintain the specified low temperature with the set operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in EGSA 107T Test Method 14.

107.3 Procedure.

107.3.1 Preparation for test.

a. Install appropriate thermocouples to measure the following temperatures. (**NOTE**: Not all sets will require instrumentation of all of the listed items. This list contains items normally instrumented, however, some sets may require additional thermal instrumentation). The thermal instrumentation shall be installed in accordance with the instructions in Test Method 23.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s) (gasoline engines).
4. Exhaust gases (The exhaust manifold(s) of reciprocating engines shall be drilled and tapped as close as possible to the combustion chamber(s). For gas turbine engines, thermocouples shall be located in the tailpipe approximately one turbine wheel diameter downstream from the last turbine stage).
5. Lubricating oil sump and gallery for preproduction sets and sets and sump only for production sets.
6. Oil cooler (inlet and outlet).
7. Hydraulic oil sump.
8. Storage battery electrolyte (thermocouple(s) shall be so located that the electrolyte temperature at the center of the electrolyte is measured).
9. Engine combustion air in (located at the inlet of the intake manifold).
10. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
11. Generator cooling air (inlet and outlet).
12. Generator stator frame (top and bottom, outside).

13. Generator exciter (stator housing for rotation exciters, transformers for static exciters).
14. Generator voltage regulator (ambient air, inside).
15. Control panel cubicle (ambient air, inside).
16. Relay and control boxes (ambient air, inside).
17. Average ambient air temperature (Test Method 23).
18. Air entering generator set for housed sets.
19. Heater coolant (air or liquid-into and out of the heater).
20. Heater exhaust.

b. 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, heater, and all coolant lines. Be sure that the set is completely drained. Fill the coolant system with the proper solution of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

c. Drain the fuel from all fuel tanks, lines, strainer, pumps and filters. Flush tanks with low temperature fuel using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets an strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuels of the proper grade (low temperature fuel specified in the contract). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

d. Drain the lubricating oil from the engine, filters, strainer and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubrication oil. Fill a small container with a sample (approximately 8 ounces) of the oil used.

e. Operate the winterization and ether systems as applicable. See that all controls work properly. It may be necessary to temporarily bypass some controls if the ambient temperature is too high. Do not operate the heater for longer than necessary to perform the checkout.

f. Operate any fuel priming pumps on the set with the discharge lines open to clear lines of normal ambient fuel.

g. On all units, as applicable, check the spark plugs, magneto, distributor, valve clearances, injector timing, etc. 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 arctic fuels and lubricant 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 all set fuel tanks as well as the oil from the air cleaners. Fill set fuel tanks, except for sets with gasoline engines. Refill the air cleaner oil reservoirs with the proper grade of lubricating oil. Fill the air cleaner oil reservoirs with the proper grade of lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of fuel and oil used.

i. Place containers of fuel, lubricant, and coolant in the cold room.

j. Place the generator set in the cold room. If the set is equipped with a three-way valve for an auxiliary fuel supply, connect the fuel supply to the engine thru the three-way valve using the auxiliary fuel hoses (length and size of hoses are specified in the contract) supplied with the generator set. The auxiliary fuel supply must have sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. This auxiliary fuel supply shall be in the cold room. Set fuel supply valve in the auxiliary fuel position.

k. Connect the load and field instrumentation for the voltage connection and frequency specified in the contract. Unless otherwise specified, connect the signal input of the test recording equipment(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage sensing input to the voltage regulator. (Power the test recording equipment(s) from the commercial utility.)

l. Where temperature measurements are made by means of thermocouples, the thermocouple leads shall be brought out of the cold room 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 cold room. In addition to step k above, provisions shall be made for measuring the voltage on the generator side of the circuit breaker with instruments located outside the cold room.

107.3.2 Test.

a. For sets with gasoline engine, decrease the temperature in the cold room and when the ambient temperature has reached approximately 0 °F (-17.7 ➡C) open the auxiliary fuel container and fill the set tank. (Note: The volatility of arctic fuel at temperatures above 0 °F (-17.7 °C) necessitates storing the fuel in sealed containers. Fill and label a small container with a sample of the fuel used. Place this sample along side samples of fuel, lubrication oil, and coolant taken previously, in preparation for test, in a location in the cold chamber where they may be observed.

b. For sets with gasoline engines, start and operate the set for approximately 15 minutes at no load to allow the fuel to thoroughly circulate. Then shut down the set.

NOTE: Applied rated load during this period of operation to assure the setting of the load bank for the operation portion of this method.

c. Expose the complete generator set (including all fuels, lubricants, coolants and hydraulic oils to be used during this method) to the specified low temperature until such time as all components are at the specified low temperature or until 24 hours have elapsed, whichever comes later. During all steps of this test, all of the eight ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the contracts. Prepare the set for extreme cold start by explicitly following the operating instructions on the set. Examine

fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet.

d. By following the operating instructions, place the heater switch in the "ON " position, if applicable. Record the time the switch was placed in the "ON" position and the elapsed time required for the ignition of the fuel. Warm up the test recording equipment(s) by placing the switch in the standby operation position, if applicable.

e. Record the readings of temperature devices continuously during the period that the winterization equipment is in operation. (See figure 107-I).

f. Operate the winterization equipment until the set is sufficiently warm to start but no longer than the time allowed in the contract. Turn on the test recording equipment(s) and leave on until the entire Test Method 107 is completed. Then start the engine in accordance with the operating instructions on the set or the technical manual. Record the number of cranks required. The set must be operating at rated voltage and rated frequency without further use of any type of starting aids or winterization equipment within the specified period from the time the heat was applied to the set. After the engine starts, allow the engine to warm up at no load, rated voltage and rated frequency for a period of 15 minutes.

NOTE: If using recording meter(s), the chart speed shall be operated at a minimum of 12 inches per hour during the portions of the test where steady-state loading conditions exist and shall be operated at a minimum speed of 12 inches per minutes at least 30 seconds before, during, and after a load change.

g. Just before applying rated load, reset the frequency to the rated value and record the amount the frequency had drifted from the time of set start.

h. Within 16 minutes after the engine starts, apply rated load in one step with the circuit interrupter, starting with the interrupter in the off position. Leave rated load on the set for 30 seconds, then drop the load to no load in one step using the circuit interrupter. Operate at no load for 30 seconds. Again, using the circuit interrupter, apply and drop rated load two more times with 30 seconds of operation in each load condition. Next apply rated load and operate for 5 minutes.

i. After 5 minutes of rated load operation, drop the load to no load in one step and operate the set at no load, rated voltage and rated frequency until temperature stabilization of the engine occurs. During this period readings of all instrumentation including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. If necessary, adjustments to the voltage and frequency may be made to maintain operation at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage and frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the contract. Adjustments to the voltage or frequency controls shall be recorded on both the data sheet and

the recording chart(s). Unless otherwise specified in the contract, engine temperature stabilization will be considered to have occurred when two consecutive recorded readings of the engine coolant and oil temperatures remain unchanged.

j. Apply rated load in one step and allow the generator set to stabilize at rated load, rated voltage, and rated frequency. During this period, readings of all instrumentation including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. When the generator set under test is diesel driven, remove the auxiliary fuel hose from the auxiliary fuel supply for 5 minutes during the time the set is operating at rated load from the auxiliary fuel supply, then replace the hose and continue operation from the auxiliary fuel supply for at least 10 minutes. Change the fuel transfer valve to the set tank position and continue the test using the set fuel tank. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the contract. Adjustments to the load, voltage or frequency controls shall be recorded on both the data sheet and recording chart(s). Unless otherwise specified in the contract, stabilization will be considered to have occurred when four consecutive voltage and frequency recorded readings of the generator line output either remain unchanged or have only minor variations within plus or minus one-half the long-term stability with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

k. After stabilization has occurred, unless otherwise specified in the contract, operate the generator set in accordance with the instructions an the set or in the technical manual and perform the following methods at the specified low temperature, voltage connection and frequency:

1. Test Method 58, Rheostat Range Test.
2. Test Method 59, Regulator Range Test.
3. Test Method 64, Indicating Instrument Test (Electrical).
4. Test Method 77, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term). In addition to the required data, all thermal instrumentation as specified in 108.3.1 shall be read and recorded at the same time for the stabilization portion of this test.

NOTE: The above methods are listed in numerical order; however they need not be performed in this order. Test Method 58 shall only be performed on sets so equipped.

l. If the total operating time between the start of the no load stabilization run (step i) and the completion of the tests listed in step k above is less than 8 hours, then continue to run the set at no load, rated voltage and rated frequency until the accumulated operating time is at least 8 hours.

107.4 Results. Results shall be as specified in the methods listed in paragraph 107.3.2(k). Compare the manner in which the generator set functioned, as denoted by the instrument and temperature readings, with the requirements of the contract.

107.5 Contract requirements. The following details must be specified in the individual contract:

a. Temperature at which method is to be performed.

b. Type of fuel, lubricating oil, and coolant to be used.

c. Additional tests to be performed not listed in 107.3.2(k) of this method.

d. Voltage connection and frequency at which this method is to be performed.

e. Allowable heating and starting.

f. Requirements for auxiliary fuel supply system.

g. Maximum and minimum voltage values between which the generator set shall perform.

h. The maximum allowable voltage regulation.

i. The accuracy requirements of the panel instruments.

j. Maximum allowable short-term frequency stability bandwidth or deviation in percent of rated frequency.

k. Maximum allowable frequency recovery time after a load change.

l. Maximum allowable frequency overshoot or undershoot during a load change.

m. Maximum allowable frequency regulation (droop).

n. Maximum allowable short-term voltage stability bandwidth or deviation in percent of rated voltage.

o. Maximum allowable voltage recovery time after a load change.

p. Maximum allowable voltage overshoot or undershoot during a load change.

q. Engine temperature requirements.

r. Requirements for checking devices in 107.3.2(c).

TEST METHOD 108

STARTING AND OPERATING TEST (MODERATE COLD, MANUAL CRANK)

108.1 General. The generator set must satisfactorily start and operate in moderate low temperature environments without the use of any winterization equipment.

108.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient and set temperatures shall be as described in EGSA 107T . In addition, test recording equipment(s) for recording voltage and frequency (speed) shall be required. The test recording equipment(s) shall be as described in EGSA 107T Test Method 1 and 4 (unless otherwise specified in the contract).

A controlled temperature room shall be used having sufficient capacity to maintain the specified low temperature with the set operating at rated load for the duration of this test. This controlled temperature room shall be as described and illustrated in EGSA 107T Test Method 14.

108.3 Procedure. If this method is performed immediately following Test Method 107, omit 108.3.1 and steps a and b of 108.3.2.

108.3.1 Preparation for test.

a. Install appropriate thermocouples to measure the following temperatures. (Note: Not all sets will require instrumentation of all of the listed items. This list contains items normally instrumented, however, some sets may require additional thermal instrumentation). The thermal instrumentation shall be installed in accordance with the instructions in Test Method 23.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s) (gasoline engines).
4. Exhaust gases (The exhaust manifold(s) of reciprocating engines shall be drilled and tapped as close as possible to the combustion chamber(s). For gas turbine engines, thermocouples shall be located in the tailpipe approximately one turbine wheel diameter downstream from the last turbine stage).
5. Lubricating oil sump and gallery for preproduction sets and sets and sump only for production sets.
6. Oil cooler (inlet and outlet).
7. Hydraulic oil sump.
8. Storage battery electrolyte (thermocouple(s) shall be so located that the electrolyte temperature at the center of the electrolyte is measured).
9. Engine combustion air in (located at the inlet of the intake manifold).
10. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
11. Generator cooling air (inlet and outlet).
12. Generator stator frame (top and bottom, outside).
13. Generator exciter (stator housing for rotation exciters, transformers for static exciters).

14. Generator voltage regulator (ambient air, inside).
15. Control panel cubicle (ambient air, inside).
16. Relay and control boxes (ambient air, inside).
17. Average ambient air temperature (Test Method 23).
18. Air entering generator set for housed sets.

b. 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, heater, and all coolant lines. Be sure that the set is completely drained. Fill the coolant system with the proper solution of antifreeze. Fill and label a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

c. Drain the fuel from all fuel tanks, lines, strainer, pumps and filters. Flush tanks with low temperature fuel using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets an strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuels of the proper grade (low temperature fuel specified in the contract). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

d. Drain the lubricating oil from the engine, filters, strainer and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubrication oil. Fill a small container with a sample (approximately 8 ounces) of the oil used.

e. Operate any fuel priming pumps on the set with the discharge lines open to clear lines of normal ambient fuel.

f. On all units, as applicable, check the spark plugs, magneto, distributor, valve clearances, injector timing, etc. Check instruction manual or operating and servicing instructions to see that all set requirements or recommendations have been performed.

g. Start and operate the generator set for approximately 15 minutes at no load to allow the fuels and lubricant 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 all set fuel tanks as well as the oil from the air cleaners. Fill set fuel tanks, except for sets with gasoline engines. Refill the air cleaner oil reservoirs with the proper grade of lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of fuel and oil used.

h. Place containers of fuel, lubricant, and coolant in the cold room.

i. Place the generator set in the cold room. If the set is equipped with a three-way valve for an auxiliary fuel supply, connect the fuel supply to the engine thru the three-way valve using the auxiliary fuel hoses (length and size of hoses are specified in the contract) supplied with the generator set. The auxiliary fuel supply must have sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. This auxiliary fuel supply shall be in the cold room. Set fuel supply valve in the auxiliary fuel position.

j. Connect the load and field instrumentation for the voltage connection and frequency specified in the contract. Unless otherwise specified, connect the signal input of the test recording equipment(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage sensing input to the voltage regulator. (Power the test recording equipment(s) from the commercial utility.)

k. Where temperature measurements are made by means of thermocouples, the thermocouple leads shall be brought out of the cold room 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 cold room. In addition to step k above, provisions shall be made for measuring the voltage on the generator side of the circuit breaker with instruments located outside the cold room.

108.3.2 Test.

a. For sets with gasoline engine, decrease the temperature in the cold room and when the ambient temperature has reached approximately 0 °F (-17.7 ➡C) open the auxiliary fuel container and fill the set tank. (Note: The volatility of arctic fuel at temperatures above 0 °F (-17.7 °C) necessitates storing the fuel in sealed containers. Fill and label a small container with a sample of the fuel used. Place this sample along side samples of fuel, lubrication oil, and coolant taken previously, in preparation for test, in a location in the cold chamber where they may be observed.

b. For sets with gasoline engines, start and operate the set for approximately 15 minutes at no load to allow the fuel to thoroughly circulate. Then shut down the set.

NOTE: Applied rated load during this period of operation to assure the setting of the load bank for the operation portion of this method.

c. Expose the complete generator set (including all fuels, lubricants, coolants and hydraulic oils to be used during this method) to the specified low temperature until such time as all components are at the specified low temperature or until 24 hours have elapsed, whichever comes later. During all steps of this test, all of the eight ambient thermocouples shall indicate temperatures equal to or colder than the specified low temperature. After all temperatures are equal to or below the specified low temperature, check all devices - such as hoses, wiring, door latches, and panel latches for compliance with requirements of the contracts. Prepare the set for extreme cold start by explicitly following the operating instructions on the set. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet.

d. Turn on the test recording equipment(s) and leave the equipment(s) on until the entire Test Method 106 is completed.

NOTE: If using recording meter(s), the chart speed shall be operated at a minimum speed of 12 inches per hour during the portions of the test where steady-state loading conditions exist and shall be operated at a minimum speed of 12 inches per minutes at least 30 seconds before, during, and after a load change.

e. By following the operating instructions on the set or in the technical manual, start the generator set within 5 minutes. Record the time when cranking is started. Record the number cranks. Record the time when the set starts. See figure 108-I.

f. Allow the engine to warm up at no-load, rated voltage and rated frequency for a period of 15 minutes.

g. Just before applying rated load, reset the frequency to the rated value and record the amount the frequency had drifted from the time of set start.

h. Within 16 minutes after the engine starts, apply rated load in one step with the circuit interrupter, starting with the interrupter in the off position. Leave rated load on the set for 30 seconds, then drop the load to no load in one step using the circuit interrupter. Operate at no load for 30 seconds. Again, using the circuit interrupter, apply and drop rated load two more times with 30 seconds of operation in each load condition. Next apply rated load and operate for 5 minutes.

i. After 5 minutes of rated load operation, drop the load to no load in one step and operate the set at no load, rated voltage and rated frequency until temperature stabilization of the engine occurs. During this period readings of all instrumentation including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. If necessary, adjustments to the voltage and frequency may be made to maintain operation at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage and frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the contract. Adjustments to the voltage or frequency controls shall be recorded on both the data sheet and the recording chart(s). Unless otherwise specified in the contract, engine temperature stabilization will be considered to have occurred when two consecutive recorded readings of the engine coolant and oil temperatures remain unchanged.

j. Apply rated load in one step and allow the generator set to stabilize at rated load, rated voltage, and rated frequency. During this period, readings of all instrumentation including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. When the generator set under test is diesel driven, remove the auxiliary fuel hose from the auxiliary fuel supply for 5 minutes during the time the set is operating at rated load from the auxiliary fuel supply, then replace the hose and continue operation from the auxiliary fuel supply for at least 10 minutes. Change the fuel transfer valve to the set tank position and continue the test using the set fuel tank. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and rated frequency. However, adjustments to the voltage and

frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the contract. Adjustments to the load, voltage or frequency controls shall be recorded on both the data sheet and recording equipment(s). Unless otherwise specified in the contract, stabilization will be considered to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made.

k. After stabilization has occurred, unless otherwise specified in the contract, operate the generator set in accordance with the instructions an the set or in the technical manual and perform the following methods at the specified low temperature, voltage connection and frequency:

1. Test Method 58, Rheostat Range Test.
2. Test Method 59, Regulator Range Test.
3. Test Method 65, Indicating Instrument Test (Electrical).
4. Test Method 77, Voltage and Frequency Regulation, Stability and Transient Response Test (Short Term). In addition to the required data, all thermal instrumentation as specified in 106.3.1 shall be read and recorded at the same time for the stabilization portion of this test.

NOTE: The above methods are listed in numerical order; however they need not be performed in this order. Test Method 58 shall only be performed on sets so equipped.

l. If the total operating time between the start of the no load stabilization run (step i) and the completion of the tests listed in step k above is less than 8 hours, then continue to run the set at no load, rated voltage and rated frequency until the accumulated operating time is at least 8 hours.

108.4 Results. Results shall be as specified in the methods listed in paragraph 106.3.2(k). Compare the manner in which the generator set functioned, as denoted by the instrument and temperature readings, with the requirements of the contract.

108.5 Contract requirements. The following details must be specified in the individual contract:

a. Temperature at which method is to be performed.

b. Type of fuel, lubricating oil, and coolant to be used.

c. Additional tests to be performed not listed in 108.3.2(k) of this method.

d. Voltage connection and frequency at which this method is to be performed.

e. Allowable starting time if different than specified in 108.3.2(f) of this method.

f. Requirements for auxiliary fuel supply system.

g. Maximum and minimum voltage values between which the generator set shall perform.

h. The maximum allowable voltage regulation.

i. The accuracy requirements of the panel instruments.

j. Maximum allowable short-term frequency stability bandwidth or deviation in percent of rated frequency.

k. Maximum allowable frequency recovery time after a load change.

l. Maximum allowable frequency overshoot or undershoot during a load change.

m. Maximum allowable frequency regulation (droop).

n. Maximum allowable short-term voltage stability bandwidth or deviation in percent of rated voltage.

o. Maximum allowable voltage recovery time after a load change.

p. Maximum allowable voltage overshoot or undershoot during a load change.

q. Engine temperature requirements.

r. Requirements for checking devices in 108.3.2(c).

TEST METHOD 109
STANDBY OPERATION TEST
(EXTREME COLD)

109.1 General. The ability of the winterization equipment to maintain engine temperatures at such values as to permit rapid starting of the generator set in arctic conditions is necessary.

109.2 Apparatus. Instrumentation for measuring load conditions, field voltage and current, and ambient and set temperatures shall be as described in EGSA 107T . In addition, a controlled temperature room as described in EGSA 107T Test Method 14 having sufficient capacity to maintain the specified low temperature throughout this method shall be required.

109.3 Procedure.

109.3.1 Preparation for test.

a. Install appropriate thermocouples to measure the following temperatures. (**NOTE**: Not all sets will require instrumentation of all of the listed items. This list contains items normally instrumented; however, some sets may require additional thermal instrumentation.) The thermal instrumentation shall be installed in accordance with the instructions in EGSA 107T , Test Method 23.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s) (gasoline engines).
4. Exhaust gases (The exhaust manifold(s) of reciprocating engines shall be drilled and tapped as close as possible to the combustion chamber(s). For gas turbine engines, thermocouples shall be located in the tailpipe approximately one turbine wheel diameter downstream from the last turbine stage).
5. Lubricating oil sump and gallery for preproduction sets and sets and sump only for production sets.
6. Oil cooler (inlet and outlet).
7. Hydraulic oil sump.
8. Storage battery electrolyte (thermocouple(s) shall be so located that the electrolyte temperature at the center of the electrolyte is measured).
9. Engine combustion air in (located at the inlet of the intake manifold).
10. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
11. Generator cooling air (inlet and outlet).
12. Generator stator frame (top and bottom, outside).
13. Generator exciter (stator housing for rotation exciters, transformers for static exciters).
14. Generator voltage regulator (ambient air, inside).
15. Control panel cubicle (ambient air, inside).
16. Relay and control boxes (ambient air, inside).
17. Average ambient air temperature (EGSA 107T , Test Method 23).

18. Air entering generator set for housed sets.

19. Heater coolant (air or liquid-into and out of the heater).
20. Heater exhaust.

b. Start and operate the generator set until the lubricating oil is warm enough to drain. Drain the coolant from the engine block, radiator, coolant pump, heater, and all coolant lines. Be sure that the set is completely drained. Fill and label the coolant system with the proper solution of antifreeze. Fill a small transparent container (approximately 8 ounces) with a sample of the antifreeze used.

c. Drain the fuel from all fuel tanks, lines, strainers, pumps and filters. Flush tanks low-temperature fuel with using approximately 10 percent of tank capacity. Clean all fuel strainers and replace filter elements. Install new gaskets on strainer and filter elements. Fill fuel tanks to approximately 10 percent rated capacity with fuels of the proper grade (low temperature fuel specified in the contract). Fill and label a small container (approximately 8 ounces) with a sample of each fuel used.

d. Drain the lubricating oil from the engine, filters, strainers and lines. Install new filters and clean the strainers. Use new gaskets. Fill with proper grade lubricating oil. Fill and label a small container with a sample (approximately 8 ounces) of the oil used.

e. Start and operate the winterization system. See that all controls work properly. It may be necessary to temporarily bypass controls if the ambient temperature is too high. Do not operate the heater for longer than necessary to perform the check-out.

f. Operate any fuel priming pumps on the set with the discharge lines open to clear lines of normal ambient fuel.

g. On all units, as applicable, check the spark plugs, magneto, distributor, valve clearances, injector timing, etc. 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 all set fuel tanks as well as the oil from the air cleaners. Fill set fuel tanks, except for sets with gasoline engines. Fill and label a small container with a sample (approximately 8 ounces) of fuel used.

i. If a storage battery is part of the set, fill it with electrolyte having the specified gravity recommended for arctic operation. The batteries shall by cycled and completely charged (see EGSA 107T , method 21) before placing them in the cold room.

j. Place containers of fuel, lubricant(s), and coolant in the cold room.

k. Place the generator set in the cold room. If the set is equipped with a three-way valve for an auxiliary fuel supply, connect the fuel supply to the engine thru the three-way valve using the auxiliary fuel hoses (length and size of hoses are specified in the contract) supplied with the generator set. The auxiliary fuel supply must have sufficient capacity to furnish fuel for a minimum period of 6 hours when operating at rated frequency (speed) and at no load. This auxiliary fuel supply shall be in the cold room. Set the fuel supply valve in the auxiliary fuel position.

l. Connect the load and field instrumentation for the voltage connection and frequency specified in the contract. Unless otherwise specified, connect the signal input of the test recording equipment(s) to the convenience receptacle of the set or to the generator coil which is used as the voltage sensing input to the voltage regulator. (Power the test recording equipment(s) from the commercial utility.)

m. Where temperature measurements are made by means of thermocouples, the thermocouple leads shall be brought cut of the cold room 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 cold. In addition to step 1 above, provisions shall be made for measuring the voltage on the generator side of the circuit breaker with instruments located outside the cold room.

109.3.2 Test.

a. For sets with gasoline engines, decrease the temperature in the cold room and when the ambient temperature has reached approximately 0 ➡F (-17.7 °C) open the auxiliary fuel container and fill the set tank. (**NOTE**: The volatility of arctic fuel at temperatures above 0 ➡F (-17.7 °C) necessitates storing the fuel in sealed containers.) Fill and label a small container with a sample of the fuel used. Place this sample alongside samples of fuel, lubricating oil, and coolant taken previously in preparation for test, in a location in the cold chamber where they may be observed.

b. Start and operate the set for approximately 15 minutes at no lead to allow the arctic fuel to thoroughly circulate. Then shut down the set.

c. As soon as the low temperature chamber reaches the specified low temperature or immediately following the shutdown of the generator set concluding Test Method 105, place the winterization equipment into standby operation in accordance with the instructions on the set or in the technical manual. If the winterization heater has separate fuel tank, fill the tank before starting the heater. During all steps of this method all of the eight ambient thermocouples shall indicate temperatures equal to or colder than the specified cold temperature. Examine fuel, oil, and coolant samples for any irregularities due to cold temperature. Record any irregularity on the data sheet.

d. Maintain the winterization equipment in standby operation for 24 hours unless otherwise specified in the contract.

e. Read and record all thermal instrumentation in maximum intervals of one hour.

f. During the specified operation period, keep a record of the amount of fuel added to the fuel tank if the winterization heater uses a separate fuel tank.

g. At each hourly reading inspect the battery temperature readings to determine if the batteries are overheating.

h. One hour before the end of the specified period, open the generator set at the side panels to determine if there are any fuel or coolant leads. In addition, determine if there is any frost build-up inside the hauling. Record findings on the data sheet.

i. At the end of the specified period, shut down the winterization equipment and start the generator set, following instructions on the set or in the technical manual. Unless otherwise specified in the contract, use the set batteries to start the set; but it will not be necessary to make trial cranking with ignition or fuel shut off before attempting to start the engine. Record the elapsed time from initial cranking until the generator set starts.

j. After the engine starts, operate the set at rated voltage and rated frequency (speed) at no load. Open the side panel and inspect the set for fuel, oil, and coolant leaks. Record findings on the data sheet.

k. Using the set circuit interrupter, apply and drop half rated load in one step several times (three should be sufficient). Record electrical instrumentation readings on the data sheet.

l. Perform additional tests or inspections are required by the contract.

109.4 Results. Compare the winterization equipment and generator set performance with the requirements of the contract.

109.5 Contract requirements. The following items must be specified in the individual contract.

a. Length of time this method is to be performed if other than 24 hours.

b. Ambient temperature at which this method is to be performed.

c. Number of hours that the winterization equipment must operate before refilling the fuel tank, if the winterization equipment has a separate fuel tank.

d. Maximum allowable temperature of battery electrolyte.

e. Cranking instructions for starting engine after standby operation tests.

f. Time limit in which the set must start after initial cranking attempt.

g. Voltage connection and frequency at which this method is to be performed.

h. Type of fuel, lubricating oil, and coolant to be used.

TEST METHOD 110

HIGH TEMPERATURE TEST

110.1 General. To assure reliable electrical power generation a generator set must be capable of operating over a wide range of environmental conditions including high ambient temperatures.

110.2 Apparatus. Apparatus as specified in each of the test methods listed in 110.3.2(f) shall be required. In addition to the above-specified instrumentation; thermal instrumentation as described in EGSA 107T Test Method 10 AND 12; and a temperature chamber as described in EGSA 107T Test Method 14 shall be required.

110.3 Procedure.

110.3.1 Preparation for test.

a. Install appropriate thermocouples to measure the following temperatures. (**NOTE**: Not all sets will require instrumentation of all of the listed items. This list contains items normally instrumented, however, some sets may require additional thermal instrumentation). The thermal instrumentation shall be installed in accordance with the instructions in Test Method 23.

1. Engine coolant (engine outlet and inlet).
2. Fuel (discharge side of fuel pump and at fuel source).
3. Spark plug(s) (gasoline engines).
4. Exhaust gases (The exhaust manifold(s) of reciprocating engines shall be drilled and tapped as close as possible to the combustion chamber(s). For gas turbine engines, thermocouples shall be located in the tailpipe approximately one turbine wheel diameter downstream from the last turbine stage).
5. Lubricating oil sump and gallery for preproduction sets and sets and sump only for production sets.
6. Oil cooler (inlet and outlet).
7. Hydraulic oil sump.
8. Engine combustion air in (located at the inlet of the intake manifold).
9. Cooling air into the radiator (four thermocouples equally spaced around the circumference of the area swept by the fan blades).
10. Generator cooling air (inlet and outlet).
11. Generator stator frame (top and bottom, outside).
12. Generator exciter (stator housing for rotation exciters, transformers for static exciters).
13. Generator voltage regulator (ambient air, inside).
14. Control panel cubicle (ambient air, inside).
15. Relay and control boxes (ambient air, inside).
16. Average ambient air temperature (EGSA 107T , Test Method 23).
17. Air entering generator set for housed sets.

b. Place the instrumented generator set in the temperature chamber. Expose the complete generator set (including all fuels, lubricants, coolants and hydraulic oils to be used during this method) to the ambient temperature within the chamber at the value specified in the contract until such time as all components are at the specified ambient temperature or until 24 hours have elapsed, whichever comes later. During all parts of this method, the average of the eight ambient thermocouples (see EGSA 107T , method 202.1) shall not be less than the specified temperature and of these eight thermocouples, none shall indicate more than 5 °F (2.78 °C) above or below the specified ambient. Connect the load and field instrumentation as required for the test methods listed in 110.3.2(f) below for a voltage connection and frequency specified in the contract. Connect switch(es) to the generator armature coil(s), for which the temperature rise is to be determined, such that the coil(s) may be isolated for resistance measurements (if rapid access is available to isolate the individual windings this step may be omitted).

110.3.2 Test.

a. Start and operate the generator set and allow the set to stabilize at rated load, rated voltage and rated frequency. During this period operate the test recording equipment(s) (if using recording meter(s), the chart speed shall not be less than 6 inches per hour), and record all instrument readings including ambient temperature at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and frequency. Adjustments to the voltage and frequency shall be limited to those adjustments available to the operator specifically adjustments to the voltage or frequency adjust devices. On sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control system shall be made unless permitted by the contract. Adjustments to load, voltage or frequency controls shall be recorded on both the data sheet and the recording equipment at the time of adjustment. Unless otherwise specified in the contract, stabilization shall be considered to have occurred when four consecutive voltage and frequency recorded readings of the generator line output either remain unchanged or have only minor variations within plus or minus one-half the long-term stability bandwidth with no evident continued increase or decrease in value after the last adjustment to the load, voltage, or frequency has been made (see figure 110-I).

b. After stabilization has occurred stop the set so that temperatures of rotating components and windings may be taken. For application of the contact method to rotating parts, or the resistance method to the armature calls (see EGSA 107T , Test Methods 10 and 23); a quick shutdown of the set is mandatory.

CAUTION: Do not connect bridges, meters or temperature measuring equipment for measuring resistance or temperature to circuits which may still be energized, e.g., during the time that the set is coming to a step.

c. Immediately after the shutdown, start to record the resistance bridge readings of the coils and the temperatures of the components where the contact method of measuring temperature rise is used.

Readings of resistance measurements shall be recorded in accordance with instructions given in EGSA 107T Test Method 10.

The first thermocouple reading shall be taken and recorded within 30 seconds after shutdown and additional readings taken and recorded at approximately 30 second intervals until one reading has been recorded after the temperature has begun to decrease, or three minutes has elapsed since set shutdown, whichever is longer, being certain that the maximum temperature reached by each component has been recorded. Continuous or multipoint temperature recorder(s) may be used to record component temperatures as long as the above time requirements are met.

d. Repeat steps a thru c above for each of the coils specified in the contract.

e. Repeat steps a thru d above at each additional specified voltage connection and frequency and stabilization voltage.

f. Unless otherwise specified, operate the generator set in accordance with the instructions on the set or in the technical manual and perform the following methods at the specified ambient temperature, voltage connection and frequency:

1. Test Method 61, Circuit Interrupter Test (Short Circuit).
2. Test Method 63, Circuit Interrupter Test (Overvoltage and Undervoltage).
3. Test Method 65, Indicating Instrument Test (Electrical).
4. Test Method 97, DC Control Test.

NOTE: The above methods are listed in numerical order; however, they need not be performed in this order.

g. Repeat paragraph a to establish stabilization values. Stabilization for the tests below will be considered valid once the set has been operated a sufficient period of time to achieve the previously established generator field voltage, current and frequency. The tests below shall be run sequentially with no shutdown between tests (if a shutdown occurs, for any reason, stabilization will have to be re-established):

1. Method 511.1, Regulator Range Test.
2. Method 511.2, Frequency Adjustment Range Test.
3. Method 512.2, Circuit Interrupter Test (Overload Current).
4. Method 608.1 Frequency and Voltage Regulation, Stability and Transient Response Test (Short Term). (In addition to the required data, all thermal instrumentation as specified in 110.3.1 shall be read and recorded at the same time for the stabilization portion of this test).
5. Test Method 78, Long Term Frequency and Voltage Stability Test. (In addition to the required data, all thermal instrumentation as specified in 110.3.1 shall be read and recorded at the same time for all portions of this test).

NOTE: The above methods are listed in numerical order; however, they need not be performed in this order.

h. Repeat steps f and g above for each additional specified voltage connection and frequency.

i. Perform the following test for gasoline, diesel and gas turbine engine-driven generator sets:

NOTE: For this test, the temperature of the fuel at the fuel source shall be stabilized at or above the temperature of the temperature chamber.

1. Operate the set at rated load until the fuel and lubricating oil temperatures are stabilized. Stabilization will be considered to have occurred when three consecutive fuel and lubrication oil temperature readings, taken at minimum intervals of 10 minutes, remain unchanged.

2. Immediately after the third stable temperature reading, shut the set down for five minutes.

3. Restart the engine and operate the set at no load. During the restart, check for evidence of excessive heat transfer to the fuel system as evidenced by vapor lock, difficult starting, or uneven running. Operate the set at no load for sufficient time to obtain steady operation. Note on the data sheet any difficulty in starting or uneven running.

110.4 Results. Results shall be as specified in methods listed in 110.3.2(f) and 110.3.2(g) and in the individual methods specified in 110.3.2(b). For the test performed in 110.3.2(i), the data sheet shall show as a minimum, whether or not the set started and operated normally and reasons for any difficult starting or uneven running. For the test performed in 110.3.2(c) the data sheet shall show the temperature rise of each winding as specified in Test Method 10. Compare these results with the requirements of the contract.

110.5 Contract requirements. The following details must be specified in the contract:

a. Ambient temperature at which this method is to be performed.

b. Temperature rise allowed for each class of insulation, giving the method of measurement.

c. Coils, components or assemblies for which the temperatures rise is to be determined.

d. Voltage connection(s) and frequency(ies) at which temperature rise is to be determined.

e. Methods to be performed in addition to or other than those listed in Methods 10.2 f and 10.2(g).

f. Contract requirements as specified in 10.2(f) and 10.2(g).

g. Starting and operating requirements for the test performed in 10.2(i).