APPENDIX A

LOAD BANKS

1 GENERAL

1.1 Scope. This appendix contains no mandatory requirements. It only provides general information and additional sources of information about load banks, mainly of the types used for evaluation and testing of electrical generator sets.

2. SOURCES OF ADDITIONAL INFORMATION

2.1 Government publications. The following documents contain information on some representative types of single-function (resistive and dual-function (combination resistive and reactive) load banks and their uses:

SPECIFICATIONS

MILITARY

MIL-T-4709	- Load Bank, Type A-1.
MIL-T-26922	- Test Set, Electrical Power A/M24T-8().
MIL-L-52366	- Load Bank, AC, 0-33kW Resistive.
MIL-D-82134	- Dummy Loads, Electrical 60/100 kW, 55/90
	- KVAR, 3 Phase, 60/400 Hertz, AC.

(Copies may be requested from Naval Publications and Forma Center, 5801 Tabor Avenue, Philadelphia, PA 19120).

2.2 Other publications.

Avtron Model T508E746 Load Bank Installation and Operation Instructions.

(Copies may be requested from Avtron Manufacturing, Inc., 10409 Meech Avenue, Cleveland, OH 44105) (FSCM 01014).

Manufacturers' data on load banks may also be requested from (but is not limited to) the following:

Essex Electra Engineers, Inc. - Bensenville, IL (FSCM 21269).
Sun Electric Corporation - Chicago, IL (FSCM 82386).
Technical Services Laboratory, Inc. - Ft. Walton Beach, FL (FSCM 51283).
UMC\ Electronics Co. - North Haven, CN (FSCM 22680).

3 DEFINITIONS

3.1 Industry recognized definitions. The following commonly accepted definitions should be helpful in understanding various terms applied or related to load banks, and to contrast load banks to similar types of equipment. Although there have been many exceptions, present general practice is to distinguish between the terms "dummy load" and "load bank" by considering "dummy loads" to be for radio frequency and microwave requirements, and "load banks" to be for AC power frequency and DC requirements.

3.1.1 Artificial load. A dissipative but essentially nonradiating device having the impedance characteristics of an antenna transmission line, or other practical utilization circuit.

3.1.2 Dummy load, electrical. A specific electrical element or set of electrical elements that are connected together to form a fixed arrangement and used as a substitute load for terminating an electrical circuit. A dummy load contains all the essential electrical characteristics necessary to terminate the circuit but does not function in the same manner as the load which it replaces. Examples are resistors used to replace antennas, batteries, loudspeakers, or the like. Includes single port termination's or twin lead, coaxial and waveguide transmission lines as low power termination's of a section of a transmission system in a specified manner. Includes conversational terminology for non catalog items. Includes dummy loads when arranged in a group or bank. Excludes power absorbers. See also "Load bank, electrical".

3.1.3 Dummy load (radio transmission). A dissipative but essentially non radiating substitute device having impedance characteristics simulating those of the substituted device. See also: "Artificial Load; radio transmission"

3.1.4 Dummy load group, electrical. A collection of items, that provide electrical dummy load facilities.

3.1.5 Load, dummy (artificial load). See "Dummy load."

3.1.6 Load bank, electrical. A set (bank) of electrical elements that are passive (resistive, inductive, capacitive) or active (motors, batteries). They are usually located adjacent to each other to form a consolidated set of any of these elements or any combination of them. A load bank is used to replace distributed or dispersed load elements contained in a power distribution system or electrical network for the purpose of providing a concentrated load. A load bank contains all the essential electrical characteristics necessary to terminate the circuit and functions in the same manner as the load which it is intended to replace. This description necessarily includes a bank of light bulbs or cone heating elements where energy conversion is primarily in the form of heat, although visible radiant energy is the natural result of incandescent heating. Load banks are intended to cover a specific range of characteristics and normally operate at DC or at power frequencies 50, 60, or 400 Hz AC. Load banks may be uninstrumented or complete with integral instrumentation and may also be furnished as skid or trailer mounted. Excludes "Test set, electrical" *. See also "Dummy load, electrical".

3.1.7 Simulator (1) (test, measurement and diagnostic equipment). A device or program used for test purposes which simulates a desired system or condition providing proper inputs and termination's for the equipment under test.

3.1.8 Support equipment. Support equipment is construed to include ground operation, handling, and servicing equipment. Support equipment is further defined as all equipment required in [on] the ground to make a weapon system operational in its intended environment. This includes all equipment required to install, launch, arrest (except Navy shipboard and shore based launching and arresting equipment), guide, control, direct, inspect, test, adjust, calibrate, appraise, gage, measure, assemble, disassemble, handle, transport, safeguard, store, actuate, service, repair, overhaul, maintain or operate the system, subsystem, or end item.

3.1.9 Support equipment (test, measurement and diagnostic equipment). Equipment required to make an item, system or facility operational in its environment. This includes all equipment required to maintain and operate the item, system or facility and the computer programs related thereto.

3.1.10 Test, measurement and diagnostic equipment (TMDE). Any system or device used to evaluate the operational condition of a system or equipment to identify and [or] isolate or both any actual or potential malfunction.

3.1.11 Test sets electrical power. A test set primarily designed for use in making examinations of electrical power generating or converting equipment's and/or transmission systems.

3.2 Other terms and synonyms for load banks. Including most of the terms defined above, load banks have been cataloged under or as the following:

Artificial load	Load, test
Dummy load, electrical	Load test machine, generator
Dummy load group, electrical	Load test set
Dummy load (radio transmission)	Load, variable
Load assembly, simulated	Load bank
Load bank, electrical	Test set, electrical
Load, dummy (artificial load)	Test set, electrical (load bank)
Load set	Test set, electrical power
Load simulator	Test set, electrical power (load bank)

4 GENERAL CHARACTERISTICS

4.1 Types of load banks associated with electrical power generators. Load banks can be appropriately categorized as "Support Equipment" and may be classified according to their principle(s) of operation as resistive, reactive or combination resistive and reactive.

Resistive type load banks directly convert all of the electrical energy applied to them to heat.

Reactive types operate on the principle of either capacitance or inductance. (Reactive capacitance types of load banks create leading power factor conditions, and are not commonly used for.test purposes.) Reactive inductance types, also referred to as "impedance types", are commonly used when lagging power factor conditions are required. Some of the electrical energy applies to reactive inductance load banks is converted to heat, but much of it is temporarily stored as magnetic energy, which can be reconverted to electrical energy and returned to the supply system.

Load banks vary from inexpensive, 2 cubic feet, under 100 pounds versions to high-value, 250 cubic feet, major equipment items weighing over 2000 pounds.

4.2 Uses of load banks. Load banks may be further classified according to their use or application as follows:

4.2.1 Parasitic load banks. Diesel engines with governors are used to drive some electrical generators and are selected according to the horsepower requirements and maximum thermal efficiency for generating at maximum electrical loads. Under conditions of less than maximum electrical loads, the governed engine's fuel burning efficiency declines and maintenance problems may occur due to lower engine temperatures, incomplete burning of fuel, and resulting carbon and sludge deposits. Parasitic load banks are used with diesel engine-driven generator sets to minimize these problems. These load banks are usually of the resistive type and are called "parasitic" because they are constantly connected to the output power circuit and are activated when actual power use requirements drop below pre-determined levels. Parasitic load banks may be either attached components of an electrical power generator set, or ancillary issued items which usually remain constantly with a particular generator set or group of sets. Parasitic loads may also be used during maintenance and service checks to verify generator set conditions under various load conditions.

4.2.3 Mobile load banks. These load banks may be resistive, reactive or combination resistive and reactive. Mobile load banks are mounted on wheeled, trainable carriages and are used for service and maintenance checks, inspection and testing. They may also be used as parasitic loads.

4.2.4 Portable and semi-portable load banks. Portable and semi-portable load banks may be resistive, reactive or combination resistive and reactive.. Portable and semi-portable load banks may be transported by man, vehicle, aircraft, railway car or marine vessel, depending on the size and weight of the load banks. They may also be used for the same purposes as parasitic and mobile load banks.

5. DETAIL CHARACTERISTICS

5 1 Load banks used for evaluation and testing. Description, functional characteristics and quality assurance provisions extracted from a purchase description for a typical load bank used for generator set evaluation and testing are listed below. This information is intended to be an example and should be used only for guidance. Because generator set test conditions of "0.8 power factor, lagging" are required in many of the procedures, load banks used in conjunction with those particular parts of EGSA 107T must provide reactive inductance loads. The capacity

or load range of load banks must equal or be greater than the rated power output of the generator being evaluated or tested; therefore it is often necessary to connect load bank sections in series, parallel, or series-parallel to attain required loads. In three-phase circuits, balanced loading is provided by connecting equal load sections across the three generator line output terminals.

5.2 Description and functional characteristics for a typical load bank.

5.2.1 Description. The load bank shall provide a 0 - l00 kW resistive load and a 0 - 100% KVAR reactive load for each of the six conditions resulting from the connections of 120/208 volts or 240t416 volts at 50, 60, or 400 Hertz. A stepped selection of any balanced three phase load from 0 - 100% kW and 0 - 100% KVAR shall be provided in addition to provisions for 100 percent unbalanced load on any phase. Additional infinite variation shall also be provided for the ranges between each of the steps. The load bank shall operate continuously without damage.

5.2.1.1 Load steps. The load bank steps shall be such that any load between 0 and 100% of the load bank rating can be obtained. An example of the steps of one phase of a typical load bank is as follows:

Step No.	kW or KVAR (per phase).
1	0-3 1/3 (variable)
2	3
3	6
4	9
5	12
6	15
7	18
8	21
9	24
10	27
11	30
12	33
13	36

5.2.2 Operating environment temperatures, and humidity. When equipped with all accessories and at specified loads within its rating, the load bank shall perform all its required functions at ambient temperatures of -54 °C and +52 °C at specified relative humidities.

5.2.3 Resistive elements. The resistive elements shall be fabricated from a corrosion-resistant, low resistance-temperature coefficient alloy wire having a change of cold to hot resistance as specified in the procurement document. The resistors shall be insulated from ground (1800 volts) and shall have a power factor greater than 0.995 at 400 Hertz. When individual coils are

stretched to their installed length, there shall be at least three wire diameters clearance between adjacent coil turns.

5.2.4 Reactive elements. The reactors shall be of iron core construction with clearances which limit the flux density in the iron to at least fifty percent below the saturation point. Wave form distortion shall be less than one 'half of one percent. Power factor of the reactors shall be less than 0.05 at 400 Hertz. Reactor coils shall be tapped for use at 60 and 400 Hertz.

5.2.4.1 Temperature rises. Allowable temperature rise of windings shall not exceed the following:

	Type of Insulation per MIL-E-917		
Method	Class A	Class B	Class F
By thermometer	65 °C	75 °C	85 °C
By rise in resistance	75 ➡C	95 °C	105 °C

5.2.5 Load tolerances. When rated voltages at 60 or 400 Hertz are applied, in each of the cases the resistive load shall be within two percent and the reactive load shall be within five percent of the control switch settings. Corresponding loads in each of the individual phases shall be balanced within three percent of each other (based on current).

5.2.6 Dielectric strength and insulation resistance. Reactive and resistive load elements shall withstand 1800 volts at a frequency of 60 Hertz applied between the member and ground for one minute. All other circuits shall withstand 1000 volts at 60 Hertz applied between the circuit and ground for one minute. The insulation resistance shall not be less than one megohm.

5.3 Quality assurance of reactive modes of a typical load bank for use in evaluation or acceptance testing of generator sets. Accuracy and consistency of the load bank described in 50.2 above may be determined using the following equipment and methods. This equipment and these methods may also be used for assurance of similar reactive types or modes of load banks. Strict adherence to the applicable technical manual or load bank manufacturer's operating instructions should assure consistent test results.

5.3.1 Test instruments. Test instruments for measurement of load bank performance shall be accurate within plus or minus 0.0075 times the applicable U.S. National Bureau of Standards (NBS) reference or "master". Certification of this accuracy must be traceable to NBS. Evidence of calibration within 180 days or less prior to the completion date of the load bank testing, for which the instrument is to be (or was) used, shall be available for examination by the Government's inspection representative. Recalibration may be required for reasonable cause at any time by the customer’s inspection representative. If immediately following a test, an instrument is determined to be "out of calibration", or to be not calibrated, the customer’s inspection representative may require repetition of the test or portions thereof.

5.3.2 Tests. Each load bank shall be subjected to the following tests:

a. Insulation resistance and ability to withstand high voltage.

b. Reactor saturation.

c. Load balance.

d. Load control switch step markings.

e. Harmonic content.

f. Full load run.

5.3.2.1 Insulation resistance and ability to withstand high voltage. Typically, ANSI or IEEE insulation "hi-pot" tests are employed, unless another procedure is specified in the contract.

5.3.2.2 Reactor saturation. One of each size reactor used in the load bank shall be subjected to the following saturation test at 60 and 400 Hertz: Apply voltage to the reactor in steps of 20 volts from 0 - 160 volts. Record voltage applied and current drawn by the reactor. Plot voltage versus current. Any evidence of saturation (departure from a straight line voltage - current relationship) that is not within the specified limits shall constitute failure of this test.

5.3.2.3 Load balance. With the load bank connected for 120/208 volts, 60 Hertz, check the current balance for each load step of each reactive element. Vernier load is to be set at maximum value for each step. At each load step, determine by use of the vernier load if an overlap exists on the preceding load (line currents must be balanced). When this test is complete, reconnect the load bank for 240/416 volts, 60 Hertz and repeat the teat. Repeat the test for both voltage connections using a 400 Hertz source. Under any of the load conditions, a difference in current between any two phases exceeding three percent of the lowest phase current, shall constitute failure of this test. Non-overlapping of load steps shall constitute failure of this test. This test may be conducted in conjunction with the test specified in 5.3.2.4.

5.3.2.4 Load control switch step markings. With the load bank connected for 120/208 volts, 60 Hertz, check the control panel resistive control switch markings for each step against the actual KVAR load. The vernier step shall be checked at 0, 1, 2, and 3 KVAR points. When this test is complete, reconnect the load bank for 240/415 volts, 60 Hertz, and repeat the test. Repeat the test for both voltage connections, using a 400 Hertz source. Under any of the load conditions, a difference of five percent between the control switch markings and the actual load shall constitute failure of this test. This test may be conducted in conjunction with the tests specified in paragraph 5.3.2.3.

5.3.2.5 Harmonic content. With all reactive load elements energized at 120 volts, 60 Hertz, determine for each harmonic (let through 15th) its percent with respect to the fundamental frequency. Repeat the test with all the reactive load elements energized at 120 volts, 400 Hertz. Any harmonic exceeding two percent of the fundamental shall constitute failure of this test. If this

test has previously been performed on reactors of identical design, the contractor may generally submit certified test data to the contracting authority, and upon approval, be relieved of running this test.

5.3.2.6 Full load run. The complete load bank (all circuits operative) shall be connected for 120/208 volts, 60 Hertz and operated at rated capacity* continuously for twelve hours. Any failure or damage or evidence of impending failure or damage during or after the twelve hour run shall constitute failure of this test. Prior to the start of this twelve hour run, select one reactive load element on which the temperature rise shall be determined. Failure to meet the limits specified in paragraph 5.2.4.1 shall constitute failure of this test.

(* Rated capacity is that load which is produced with all load circuits energized at their maximum values and at nominal voltage.)

6. NOTES

6.1 Procurement documents must specify the following:

a. Cold to hot resistance limits - para 5.2.3.

b. Leakage current limits - para 5.3.2.1.

c. Saturation limits - para 5.3.2.2.

6.2 Air cooled load banks potentially subject to coil over-heating and damage from thermal shock. Cooling fan systems in air cooled load banks may be powered from the generator set through the load banks internal circuitry, or externally from local utility line power. After using a load bank for a sustained period of time, it is usually advisable to gradually reduce the load settings and run the fans long enough afterwards to assure gradual and sufficient "cool-down" of heat-sensitive components within the load bank.

6.3 Operator's manuals. Typically, the applicable load bank manufacturer's manual or instructions should be used.
If US Government contracts are involved, U.S. Army Technical Manuals (TM's), Air Force Technical Orders (AFTO's), Navy and Marine Corps manuals exist for many types of load banks. When the National Stock Number (NSN) of a Specific load bank is known, determination of a specific or related manual can be made by consulting MIL-HDBK-300 or Department of the Army Pamphlet DA PAM 310-4

(Copies of MIL-HDBK-300 may be requested from the Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120. Non-government requests for information from DA PAM 310-4 may be made to the applicable Government representative.)

APPENDIX B

Cross Referance
MIL STD 705 Method Number to EGSA 107T Test Method Number

This conversion table is provided as a cross referance aid to assist those accustomed to using the Methods of MIL STD 705 in converting to the Test Methods of EGSA 107T.

MIL STD 705 Method No.	Method Title	EGSA 107T Test Method No.
101.1	Measurement of Potential	1
102.1	Measurement of Current	2
103.1	Measurement of Power	3
104.1	Measurement of Frequency	4
105.1	Measurement of Resistance	5
106.1	Measurements of Transients and Waveforms	6
107.1	Measurement of Power Factor	7
108.1	Measurement of Time	8
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