Chapter 8 Routine Maintenance and Operational Testing

8.1* General.

8.1.1 The routine maintenance and operational testing program shall be based on all of the following:

(1) Manufacturer's recommendations

(2) Instruction manuals

(3) Minimum requirements of this chapter

(4) The authority having jurisdiction

8.1.2 Consideration shall be given to temporarily providing a portable or alternate source whenever the emergency generator is out of service.

8.2* Manuals, Special Tools, and Spare Parts.

8.2.1 At least two sets of instruction manuals for all major components of the EPSS shall be supplied by the manufacturer(s) of the EPSS and shall contain the following:

(1) A detailed explanation of the operation of the system

(2) Instructions for routine maintenance

(3) Detailed instructions for repair of the EPS and other major components of the EPSS

(4) An illustrated parts list and part numbers

(5) Illustrated and schematic drawings of electrical wiring systems, including operating and safety devices, control panels, instrumentation, and annunciators

8.2.2 For Level 1 systems, instruction manuals shall be kept in a secure, convenient location, one set near the equipment, and the other set in a separate location.

8.2.3 Special tools and testing devices necessary for routine maintenance shall be available for use when needed.

8.2.4 Replacement for parts identified by experience as high mortality items shall be maintained in a secure location(s) on the premises.

8.2.4.1 Consideration shall be given to stocking spare parts as recommended by the manufacturer.

8.3 Maintenance and Operational Testing.

8.3.1* The EPSS shall be maintained to ensure to a reasonable degree that the system is capable of supplying service within the time specified for the type and for the time duration

specified for the class.

8.3.2 A routine maintenance and operational testing program shall be initiated immediately after the EPSS has passed acceptance tests or after completion of repairs that impact the operational reliability of the system.

8.3.2.1 The operational test shall be initiated at an automatic transfer switch and shall include testing of each EPSS component on which maintenance or repair has been performed, including the transfer of each automatic and manual transfer switch to the alternate power source, for a period of not less than 30 minutes under operating temperature.

8.3.3 A written schedule for routine maintenance and operational testing of the EPSS shall be established.

8.3.4 A permanent record of the EPSS inspections, tests, exercising, operation, and repairs shall be maintained and readily available.

8.3.4.1 The permanent record shall include the following:

(1) The date of the maintenance report

(2) Identification of the servicing personnel

(3) Notation of any unsatisfactory condition and the corrective action taken, including parts replaced

(4) Testing of any repair for the time as recommended by the manufacturer

8.3.5* Transfer switches shall be subjected to a maintenance and testing program that includes all of the following operations:

(1) Checking of connections

(2) Inspection or testing for evidence of overheating and excessive contact erosion

(3) Removal of dust and dirt

(4) Replacement of contacts when required

8.3.6 Paralleling gear shall be subject to inspection, testing, and maintenance program that includes all of the following operations:

(1) Checking of connections

(2) Inspection or testing for evidence of overheating and excessive contact erosion

(3) Removal of dust and dirt

(4) Replacement of contacts when required

8.3.7* Storage batteries, including electrolyte levels or battery voltage, used in connection with systems shall be inspected weekly and maintained in full compliance with manufacturer's

specifications.

8.3.7.1 Maintenance of lead-acid batteries shall include the monthly testing and recording of electrolyte specific gravity. Battery conductance testing shall be permitted in lieu of the testing of specific gravity when applicable or warranted.

8.3.7.2 Defective batteries shall be replaced immediately upon discovery of defects.

8.3.8 A fuel quality test shall be performed at least annually using tests approved by ASTM standards.

8.4 Operational Inspection and Testing.

8.4.1* EPSSs, including all appurtenant components, shall be inspected weekly and exercised under load at least monthly.

8.4.1.1 If the generator set is used for standby power or for peak load shaving, such use shall be recorded and shall be permitted to be substituted for scheduled operations and testing of the generator set, providing the same record as required by 8.3.4.

8.4.2* Diesel generator sets in service shall be exercised at least once monthly, for a minimum of 30 minutes, using one of the following methods:

(1) Loading that maintains the minimum exhaust gas temperatures as recommended by the manufacturer.

(2) Under operating temperature conditions and at not less than 30 percent of the EPS nameplate kW rating.

(3) If the engine cannot be loaded as required in (2), the engine shall be operated until the water temperature and the oil pressure have stabilized and then the test shall be terminated before the 30 minute time period expires.

8.4.2.1 The date and time of day for required testing shall be decided by the owner, based on facility operations.

8.4.2.2 Equivalent loads used for testing shall be automatically replaced with the emergency loads in case of failure of the primary source.

8.4.2.3* Diesel-powered EPS installations that do not meet the requirements of 8.4.2 shall be exercised monthly with the available EPSS load and exercised annually with supplemental loads at 25 percent of nameplate rating for 30 minutes, followed by 50 percent of nameplate rating for 30 minutes, followed by 75 percent of nameplate rating for 60 minutes, for a total of 2 continuous hours.

8.4.2.4 Spark-ignited generator sets in service shall be exercised at least once monthly, for a minimum of 30 minutes, using one of the following methods:

(1) Loading that maintains the minimum exhaust gas temperatures as recommended by the

manufacturer

(2) Under operating temperature conditions and at not less than 30 percent of the EPS nameplate kW rating

8.4.2.4.1 The date and time of day for required testing shall be decided by the owner, based on facility operations.

8.4.2.4.2 Equivalent loads used for testing shall be automatically replaced with the emergency loads in case of failure of the primary source.

8.4.3 The EPS test can be initiated by simulating a power outage using the test switch(es) on the ATSs or by opening a normal breaker. Opening a normal breaker shall not be required.

8.4.4 Load tests of generator sets shall include complete cold starts.

8.4.5 Time delays shall be set as follows:

(1) Time delay on start:

(a) 1 second minimum

(b) 0.5 second minimum for gas turbine units

(2) Time delay on transfer to emergency: no minimum required

(3) Time delay on restoration to normal: 5 minutes minimum

(4) Time delay on shutdown: 5 minutes minimum

8.4.6 Transfer switches shall be operated monthly.

8.4.6.1 The monthly test of a transfer switch shall consist of electrically operating the transfer switch from the standard position to the alternate position and then a return to the standard position.

8.4.7* EPSS circuit breakers for Level 1 system usage, including main and feed breakers between the EPS and the transfer switch load terminals, shall be exercised annually with the EPS in the “off” position.

8.4.7.1 Circuit breakers rated in excess of 600 volts for Level 1 system usage shall be exercised every 6 months and shall be tested under simulated overload conditions every 2 years.

8.4.8 The routine maintenance and operational testing program shall be overseen by a properly instructed individual.

8.4.9* Level 1 EPSS shall be tested for the duration of its assigned class *(see Section 4.2)*, for at least 4 hours, at least once within every 36 months.

8.4.9.1 The load shall be the EPSS system load running at the time of the test. The test shall be initiated by opening all switches or breakers supplying normal power to the EPSS.

8.4.9.2 A power interruption to non-EPSS loads shall not be required.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.4 See NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*.

A.1.1.5(3) See Chapter 4.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.1 Battery Certification. One such certifier of batteries is the American Association of Battery Manufacturers.

A.3.3.4 Emergency Power Supply (EPS). For rotary energy converters, components of an EPS include the following:

(1) Prime mover

(2) Cooling system

(3) Generator

(4) Excitation system

(5) Starting system

(6) Control system

(7) Fuel system

(8) Lube system, if required

The EPS includes all the related electrical and mechanical components of the proper size and/or capacity required for the generation of the required electrical power at the EPS output terminals.

A.3.3.5 Emergency Power Supply System (EPSS). See Annex B for diagrams of typical systems.

A.4.1 This standard specifies requirements for the EPSS as a complete functioning system in terms of types, classes, and levels. It is not the intent of this standard to recommend the EPSS most suitable for any given application. The terms *emergency power supply systems* and *standby power supply systems* as used in this standard include, but are not limited to, such terms as the following:

(1) Alternate power systems

(2) Standby power systems

(3) Legally required standby systems

(4) Alternate power sources

Since this standard specifies the installation, performance, maintenance, and test requirements in terms of types, classes, and levels, any of these terms might be appropriate for describing the application or use, depending on the need and the preference of the parties involved.

A.4.2 Selection of the class of the EPSS should take into account past outage records and fuel delivery problems due to weather, shortages, and other geographic and environmental conditions. Class “X” is a calculated value that usually represents between 48 and 96 hours of fuel for a Level 1 facility.

A.4.4 It is recognized that EPSSs are utilized in many different locations and for many different purposes. The requirement for one application might not be appropriate for other applications.

A.4.4.1 Typically, Level 1 systems are intended to automatically supply illumination or power,

or both, to critical areas and equipment in the event of failure of the primary supply or in the event of danger to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life.

Level 1 systems usually supply emergency power for assembly occupancies greater than 1000 persons or in buildings above 23 m (75 ft) in height with any of the following occupancy classes: assembly, educational, detention, correctional, business, residential, and mercantile. Another occupancy typically served by Level 1 systems is health care where the combined load of the critical branch, life safety branch, and equipment system is greater than 150 kVA.

Essential electrical systems can provide power for the following essential functions:

(1) Life safety illumination

(2) Fire detection and alarm systems

(3) Elevators

(4) Fire pumps

(5) Public safety communications systems

(6) Industrial processes where current interruption would produce serious life safety or health hazards

(7) Essential ventilating and smoke removal systems

A.4.4.2 Typically, Level 2 systems are intended to supply power automatically to selected loads (other than those classed as emergency systems) in the event of failure of the primary source.

Level 2 systems typically are installed to serve loads, such as the following, that, when stopped due to any interruption of the primary electrical supply, could create hazards or hamper rescue or fire-fighting operations:

(1) Heating and refrigeration systems

(2) Communications systems

(3) Ventilation and smoke removal systems

(4) Sewage disposal

(5) Lighting

(6) Industrial processes

A.4.4.4 It is important to recognize that an EPSS might react substantially different from commercial power during transient and short circuit conditions due to the relatively small capacities of the EPSS compared to the primary commercial power source. *(See ANSI C84.1, Standard for Electric Power Systems and Equipment Voltage Ratings.)*

A.5.1.1 Examples of probability of interruption could include the following: earthquake, flood damage, or a demonstrated utility unreliability.

A.5.1.1(1) See A.5.5.3 for shelf-life precautions for fuel supplies.

A.5.1.4 On-site energy conversion is not restricted to rotating-type generating systems. Other types of continuous energy conversion systems can be used, including fuel-cell systems.

A.5.2.2 The following devices are typical of energy converters and energy sources that should be reviewed carefully as part of Level 1 EPSs:

(1) Motor-generator/engine

(2) Motor-generator/flywheel

(3) Steam turbine

Connection to the primary power source ahead of the primary source main service disconnect and a separate service should be excluded as a sole source of EPS.

A.5.4 It is recognized that in some installations part or all of the output of the EPS might be used for peak shaving or part of the output might be used for driving nonessential loads during loss of the primary power source. Load-shedding of these loads when the output of the energy converter is needed is one way of meeting the requirements of Section 5.4. The load should be reviewed to ascertain that load growth has not exceeded EPS capability.

A.5.5.2 The low-fuel alarm point for liquid-fueled engines is defined as the point when the main fuel tank contains insufficient fuel to meet the required full load operating hours and is the point at which this condition is signaled.

A.5.5.3 Consideration should be given to sizing tanks in order to meet minimum fuel supplier delivery requirements, particularly for small tanks. Consideration also should be given to oversizing tanks, because many fuels have a shelf life and deteriorate with age. Where large tanks are required, it is recommended that fuels be periodically pumped out and used in other services and replaced with fresh fuel. Prudent disaster management could require much larger on-site temporary or permanent fuel storage.

A.5.6.4.2 See Figure A.5.6.4.2 for a diagram of cranking cycles.

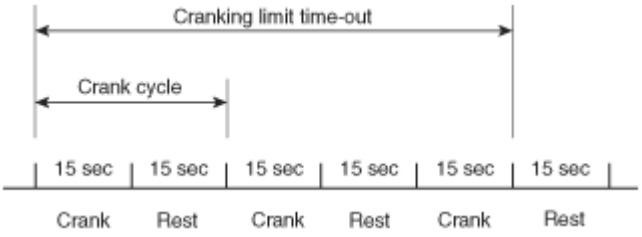

FIGURE A.5.6.4.2 Diagram of Cranking Cycles.

A.5.6.4.3 A battery unit is one or more batteries or a group of cells, a series, or a parallel series

connected to provide the required battery unit voltage and capacity.

A.5.6.4.4 Cold-cranking amperes, or cranking performance, are the number of amperes a fully charged battery at -17.8°C (0°F) can continuously deliver for 30 seconds while maintaining 1.2 V per cell.

A.5.6.4.5.1 It is recommended that lead-acid starting batteries be replaced every 24 to 30 months.

A.5.6.4.6 It is intended that the battery charger be factory-built, adjusted, and approved for the specific type, construction, and capacity of the battery. For lead-acid batteries, the battery charger should be tested for the specific gravity, type, and concentration of grid alloys, such as high or low gravity, high or low antimony, calcium, or none.

A.5.6.5.6 For systems located outdoors, the manual shutdown should be located external to the weatherproof enclosure and should be appropriately identified.

A.5.6.9.1 See ANSI/NEMA MG1, *Standard for Motors and Generators*, and ANSI/NEMA MG2, *Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators*.

A.5.6.10.3 Where unusual vibration conditions are anticipated, adequate isolation treatment should be supplied.

A.6.1.1 Electrical switching is electrical equipment or devices used to do any or all of the following:

(1) Transfer connected electrical loads from one power source to another

(2) Perform load-switching functions

(3) Bypass, isolate, and test the transfer switch

A.6.1.2 Electrical protection equipment is sensing and overcurrent protective devices used to protect against damage due to fault or overload to conductors and equipment connected to the output of the emergency energy source, up to and including the load terminals of the transfer switch(es).

A.6.1.6 See Section 700.6 of NFPA 70, *National Electrical Code*, and 10.8.2 of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, for listing and installation requirements for transfer switches used with fire pumps.

A.6.2.1 For most applications in this standard, the automatic transfer switch is used to transfer a load from a primary source of supply to an engine generator set.

An automatic transfer switch might include circuit breakers, contactors, switches, or vacuum and solid-state power devices operating in conjunction with automatic-sensing and logic devices to perform the defined function.

A.6.2.2.1 Where special loads require more rapid detection of power loss, underfrequency

monitoring also might be provided. Upon frequency decay below the lower limit necessary for proper operation of the loads, the transfer switch should automatically initiate transfer to the alternate source. *(See A.6.2.15.)*

A.6.2.2.1(2) See 6.2.5 and 6.2.7.

A.6.2.4 Authorized personnel should be available and familiar with manual operation of the transfer switch and should be capable of determining the adequacy of the alternate source of power prior to manual transfer.

A.6.2.5 For most applications, a nominal delay of 1 second is adequate. The time delay should be short enough so that the generator can start and be on the line within the time specified for the type classification.

A.6.2.8 It is recommended that the timer for delay on retransfer to the primary source be set for 30 minutes. The 30-minute recommendation is to establish a "normalized" engine temperature, when it is beneficial for the engine. NFPA 70, *National Electrical Code*, establishes a minimum time requirement of 15 minutes.

A.6.2.13 For maintenance purposes, consideration should be given to a transfer switch counter.

A.6.2.15 Automatic transfer switches (ATSs) can be provided with accessory controls that provide a signal to operate remote motor controls that disconnect motors prior to transfer and to reconnect them after transfer when the residual voltage has been substantially reduced. Another method is to provide in-phase monitors within the ATS in order to prevent retransfer to the primary source until both sources are nearly synchronized. A third method is to use a programmed neutral position transfer switch. See Section 230.95 of NFPA 70, *National Electrical Code*.

A.6.2.16 Standards for nonautomatic transfer switches are similar to those for automatic transfer switches, as defined in 3.3.9.1 and 3.3.9.3, with the omission of automatic controls.

A.6.4.3 See Section 700.3 of NFPA 70, *National Electrical Code*.

A.6.4.4 Consideration should be given to the effect that load interruption could have on the load during maintenance and service of the transfer switch.

A.6.5.1 It is important that the various overcurrent devices be coordinated, as far as practicable, to isolate faulted circuits and to protect against cascading operation on short circuit faults. In many systems, however, full coordination is not practicable without using equipment that could be prohibitively costly or undesirable for other reasons. Primary consideration also should be given to prevent overloading of equipment by limiting the possibilities of large current inrushes due to instantaneous reestablishment of connections to heavy loads.

A.6.5.3 See 9.6.5 of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

A.7.1.1 The performance of the EPS and the EPSS is dependent on many factors, one of which is correct initial installation, primarily as the installation relates to the location and

environmental conditions. Although this standard is not intended to serve as a design standard for EPSS installation and environmental considerations, certain minimum standards are recognized as essential for successful start-up and performance, safe operation, and utilization of the EPSS where required.

A.7.1.2 The environmental conditions to be considered in the EPSS design should include, but not be limited to, heating, ventilating, and air-conditioning systems; protection from floods, fire, vandalism, wind, earthquakes, lightning, and other similar or applicable environmental conditions common to geographic locations; and other factors affecting the location of the EPSS equipment.

The probability and frequency of power failures that do or can occur as a result of lightning, wind, and rain produced by thunderstorms, hurricanes, tornadoes, and similar weather conditions associated with the user's geographic location should be considered.

A.7.2.2 The intent of this requirement is to provide maximum fire protection to the most critical, high energy systems. Consideration should be given to the potential fire hazard when locating Level 2 EPSS equipment in the normal electrical service room, or to Level 1 systems below 1000 amperes and 150 volts to ground.

A.7.2.3 EPSS equipment should be located above known previous flooding elevations where possible.

A.7.2.4 When installing the EPSS equipment and related auxiliaries, environmental considerations should be given, particularly with regard to the installation of the fuel tanks and exhaust lines, or the EPS building, or both.

To protect against disruption of power in the facility, it is recommended that the transfer switch be located as close to the load as possible. The following are examples of external influences:

(1) Natural conditions

- (a) Storms
- (b) Floods
- (c) Earthquakes
- (d) Tornadoes
- (e) Hurricanes
- (f) Lightning
- (g) Ice storms
- (h) Wind
- (i) Fire

(2) Human-caused conditions

(a) Vandalism

(b) Sabotage

(c) Other similar occurrences

(3) Material and equipment failures

For natural conditions, EPSS design should consider the “100-year storm” flooding level or the flooding level predicted by the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) models for a Class 4 hurricane.

A.7.3.3 Where units housed outdoors are used, it is recommended that a flashlight or battery-powered light with a flexible cord be maintained in the housing.

A.7.5 Generally, integral rubber vibration isolators are used on the rotating energy converters, and spring-type or pad-type isolators are used on the larger energy converter units. In some cases, high deflection spring-type isolators should be used where a high degree of vibration attenuation is required. The EPS manufacturer should be consulted during consideration of the specific type of vibration control. Inertia bases should be considered where unusual vibration conditions are anticipated.

A.7.6 Generally, exhaust noises can be attenuated by using the proper mufflers. The mufflers used should be in accordance with the EPS manufacturer's recommendations. Depending on the degree of silencing required, the muffler should be rated accordingly for “commercial,” “semicritical,” and “critical” (high degree of silencing) service. To attenuate other noises, line-of-sight barriers having acoustical treatment or total acoustical enclosures can be used. The EPS should be installed away from critical areas.

A.7.7.1 During operation, EPS and related equipment reject considerable heat that needs to be removed by proper ventilation or air-cooling. In some cases, outdoor installations rely on natural air circulation, but enclosed installations need properly sized, properly positioned ventilation facilities, to prevent recirculation of cooling air. The optimum position of air-supply louvers and radiator air discharge is on opposite walls, both to the outdoors.

A.7.8.2 It should be recognized that the reliability of municipal water-cooling is strictly dependent upon the reliability of the water utility. It should also be recognized that, during such natural disasters as earthquakes and floods, the water supply can be interrupted simultaneously with the primary electric power supply. Methods of cooling the energy converter(s) consist of radiator cooling, either unit-mounted or remote, utility-furnished (city) water-cooling, heat exchangers, and air-cooling.

A.7.9.1.2 Commercial distillate fuel oils used in modern diesel engines are subject to various detrimental effects. The origin of the crude oil, refinement processing techniques, time of year, and geographical consumption location all aid in the determination of fuel blend formulas. Sulfur, naturally occurring gums, waxes, soluble metallic soaps, water, dirt, and temperature all begin to degrade fuel as it is handled and stored. These effects begin at the time of fuel

refinement and continue until consumption.

Proper fuel storage is critical to engine start-up, efficiency, and longevity. Storage tanks should be kept water-free and have provisions for drainage on a scheduled basis. Water can contribute to steel tank corrosion and the potential development of microbiological growth where fuel and water interface. Copper and its alloys, along with zinc or zinc coatings, should be avoided in fuel-handling systems. These elements can react with fuel to form certain gels or organic acids, resulting in clogging of filters or further system corrosion. Stable storage temperatures are conducive to fuel health. Tanks that are aboveground and subject to extreme daily temperature variations cause fuel to degrade more rapidly. This is further exacerbated with large aboveground tanks that are less than full. Airspace allows for condensation that can further add to the contaminant levels. Reflective exterior tank coatings reduce but do not eliminate the solar heating effect.

Scheduled fuel maintenance and testing help to reduce or nearly eliminate fuel contamination. Fuel maintenance filtration can remove contaminants and water and return fuel to conditions where it will provide reliability and efficiency for standby generators when called upon in emergency conditions. Fuel maintenance and testing should begin the day of installation and first fill to establish a benchmark guideline for further comparison. Fuel monitoring and testing services are available nationwide from many companies.

A.7.9.6 See NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*; NFPA 54, *National Fuel Gas Code*; and NFPA 58, *Liquefied Petroleum Gas Code*.

A.7.9.7 Valving for natural gas–fueled prime movers should be configured so that the gas supply to the prime mover cannot be inadvertently or intentionally shut off by anyone other than qualified personnel such as the gas supplier. If valves are placed in an isolated area, a secure area or locking the valve(s) open is recommended.

A.7.10.3 Consideration should also be given to utilizing dampening supports where it is necessary to reduce exhaust noise vibration transmission.

A.7.11.2 If a fire suppression system is used in EPS rooms or separate buildings housing EPS equipment, consideration should be given to preaction-type suppression systems.

A.7.11.5 Consideration should be given to the location of the EPS equipment, both as it relates to the building structure and to the effects of an earthquake.

All emergency power equipment support or subsupport systems should be designed and constructed so that they can withstand static or anticipated seismic forces, or both, in any direction, with the minimum force value used being equal to the equipment weight.

Bolts, anchors, hangers, braces, and other restraining devices should be provided to limit earthquake-generated differential movements between the EPS nonstructural equipment and the building structure. However, the degree of isolation required for vibration and acoustical control of the EPS equipment and other equipment should be maintained.

Suspended items such as piping, conduit, ducts, and other auxiliary equipment related to the EPSS should be braced in two directions to resist swaying and excessive movement in earthquake risk areas.

Battery racks for EPS equipment and electrical items or related auxiliaries, or both, should be designed to resist internal damage and damage at the equipment supports resulting from earthquake-generated motion. Battery racks should be capable of withstanding seismic forces equal to the supported weight in any direction. Batteries should be restrained to their support to prevent vibration damage, and electrical interconnections should be provided with adequate slack to accommodate all relative deflections.

Transfer switch enclosures should be mounted so that their anchors and support structures can withstand static forces equal to the anticipated seismic shock in any direction.

Transfer switch components should be of the type that resist malfunction during dynamic excitation and should be designed to resist the anticipated seismic shock.

Where possible, EPS equipment and associated cooling systems and controls should be mounted on a single frame. The frame, in turn, should be rigidly attached to its foundation so that its anchorage can withstand static forces equal to the equipment weight in any direction. Where engine generator sets and associated cooling systems' controls cannot be mounted as an integral unit, each should be secured to meet the floating requirements previously described. Equipment not using the preferred rigid mounting should have vibration isolators with restraints capable of withstanding static forces equal to twice the weight of the supported equipment in any direction. In addition, interconnecting power, fuel, and cooling lines should be provided with adequate flexibility to allow maximum anticipated excursions without damage.

Appendages to the EPS equipment, such as day tanks, should be mounted to withstand static forces equal to the anticipated seismic shock in any direction.

A.7.11.6 Seismic shock should be simulated at the factory or in a testing laboratory on a prototype unit. Simulation should consist of a test(s) approximating actual time-history records of known seismic shocks applied to the equipment under test. Subassemblies of the total equipment could be tested separately where it is neither practical nor feasible to test the complete unit.

A.8.1 The continuing reliability and integrity of the EPSS are dependent on an established program of routine maintenance and operational testing.

A.8.2 Where adequately secured from public access, it is desirable to locate an instruction manual, special tools and testing devices, and spare parts in the room in which the EPS is located. The articles should be mounted at a convenient location on a wall and should be enclosed in a metal or other suitable cabinet. The cabinet should accommodate the instruction manual on the inside of the door.

A.8.3.1 The suggested maintenance procedure and frequency should follow those

recommended by the manufacturer. In the absence of such recommendations, Figure A.8.3.1(a) and Figure A.8.3.1(b) indicate alternate suggested procedures.

Maintenance Schedule

Component (as applicable)	Procedure (X — Action, R — Replace, if needed)					Frequency (W — Weekly, M — Monthly, Q — Quarterly, S — Semiannually, A — Annually, Nos. indicate hours)	
	Visual Inspection	Check	Change	Clean	Test	Level 1	Level 2
1. Fuel							
(a) Main supply tank level		X				W	M
(b) Day tank level	X	X				W	M
(c) Day tank float switch	X				X	W	Q
(d) Supply or transfer pump operation	X				X	W	Q
(e) Solenoid valve operation	X				X	W	Q
(f) Strainer, filter, dirt leg, or combination				X		Q	Q
(g) Water in system		X		X		W	Q
(h) Flexible hose and connectors	X		R			W	M
(i) Tank vents and overflow piping unobstructed		X			X	A	A
(j) Piping	X					A	A
(k) Gasoline in main tank (when used)			R			A	A
2. Lubrication System							
(a) Oil level	X	X				W	M
(b) Oil change			R			50 or A	50 or A
(c) Oil filter(s)			R			50 or A	50 or A
(d) Lube oil heater		X				W	M
(e) Crankcase breather	X		R	X		Q	S
3. Cooling System							
(a) Level	X	X				W	M
(b) Antifreeze protection level					X	S	A
(c) Antifreeze			R			A	A
(d) Adequate cooling water to heat exchanger		X				W	M
(e) Rod out heat exchanger				X		A	A
(f) Adequate fresh air through radiator		X				W	M
(g) Clean exterior of radiator				X		A	A
(h) Fan and alternator belt	X	X				M	Q
(i) Water pump(s)	X					W	Q
(j) Condition of flexible hoses and connection	X	X				W	M
(k) Jacket water heater		X				W	M
(l) Inspect duct work, clean louvers	X	X		X		A	A
(m) Louver motors and controls	X			X	X	A	A
4. Exhaust System							
(a) Leakage	X	X				W	M
(b) Drain condensate trap		X				W	M

FIGURE A.8.3.1(a) Suggested Maintenance Schedule for Emergency Power Supply Systems.

Maintenance Schedule *(continued)*

Component (as applicable)	Procedure (X — Action, R — Replace, if needed)					Frequency (W — Weekly, M — Monthly, Q — Quarterly, S — Semiannually, A — Annually, Nos. indicate hours)	
	Visual Inspection	Check	Change	Clean	Test	Level 1	Level 2
(c) Insulation and fire hazards	X					Q	Q
(d) Excessive backpressure					X	A	A
(e) Exhaust system hangers and supports	X					A	A
(f) Flexible exhaust section	X					S	S
5. Battery System							
(a) Electrolyte level		X				W	M
(b) Terminals clean and tight	X	X				Q	Q
(c) Remove corrosion, case exterior clean and dry	X			X		M	M
(d) Specific gravity or state of charge					X	M	M
(e) Charger and charge rate	X					M	M
(f) Equalize charge		X				M	M
6. Electrical System							
(a) General inspection	X					W	M
(b) Tighten control and power wiring connections		X				A	A
(c) Wire chafing where subject to movement	X	X				Q	S
(d) Operation of safeties and alarms		X			X	S	S
(e) Boxes, panels, and cabinets				X		S	S
(f) Circuit breakers, fuses Note: Do not break manufacturer's seals or perform internal inspection on these devices.	X	X	R	X	X	M	A
(g) Transfer switch main contacts	X			X		A	A
(h) Calibration of voltage-sensing relays/devices		X			X	A	A
(i) Wire insulation breakdown					X	5/500[a]	3/500[b]
7. Prime Mover							
(a) General inspection	X					W	M
(b) Service air cleaner			R	X		S	S
(c) Governor oil level and linkage	X	X				M	M
(d) Governor oil			R			A	A
(e) Ignition system — plugs, points, coil, cap, rotor, secondary wire insulation	X	X	R	X	X	A	A
(f) Choke setting and carburetor adjustment		X				S	S
(g) Injector pump and injectors for flow rate pressure and/or spray pattern					X	A	A
(h) EPS at minimum of 80% nameplate rating					X	3/4[c]	3/4[c]

FIGURE A.8.3.1(a) ***Continued***

Maintenance Schedule *(continued)*

Component (as applicable)	Procedure (X — Action, R — Replace, if needed)					Frequency (W — Weekly, M — Monthly, Q — Quarterly, S — Semiannually, A — Annually, Nos. indicate hours)	
	Visual Inspection	Check	Change	Clean	Test	Level 1	Level 2
(i) Valve clearance					X	3/500[b]	3/500[b]
(j) Torque bolts					X	3/500[b]	3/500[b]
8. Generator							
(a) Brush length, appearance, free to move in holder	X	X		X		S	S
(b) Commutator and slip rings	X			X		A	A
(c) Rotor and stator	X			X		A	A
(d) Bearing(s)	X		R			A	A
(e) Bearing grease		X	R			A	A
(f) Exciter	X	X		X		A	A
(g) Voltage regulator	X	X		X		A	A
(h) Measure and record resistance readings of windings with insulation tester (Megger)					X	A	A
9. (a) General condition of EPSS, any unusual condition of vibration, leakage, noise, temperature, or deterioration	X			X		W	M
(b) Service room or housing housekeeping	X			X		W	M
10. Restore system to automatic operation condition	X					W	M

[a] Every 5 years or 500 hours
[b] Every 3 years or 500 hours
[c] Every 3 years for 4 hours

FIGURE A.8.3.1(a) ***Continued***

Maintenance Log

Frequency
W — Weekly S — Semiannually
M — Monthly A — Annually
Q — Quarterly Nos. indicate hours

Performed by

Component	Service Frequency		Date											
	Level 1	Level 2	Fill in Appropriate Readings											
1. Fuel														
(a) Main supply tank level	W	M												
(b) Day tank level	W	M												
(c) Day tank float switch	W	Q												
(d) Supply or transfer pump operation	W	Q												
(e) Solenoid valve operation	W	Q												
(f) Strainer, filter, dirt leg, or combination	Q	Q												
(g) Water in system	W	Q												
(h) Flexible hose and connectors	A	A												
(i) Tank vents and overflow piping unobstructed	A	A												
(j) Piping	A	A												
(k) Gasoline in main tank (when used)	A	A												
2. Lubrication System														
(a) Oil level	W	M												
(b) Oil change	50 or A	50 or A												
(c) Oil filter(s)	50 or A	50 or A												
(d) Lube oil heater	W	M												
(e) Crankcase breather	Q	S												
3. Cooling System														
(a) Level	W	M												
(b) Antifreeze protection level	S	A												
(c) Antifreeze	A	A												
(d) Adequate cooling water to heat exchanger	W	M												
(e) Rod out heat exchanger	A	A												
(f) Adequate fresh air through radiator	W	M												
(g) Clean exterior of radiator	A	A												
(h) Fan and alternator belt	M	Q												
(i) Water pump(s)	W	Q												
(j) Condition of flexible hoses and connection	W	M												
(k) Jacket water heater	W	M												
(l) Inspect duct work, clean louvers	A	A												
(m) Louver motors and controls	A	A												
4. Exhaust System														
(a) Leakage	W	M												
(b) Drain condensate trap	W	M												

FIGURE A.8.3.1(b) Sample Maintenance Log — Routine Maintenance, Operation, and Testing (RMOT).

Maintenance Log *(continued)*

Frequency
W — Weekly S — Semiannually
M — Monthly A — Annually
Q — Quarterly Nos. indicate hours

Performed by

Component	Service Frequency		Date											
	Level 1	Level 2	Fill in Appropriate Readings											
(c) Insulation and fire hazards	Q	Q												
(d) Excessive backpressure	A	A												
(e) Exhaust system hangers and supports	A	A												
(f) Flexible exhaust section	S	S												
5. Battery System														
(a) Electrolyte level	W	M												
(b) Terminals clean and tight	Q	Q												
(c) Remove corrosion, case exterior clean and dry	M	M												
(d) Specific gravity or state of charge	M	M												
(e) Charger and charge rate	M	M												
(f) Equalize charge	M	M												
6. Electrical System														
(a) General inspection	W	M												
(b) Tighten control and power wiring connections	A	A												
(c) Wire chafing where subject to movement	Q	S												
(d) Operation of safeties and alarms	S	S												
(e) Boxes, panels, and cabinets	S	S												
(f) Circuit breakers, fuses Note: Do not break manufacturer's seals or perform internal inspection on these devices.	2 or M	2 or A												
(g) Transfer switch main contacts	A	A												
(h) Calibration of voltage-sensing relays/devices	5 or A	5 or A												
(i) Wire insulation breakdown	5/500[a]	3/500[b]												
7. Prime Mover														
(a) General inspection	W	M												
(b) Service air cleaner	S	S												
(c) Governor oil level and linkage	M	M												
(d) Governor oil	A	A												
(e) Ignition system — plugs, points, coil, cap, rotor, secondary wire insulation	A	A												
(f) Choke setting and carburetor adjustment	S	S												
(g) Injector pump and injectors for flow rate pressure and/or spray pattern	A	A												
(h) EPS at minimum of 80% nameplate rating	3/4[c]	3/4[c]												

FIGURE A.8.3.1(b) ***Continued***

Maintenance Log *(continued)*

Frequency
W — Weekly S — Semiannually
M — Monthly A — Annually
Q — Quarterly Nos. indicate hours

Component	Service Frequency Level 1	Service Frequency Level 2	Performed by / Date / Fill in Appropriate Readings
(i) Valve clearance	3/500[b]	3/500[b]	
(j) Torque bolts	3/500[b]	3/500[b]	
8. Generator			
(a) Brush length, appearance, free to move in holder	W	M	
(b) Commutator and slip rings	S	S	
(c) Rotor and stator	A	A	
(d) Bearing(s)	A	A	
(e) Bearing grease	A	A	
(f) Exciter	A	A	
(g) Voltage regulator	A	A	
(h) Measure and record resistance readings of windings with insulation tester (Megger)	A	A	
9. (a) General condition of EPSS, any unusual condition of vibration, leakage, noise, temperature, or deterioration	W	M	
(b) Service room or housing housekeeping	W	M	
10. Restore system to automatic operation condition	W	M	

[a] Every 5 years or 500 hours
[b] Every 3 years or 500 hours
[c] Every 3 years for 4 hours

FIGURE A.8.3.1(b) ***Continued***

A.8.3.5 Where sealed devices are used, replacement of the complete device might be necessary. Maintenance should be performed according to manufacturer's recommendations. In the absence of such recommendations, the list given in 8.3.5 suggests minimal procedures.

Transfer switches should be subjected to an annual maintenance program including (one) major maintenance and (three) quarterly inspections. Programs should include all of the following operations. Note: Due to the critical nature of these devices, permission should be gained to perform these tasks since some of the following recommendations could cause disruption of power to the load. The following tasks should be carefully reviewed with facility management

personnel to ensure agreement and plan for contingencies.

Major Maintenance.

(1) Check connections.

(a) A thermographic or temperature scan should be done prior to this visit while the ATS is under normal (peak) load. This thermographic scan should be repeated during the EPSS load test. Results should be available to the maintenance provider so that suspect conditions can be addressed during this activity.

(b) With power connected to the normal source, measure and record millivolt drop levels across each pole. Note: Any reading that is greater than 25 percent of the average of all poles should be carefully inspected when the ATS is de-energized.

(c) With power connected to the emergency source, measure and record millivolt drop levels across each pole. Note: Any reading that is greater than 25 percent of the average of all poles should be carefully inspected when the ATS is de-energized.

(d) If the ATS is equipped with a bypass isolation feature, operate the bypass to the connected source (emergency or normal) and repeat the steps in (a), (b), and (c). Levels should drop to approximately 50 percent of initial levels and be uniform relative to initial readings. This step verifies that the bypass feature is properly connected and that the connected load will not be affected when the automatic portion is isolated for maintenance.

(e) With power secured and both the emergency and normal sources properly locked out and tagged out, measure the micro-ohm resistance levels across the following connection points:

i. Emergency source cabling lug to bus

ii. Normal source cabling lug to bus

iii. Load cabling lug to bus

iv. Neutral cabling lug to bus

v. Load connected to normal across each pole

vi. Load connected to emergency across each pole

Notes: If the ATS is equipped with an isolation bypass and the bypass remains energized, perform these tests on the isolated transfer switch unit only. DO NOT APPLY DIGITAL LOW RESISTANCE OHMMETER (DLRO) TO ENERGIZED CIRCUITS.
Any value greater than 20 percent of the average value of all similar type connections requires further investigation.

(2) Inspect or test for evidence of overheating or excessive contact corrosion.

(a) With power from both sources secured and properly locked out and tagged out, remove all protective pole covers and arc chutes.

(b) Carefully inspect main contacts and other current-carrying parts for signs of corrosion or overheating. Note: Observation should correlate with previous results (i.e., thermographic or temperature evidence of higher than normal temperatures or heat migration, abnormal millivolt drop readings as previously noted, or abnormal micro-ohm (DLRO) readings as previously noted).

(c) Carefully inspect insulating materials or standoff insulators for signs of contamination (i.e., dirt, grime, oil, etc.). The combination of contaminants and possible introduction of high humidity or moisture could lead to insulation breakdown and subsequent destructive faults. Clean contaminated surfaces with a solvent approved for this purpose.

(d) Inspect control connection, plugs, and harnesses for signs of corrosion, heat, contamination, and so forth.

(e) Using a vacuum, remove all dust and debris from the ATS cabinet, transfer switch mechanism, bus, and so forth. Note: Never use compressed air to blow out dust. Doing so can blow dust and debris into controls and the transfer switch mechanism.

(f) Inspect cabinets for proper sealing. Open conduit knockouts or other penetrations should be properly sealed to prevent the introduction of dust, moisture, or other alien matter. Enclosures installed outside should be inspected for proper seal and appropriate gasketing. Ensure that enclosure door securing devices are intact and properly secured.

(g) Replace and secure all protective pole covers and chutes. Remove lockout devices and resupply normal power. If the ATS is of the bypass isolation type, reconnect the transfer switch mechanism. Observe proper manufacturer's procedures.

(3) Verify control and feature setpoints and operation.

(a) Measure and record the following data and setpoints:

i. Normal source voltage phase to phase, phase to ground, and phase to neutral

ii. Engine start time (from crank start to source available light or relay pickup)

iii. Emergency source voltage phase to phase, phase to ground, and phase to neutral

iv. Load current each phase

v. Momentary override normal deviation where provided

vi. Transfer time delay where provided

vii. Return to normal source time delay where provided

viii. Engine cooldown where provided

(b) If the connection is to a multiple-source EPS, verify the load priority of the ATS being tested and confirm this is correct given the criticality of the connected load.

(c) Verify proper operation of all indicator lights and meters and controls.

(d) Return ATS to normal service.

Quarterly Inspections.

(1) Visually inspect the transfer switch control mechanism, control panel, harnesses, and cable connections for signs of moisture, corrosion, or heating.

(2) Measure and record the following data and setpoints:

(a) Normal source voltage phase to phase, phase to ground, and phase to neutral

(b) Engine start time (from crank start to source available light or relay pickup)

(c) Emergency source voltage phase to phase, phase to ground, and phase to neutral

(d) Load current each phase

(e) Momentary override normal deviation where provided

(f) Transfer time delay where provided

(g) Return to normal source time delay where provided

(h) Engine cooldown where provided

(3) If the connection is to a multiple-source EPS, verify the load priority of the ATS being tested and confirm this is correct given the criticality of the connected load.

(4) Verify proper operation of all indicator lights and meters and controls.

(5) Inspect cabinets for proper sealing. Open conduit knockouts or other penetrations should be properly sealed to prevent the introduction of dust, moisture, or other alien matter. Enclosures installed outside should be inspected for proper seal and appropriate gasketing. Ensure that enclosure door securing devices are intact and properly secured.

(6) Perform a load test using the test switch if permitted. Note: This will cause the emergency power source to start and the ATS to transfer. Be sure to gain permission from the facility management prior to performing this test.

A.8.3.7 A battery load test should be performed quarterly.

A.8.4.1 See Figure A.8.4.1(a) and Figure A.8.4.1(b).

Operation and Testing Log

Item*	Performed by / Date / Fill in Appropriate Readings																		
1. Maintenance schedule																			
2. RTM																			
3. Power fail																			
4. T/D start																			
5. Crank time																			
6. Transfer																			
7. (a) ac voltage																			
(b) Hz																			
(c) ac amperage																			
8. (a) Oil pressure																			
(b) dc amperage																			
9. (a) Oil pressure																			
(b) dc amperage																			
(c) W/A temp.																			
10. Restore normal																			
11. (a) Oil pressure																			
(b) dc amperage																			
(c) W/A temp.																			
(d) ac voltage																			
(e) Hz																			
(f) ac amperage																			
12. T/D retransfer																			
13. T/D stop																			
14. Auto mode																			

Comments

* See Suggested Operation and Testing Procedures for explanation of items.

FIGURE A.8.4.1(a) Sample Operation and Testing Log for Rotating Equipment.

Suggested Operation and Testing Procedures

Item*	Procedure	Item*	Procedure
1.	Perform maintenance per Maintenance Schedule	8.	Record initial oil pressure and battery-charging rate.
2.	Record running time meter (RTM) reading at start and end of test.	9.	Record oil pressure, battery-charging rate, and water or air temperature after 15 minutes running time.
3.	Simulate normal power failure from a "cold start" by use of the test switch in automatic transfer switch or by opening normal power supply to EPSS.	10.	Return test switch to normal or reestablish normal power supply at such time to cause a minimum running time of 30 minutes under load.
4.	Observe and record time delay (T/D) on start.	11.	Record prime mover and ac instruments just prior to transfer.
5.	Record cranking time (terminates when engine starts).	12.	Record time delay on retransfer.
6.	Transfer load to EPS.	13.	Record time delay on shutdown for units so equipped.
7.	Record ac voltage, frequency, amperage.	14.	Place unit in automatic operation mode.

*See Operation and Testing Log.

FIGURE A.8.4.1(b) Operation and Testing Procedures Suggested for Rotating Equipment.

A.8.4.2 Light loading creates a condition termed *wet stacking*, indicating the presence of unburned fuel or carbon, or both, in the exhaust system. Its presence is readily indicated by the presence of continual black smoke during engine-run operation. The testing requirements of 8.4.2 are intended to reduce the possibility of wet stacking. If equivalent loads are used for exercising, it is suggested that all essential loads be energized first, with the equivalent load used only to supplement the test. If the normal power were to fail during the exercise period, it would negate the urgency to automatically remove the equivalent load as described at 8.4.2.2.

A.8.4.2.3 The EPS should be exercised for the duration of its assigned class *(see Section 4.2)*, or for a duration agreed to by the authority having jurisdiction not to exceed 6 hours, at least once annually under the conditions required by this section.

The intent of this requirement is to provide reasonable assurance that the EPS with all of its auxiliary subsystems is capable of running for the duration of its assigned class.

A.8.4.7 Circuit breakers should be tested under simulated overload conditions every 2 years.

A.8.4.9 The intent of this requirement is to provide reasonable assurance that the EPSS with all of its auxiliary subsystems is capable of running for the duration of its assigned class with its running load. A full facility power outage is not intended for this test but is recommended where a total facility power outage has not occurred within the last 36 months. Supplemental load banks are not required. After the test, the fuel supply should be replenished if necessary.

Annex B Diagrams of Typical Systems

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Typical Power Supply Systems.

See Figure B.1(a) through Figure B.1(d) for examples.

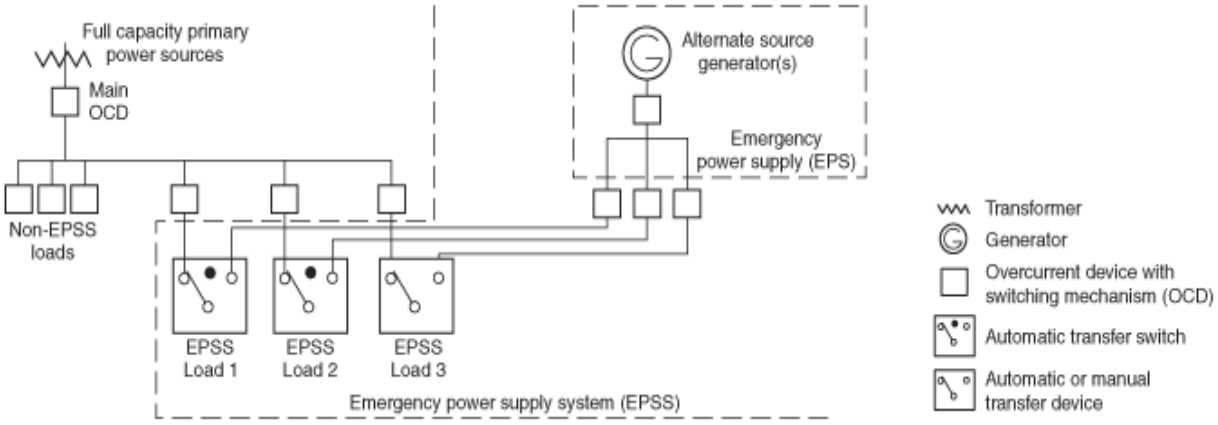

FIGURE B.1(a) Typical Rotating Emergency Power Supply System.

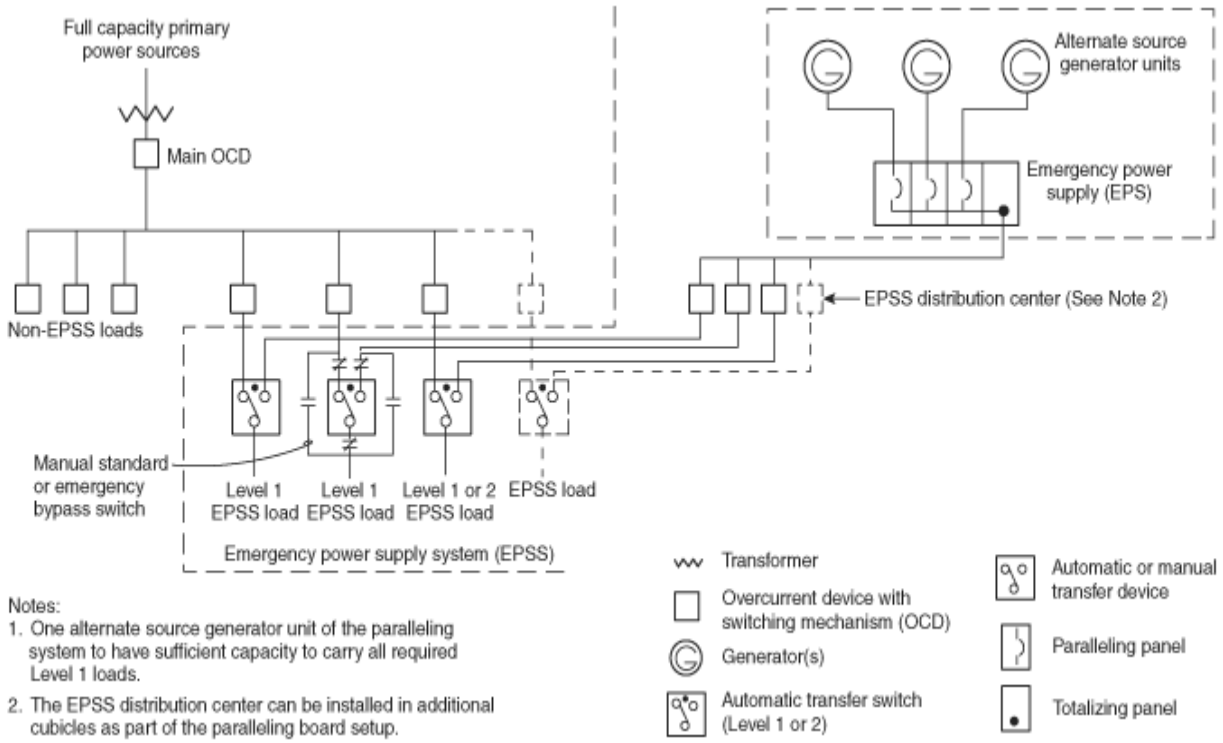

FIGURE B.1(b) Typical Multiple-Unit Emergency Power Supply System.

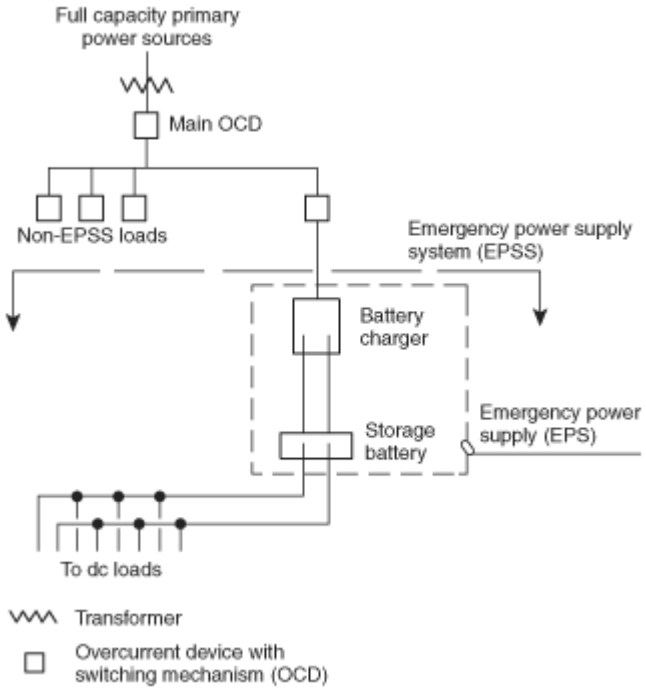

FIGURE B.1(c) Typical Uninterruptible Power Supply (UPS) System.

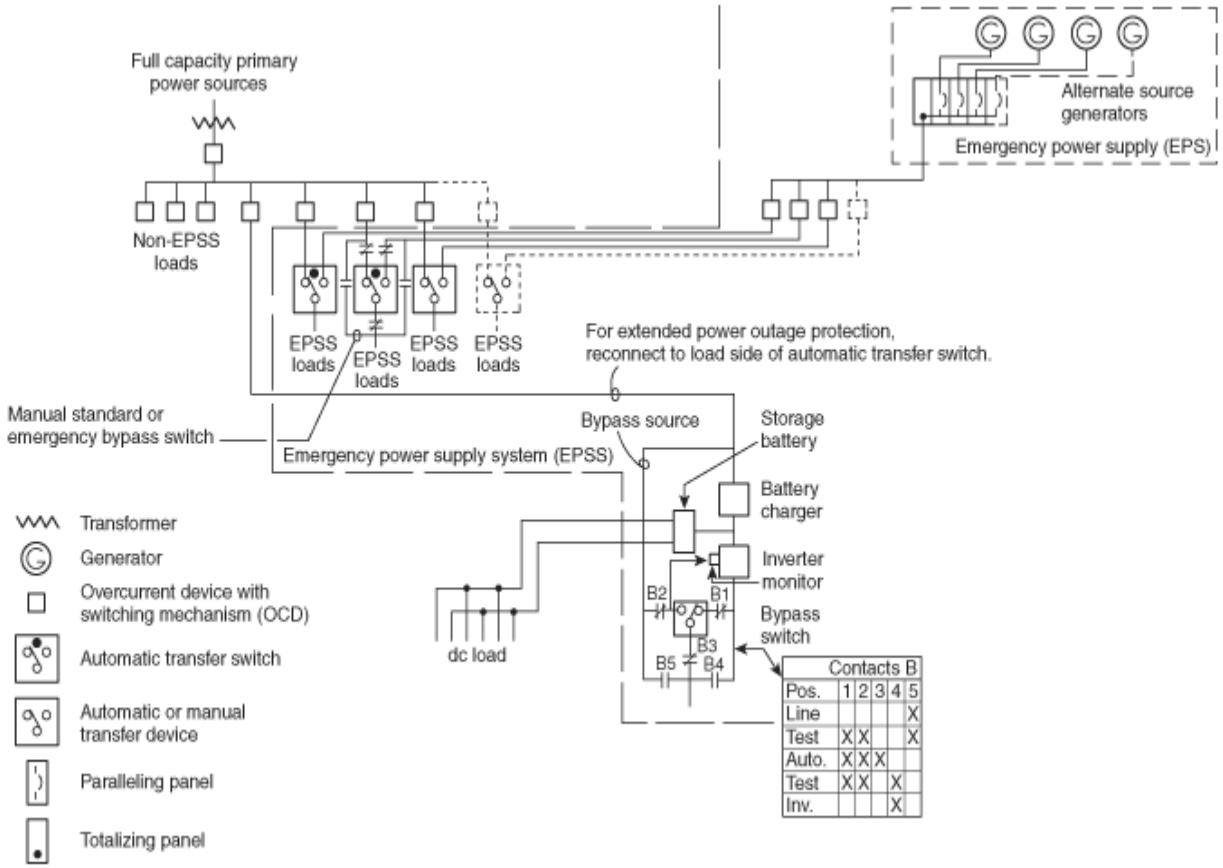

FIGURE B.1(d) Typical Composite Emergency Power Supply System.

Annex C Informational References

C.1 Referenced Publications.

The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

C.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2003 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2002 edition.

NFPA 54, *National Fuel Gas Code*, 2002 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2004 edition.

NFPA 70, *National Electrical Code®*, 2005 edition.

NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, 2001 edition.

C.1.2 Other Publications.

C.1.2.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI C84.1, *Standard for Electric Power Systems and Equipment Voltage Ratings*, 1995.

ANSI/NEMA MG1, *Standard for Motors and Generators*, 1998.

ANSI/NEMA MG2, *Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators*, 1989.

C.1.2.2 ASCE Publication. American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191.

ASCE 7, *Minimum Design Loads for Buildings and Other Structures*, 2002.

C.1.2.3 Other Publications. *Merriam-Webster's Collegiate Dictionary*, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

C.2 Informational References.

The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

C.2.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, 2002 edition.

NFPA 72®, *National Fire Alarm Code®*, 2002 edition.

NFPA 99, *Standard for Health Care Facilities*, 2005 edition.

NFPA *101®*, *Life Safety Code®*, 2003 edition.

C.3 References for Extracts. (Reserved)