

NFPA®

110

Standard for
Emergency and Standby
Power Systems

2022



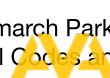
NFPA[®] 110

Standard for Emergency and Standby Power Systems

2022 Edition



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NFPA® 110

Standard for

Emergency and Standby Power Systems

2022 Edition

This edition of NFPA 110, *Standard for Emergency and Standby Power Systems*, was prepared by the Technical Committee on Emergency Power Supplies and released by the Correlating Committee on National Electrical Code®. It was issued by the Standards Council on March 18, 2021, with an effective date of April 8, 2021, and supersedes all previous editions.

This edition of NFPA 110 was approved as an American National Standard on April 8, 2021.

Origin and Development of NFPA 110

The Technical Committee on Emergency Power Supplies was organized in 1976 by NFPA in recognition of the demand for viable guidelines for the assembly, installation, and performance of electrical power systems used to supply critical and essential needs during outages of the primary power source. The intent was to establish the equipment requirements necessary to achieve an on-site auxiliary electrical power source suitable to the needs of the applicable requirements and user criteria.

In 1979, the committee's report proposing adoption of NFPA 110 was published but withdrawn because of issues involving the scope of the committee. In 1981, a revised report was returned to the committee to resolve differences with other NFPA documents. At the 1982 NFPA Fall Meeting, the committee's report was adopted as a tentative standard (NFPA 110T-1983) to expose the document to public review.

NFPA 110 was formally adopted as a standard at the 1984 NFPA Fall Meeting and designated as the 1985 edition, which clarified scope statements, prototype testing, battery and bypass-isolation switch requirements, and revised maintenance requirements.

The 1988 edition included several new definitions and further clarified transfer switch and installation testing requirements.

The 1993 edition reflected the adoption of NFPA 111, *Standard on Stored Electrical Energy Emergency and Standby Power Systems*, a basic requirement for one-step loading for all prime movers, an update on battery technology, restrictions on unnecessary transferring of loads, and the need for battery maintenance.

The 1996 edition added revised monthly load testing requirements for generator sets, consideration for potential wet stacking, various types of fuel tanks and spillage considerations, restrictions on the types of permitted batteries, and working space requirements. It also clarified the minimum number of cranks that an engine must be capable of completing, cooling system requirements, and timing devices in health care facilities for testing a generator.

The 1999 edition deleted the testing of generator sets at 50 percent of the emergency power supply system load because the relevant measure is the nameplate rating. The exception for wet stacking was also deleted. Exhaust temperature monitoring was added because it is an acceptable performance measure of proper emergency power supply loading.

The 2002 edition was restructured to comply with the *Manual of Style for NFPA Technical Committee Documents*. Introductory material in Chapter 1 was formatted for consistency among all NFPA documents. Referenced publications were relocated from the last chapter to Chapter 2, resulting in the renumbering of chapters. Definitions in Chapter 3 were made consistent with definitions in other NFPA documents, systematically aligned, and individually numbered. Paragraphs were revised to provide one mandatory requirement per section, subsection, or paragraph. Information that accompanied many of the requirements was moved to Annex A, Explanatory Material. Many exceptions were deleted or rephrased into mandatory text.

Changes in the 2002 edition included definitive and broad-based requirements regarding electrical installations in accordance with *NFPA 70®*, *National Electrical Code®*; additional EPS controls and safeguards, such as alerting staff of impending failure of the EPS to start; access and working space around the generator set; ventilation; energy converters; and EPSS testing requirements.

The 2005 edition revised clearance distances between transfer switches and service equipment, revised the definitions for both lead-acid (flooded) and valve-regulated lead-acid (VRLA) batteries, and changed the testing and maintenance section to include testing for spark-ignited engines that parallels those for diesel. Changes also included new annex material for diesel fuel testing and maintenance procedures, as well as transfer switches.

Significant revisions to the 2010 edition included the following:

- (1) Clarified that the requirements to systems classed as optional standby is not mandatory
- (2) Clarified that the operation testing and routine maintenance requirements of Chapter 8 cover both new and existing EPSSs
- (3) Aligned the definitions of transfer switch types with NFPA 111 and relevant product standards
- (4) Revised the Chapter 7 requirements for acceptance testing and differentiated what is required for new and unoccupied buildings and facilities from what is required for existing occupied buildings and facilities
- (5) Revised the Chapter 8 requirements for operational test durations, loading conditions, and method of test initiation for the emergency power supply

A noteworthy change for the 2013 edition was the deletion of the mandatory 96-hour fuel supply requirement (5.1.2) for seismic categories. The need for continued operation and the minimum operational time without refueling is a design consideration or is directed by another standard. Several references to ASTM standards and additional annex material were added to address fuel quality and storage issues. The prime mover cooling and ventilation system construction and installation requirements were reorganized.

The 2016 edition was revised to prohibit the installation of an automatically actuated valve into the fuel lines to prevent the inadvertent cutoff of fuel at critical times. The proper operation of systems connected in parallel was addressed by adding acceptance testing and maintenance items for paralleling gear. To test all transfer switches, a requirement to rotate the transfer switch initiating the monthly test was added where multiple transfer switches are installed. A new section was added to consolidate record management and define record retention requirements.

For the 2019 edition, several existing requirements were clarified to assist users with the proper application. Clarifications included the location and access to the remote emergency stop switch, testing of fuel in accordance with the manufacturer's recommendations in lieu of an ASTM standard, and battery charger specifications.

The 2022 edition introduces requirements for fuel cell systems used for Level 1 or Level 2 standby power. The fuel cell performance requirements parallel the performance requirements for generator sets. Annex information has been added to help users understand fuel quality issues, identify applicable standards and types of tests available, as well as provide guidance on how to mitigate deficiencies.

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Committee Scope: This Committee shall have primary responsibility for documents on minimizing the risk of electricity as a source of electric shock and as a potential ignition source of fires and explosions. It shall also be responsible for text to minimize the propagation of fire and explosions due to electrical installations.

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(Alt. to Dan Chisholm, Sr.)

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(Alt. to Timothy Evans)

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on performance criteria for the selection and assembly of the components for emergency power systems in buildings and facilities, including categories of power supplies, transfer equipment, controls, supervisory equipment, and all related electrical and mechanical auxiliary or accessory equipment needed to supply emergency power to the utilization equipment. The Committee also shall be responsible for criteria on the maintenance and testing of the system. This Committee does not cover requirements for the application of emergency power systems, self-contained emergency lighting units, and electrical wiring, except that wiring that is an integral part of the system up to the load side of the transfer switch(es). This Committee shall report to Correlating Committee of the National Electrical Code.

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A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration

1.1 Scope. This standard contains requirements covering the performance of emergency and standby power systems providing an alternate source of electrical power to loads in buildings and facilities in the event that the primary power source fails.

1.1.1 Power systems covered in this standard include power sources, transfer equipment, controls, supervisory equipment, and all related electrical and mechanical auxiliary and accessory equipment needed to supply electrical power to the load terminals of the transfer equipment.

1.1.2 This standard covers installation, maintenance, operation, and testing requirements as they pertain to the performance of the emergency power supply system (EPSS).

1.1.3 This standard does not cover the following:

- (1) Application of the EPSS
- (2) Emergency lighting unit equipment
- (3) Distribution wiring
- (4) Utility service when such service is permitted as the EPSS
- (5) Parameters for stored energy devices

- (6) The equipment of systems that are not classed as Level 1 or Level 2 systems in accordance with Chapter 4 of this standard

1.1.4* This standard does not establish criteria for stored energy systems.

1.1.5 The selection of any of the following is not within the scope of this standard:

- (1) Specific buildings or facilities, or both, requiring an EPSS
- (2) Specific loads to be served by the EPSS
- (3)* Assignment of type, class, or level to any specific load

1.2 Purpose. This standard contains performance requirements for an EPSS.

1.2.1 It is the role of other NFPA standards to specify which occupancies require an EPSS and the applicable level, type, and class. This standard does not specify where an EPSS is required.

1.2.2 This standard also is intended to provide guidance for inspectors, designers, installers, manufacturers, and users of EPSSs and to serve as a vehicle for communication between the parties involved. It is not intended as a design manual.

1.2.3 Compliance with this standard is not intended to exempt the parties involved from their respective responsibilities for the design, installation, maintenance, performance, or compliance with other applicable standards and codes.

1.3 Application. This document applies to new installations of EPSSs, except that the requirements of Chapter 8 shall apply to new and existing systems. Existing systems shall not be required to be modified to conform, except where the authority having jurisdiction determines that nonconformity presents a distinct hazard to life.

1.4 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety to those prescribed by this standard.

1.4.1* Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.4.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

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

NFPA 2, *Hydrogen Technologies Code*, 2020 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2021 edition.

NFPA 54, *National Fuel Gas Code*, 2021 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2020 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2019 edition.

NFPA 99, *Health Care Facilities Code*, 2021 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2020 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2020 edition.

2.3 Other Publications.

2.3.1 ASCE Publications. American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191.

ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*, 2016.

2.3.2 IEC Publications. International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 62282-3-100, *Fuel cell technologies - Part 3-100: Stationary fuel cell power systems safety*, 2019.

2.3.3 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 1, *Fire Code*, 2021 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies*, 2021 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated

standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1* Battery Certification. The certification by a battery manufacturer that a battery is built to industry standards.

3.3.2 Black Start. Where the stored energy system has the capability to start the prime mover without using energy from another source.

3.3.3* Emergency Power Supply (EPS). The source of electric power of the required capacity and quality for an emergency power supply system (EPSS).

3.3.4* Emergency Power Supply System (EPSS). A complete functioning EPS system coupled to a system of conductors, disconnecting means and overcurrent protective devices, transfer switches, and all control, supervisory, and support devices up to and including the load terminals of the transfer equipment needed for the system to operate as a safe and reliable source of electric power.

3.3.5 Field Evaluation Body (FEB). An organization, or part of an organization, that performs field evaluations of electrical or other equipment. [790, 2021]

3.3.6 Field Labeled (as applied to evaluated products). Equipment or materials to which has been attached a label, symbol, or other identifying mark of an FEB indicating the equipment or materials were evaluated and found to comply with requirements as described in an accompanying field evaluation report. [70:100]

3.3.7 Fuel Cell. An electrochemical system that consumes fuel to produce an electric current. In such cells, the main chemical reaction used for producing electric power is not combustion. However, there may be sources of combustion used within the overall cell system, such as reformers/fuel processors. [70:100]

3.3.8 Fuel Cell System. The complete aggregate of equipment used to convert chemical fuel into usable electricity and typically consisting of a reformer, stack, power inverter, and auxiliary equipment. [70:100]

3.3.9 Fuel Tank.

3.3.9.1 Day Fuel Tank. A fuel tank, located inside a structure, that provides fuel to the engine.

3.3.9.2 Enclosed Fuel Tank. A fuel tank located within a separate room, separated from other equipment.

3.3.9.3 Integral Fuel Tank in EPS Systems. A fuel tank furnished by the EPS supplier and mounted on the engine or under as a subbase.

3.3.9.4 Main Fuel Tank. A separate, main fuel tank for supplying fuel to the engine or a day tank.

3.3.10 Lamp. An illuminating indicator.

3.3.11 Lead-Acid Battery.

3.3.11.1* Valve-Regulated (VRLA). A lead-acid battery consisting of sealed cells furnished with a valve that opens to vent the battery whenever the internal pressure of the battery exceeds the ambient pressure by a set amount. [1, 2021]

3.3.11.2* Vented (Flooded). A lead-acid battery consisting of cells that have electrodes immersed in liquid electrolyte.

3.3.12 Occupancy Category. See ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*.

3.3.13 Qualified Person. One who has skills and knowledge related to the operation, maintenance, repair, and testing of the EPSS equipment and installations and has received safety training to recognize and avoid the hazards involved.

3.3.14 Switch.

3.3.14.1 Automatic Transfer Switch (ATS). Self-acting equipment for transferring the connected load from one power source to another power source.

3.3.14.2 Bypass-Isolation Switch. A manually operated device used in conjunction with an automatic transfer switch to provide a means of directly connecting load conductors to a power source and disconnecting the automatic transfer switch.

3.3.14.3 Nonautomatic Transfer Switch. A device, operated manually by a physical action or electrically by either a local or remote control, for transferring a common load between a normal and alternate supply.

Chapter 4 Classification of Emergency Power Supply Systems (EPSSs)

4.1* General. The EPSS shall provide a source of electrical power of required capacity, reliability, and quality to loads for a length of time as specified in Table 4.1(a) and within a specified time following loss or failure of the normal power supply as specified in Table 4.1(b).

Table 4.1(a) Classification of EPSSs

Class	Minimum Time
Class 0.083	0.083 hr (5 min)
Class 0.25	0.25 hr (15 min)
Class 2	2 hr
Class 6	6 hr
Class 48	48 hr
Class X	Other time, in hours, as required by the application, code, or user

Table 4.1(b) Types of EPSSs

Designation	Power Restoration
Type U	Basically uninterruptible (UPS systems)
Type 10	10 sec
Type 60	60 sec
Type 120	120 sec
Type M	Manual stationary or nonautomatic — no time limit

4.2* Class. The class defines the minimum time, in hours, for which the EPSS is designed to operate at its rated load without being refueled or recharged. [See Table 4.1(a).]

4.3 Type. The type defines the maximum time, in seconds, that the EPSS will permit the load terminals of the transfer switch to be without acceptable electrical power. Table 4.1(b) provides the types defined by this standard.

4.4* Level. This standard recognizes two levels for equipment installation, performance, and maintenance requirements.

4.4.1* Level 1 systems shall be installed where failure of the equipment to perform could result in loss of human life or serious injuries.

4.4.2* Level 2 systems shall be installed where failure of the EPSS to perform is less critical to human life and safety.

4.4.3* All equipment shall be permanently installed.

4.4.4* Level 1 and Level 2 systems shall ensure that all loads served by the EPSS are supplied with alternate power that meets all the following criteria:

- (1) Of a quality within the operating limits of the load
- (2) For a duration specified for the class as defined in Table 4.1(a)
- (3) Within the time specified for the type as defined in Table 4.1(b)

Chapter 5 Emergency Power Supply (EPS): Energy Sources, Converters, and Accessories

5.1 Energy Sources.

5.1.1* General. The following energy sources shall be permitted to be used for the emergency power supply (EPS):

- (1)* Liquid petroleum products at atmospheric pressure as specified in the applicable ASTM standards and as recommended by the engine manufacturer
- (2)* Liquefied petroleum gas (liquid or vapor withdrawal) as specified in the applicable ASTM standards and as recommended by the engine manufacturer
- (3)* Natural or synthetic gas
- (4)* Hydrogen gas

5.1.1.1 For Level 1 installations in locations where the probability of interruption of off-site fuel supplies is high, on-site storage of an alternate energy source sufficient to allow full output of the EPSS to be delivered for the class specified shall be required, with the provision for automatic transfer from the primary energy source to the alternate energy source.

5.1.2 Primary On-Site Energy Conversion. The energy sources listed in 5.1.1 shall be permitted to be used for the EPS

where the primary source of power is by means of on-site energy conversion, provided that there is separately dedicated energy conversion equipment on-site with a capacity equal to the power needs of the EPSS.

5.1.3* Public Utility. A public electric utility that has a demonstrated reliability shall be permitted to be used as the EPS where the primary source is by means of on-site energy conversion.

Δ 5.2 Energy Converters.

Δ 5.2.1 General. Energy converters shall consist only of equipment as indicated in 5.2.4.

5.2.1.1 Level 1 energy converters shall be representative products built from components that have proven compatibility and reliability and are coordinated to operate as a unit.

N 5.2.1.2* Fuel cell systems utilized as Level 1 energy converters shall be listed or field labeled.

5.2.1.3 The capability of the energy converter, with its controls and accessories, to survive without damage from common and abnormal disturbances in actual load circuits shall be demonstrable by tests on separate prototype models, or by acceptable tests on the system components as performed by the component suppliers, or by tests performed in the listing process for the assembly.

Δ 5.2.1.4 A separate prototype unit shall be permitted to be utilized in a Level 2 installation, provided that all prototype tests produce no deleterious effects on the unit, and the authority having jurisdiction, the owner, and the user are informed that the unit is the prototype test unit.

5.2.2* Rotating Equipment Prototype. The rotating equipment prototype unit shall be tested with all typical prime mover accessories that affect its power output in place and operating, including, but not limited to, the following:

- (1) Battery-charging alternator
- (2) Water pump
- (3) Radiator fan for unit-mounted radiators or oil coolers (or comparable load)
- (4) Fuel pump and fuel filter(s)
- (5) Air filter(s)
- (6) Exhaust mufflers or restriction simulating the maximum backpressure recommended by the prime mover manufacturer

5.2.3 Energy Converter Design and Testing. The energy converter for Level 1 systems shall be specifically designed, assembled, and tested to ensure intended system operation under the following conditions:

- (1) Short circuits, including phase-to-ground, phase-to-phase, and 3-phase bolted faults
- (2) Load surges due to motor starting
- (3) Elevator operations
- (4) Silicon-controlled rectifier (SCR) controllers
- (5) X-ray equipment
- (6) Overspeed, overtemperature, or overload
- (7) Adverse environmental conditions

Δ 5.2.4 Emergency Power Supply (EPS).

N 5.2.4.1 EPS utilizing rotating equipment shall consist of a generator driven by one of the following prime mover types:

- (1) Otto cycle (spark ignited)

- (2) Diesel cycle
- (3) Gas turbine cycle

N 5.2.4.2* EPS utilizing fuel cell systems shall consist of one or more of the following types:

- (1) Proton exchange membrane (PEMFC)
- (2) Solid oxide (SOFC)
- (3) Molten carbonate (MCFC)
- (4) Phosphoric acid (PAFC)
- (5) Alkaline (AFC)

5.2.4.3 For EPS utilizing rotating equipment, other types of prime movers and their associated equipment meeting the applicable performance requirements of this standard shall be permitted, if acceptable to the authority having jurisdiction.

5.2.4.4 Where used for Level 1 applications, the prime mover shall not mechanically drive any equipment other than its operating accessories and its generator.

Δ 5.2.5 Listing and Other Standards. The EPS shall be installed in accordance with *NFPA 70*.

N 5.2.5.1 When a listing process is not available for the engine-generator assembly, a field evaluation body acceptable to the authority having jurisdiction shall be permitted to affix a field label.

N 5.2.5.2 Fuel cell system EPS and their accessories shall comply with NFPA 853, except as modified in this standard.

5.3 Energy Converters — Temperature Maintenance.

5.3.1 General. The EPS shall be heated as necessary to maintain the water jacket and battery temperature determined by the EPS manufacturer for cold start and load acceptance for the type of EPSS.

N 5.3.2 Thermal Management. A fuel-cell-system-type EPS shall be provided with a thermal management system in accordance with its listing and intended installation location for cold start and load acceptance for the type of EPSS.

5.3.3 Prime Mover Heaters. All prime mover heaters shall be automatically deactivated while the prime mover is running. (For combustion turbines, see 5.3.7.)

5.3.3.1 Air-cooled prime movers shall be permitted to employ a heater to maintain lubricating oil temperature as recommended by the prime mover manufacturer.

5.3.4 Antifreeze Protection. Antifreeze protection shall be provided according to the manufacturer's recommendations.

5.3.5 Ether-Type Starting. Ether-type starting aids shall not be permitted.

N 5.3.6 Listing and Instructions. Fuel cell system EPSs shall be installed in accordance with its listing and manufacturer's recommended installation instructions and specifications.

N 5.3.6.1* Fuel cell system EPSs shall be provided with a thermal management system in accordance with its listing.

5.3.7 Ambient Air. The ambient air temperature in the EPS equipment room or outdoor housing containing Level I rotating equipment shall stabilize at not less than 4.5°C (40°F) when the equipment is not operating.

5.4* Energy Converters — Capacity. The energy converters shall have the required capacity and response to pick up and

carry the load within the time specified in Table 4.1(b) after loss of primary power.

5.5 Energy Converters — Fuel Supply.

5.5.1 General. The fuel supplies specified in 5.1.1(1) and 5.1.1(2) for energy converters intended for Level 1 use shall not be used for any other purpose. *(For fuel system requirements, see Section 7.9.)*

5.5.1.1 Enclosed fuel tanks shall be permitted to be used for supplying fuel for other equipment, provided that the draw-down level or other passive features are designed into the fuel system to guarantee that the required quantity of fuel is available for the EPSS.

5.5.1.2 Vapor-withdrawal LP-Gas systems shall have a dedicated fuel supply.

5.5.2* Low Fuel. A low-fuel sensing switch shall be provided for the main fuel supply tank(s) using the energy sources listed in 5.1.1(1) and 5.1.1(2) to indicate when less than the minimum fuel necessary for full load running, as required by the specified class in Table 4.1(a), remains in the main fuel tank.

5.5.3* Fuel Tank Capacity. The main fuel tank shall have a minimum capacity of at least 133 percent of either the low-fuel sensor quantity specified in 5.5.2 or the quantity required to support the duration of run specified in Table 4.1(a).

5.6 Rotating Equipment.

5.6.1 General. Prime movers and accessories shall comply with NFPA 37 except as modified in this standard.

5.6.2 Prime Mover Ratings. Proper derating factors, such as altitude, ambient temperature, fuel energy content, accessory losses, and site conditions as recommended by the manufacturer of the engine shall be used in determining whether or not brake power meets the connected load requirements.

5.6.3 Prime Mover Accessories.

5.6.3.1 Governors shall maintain a bandwidth of rated frequency for any constant load (steady-state condition) that is compatible with the load.

5.6.3.1.1 The frequency droop between no load and full load shall be within the range for the load.

5.6.3.1.2 The frequency dip upon one-step application of the full load shall not be outside the range for the load, with a return to steady-state conditions occurring within the requirements of the load.

5.6.3.2 Solenoid valves, where used, both in the fuel line from the supply or day tank closest to the generator set and in the water-cooling lines, shall operate from battery voltage.

5.6.3.2.1 Solenoid valves shall have a manual (nonelectric) operation, or a manual bypass valve shall be provided.

5.6.3.2.1.1 The manual bypass valve shall be visible and accessible and its purpose identified.

5.6.3.2.1.2 The fuel bypass valve shall not be the valve used for malfunction or emergency shutdown.

5.6.3.3 The prime mover shall be provided with the following instruments:

- (1) Oil pressure gauge to indicate lubricating oil pressure when a pressurized lubricating system is provided
- (2) Temperature gauge to indicate cooling medium temperature when a liquid medium cooling system is used
- (3) Hour meter to indicate actual total running time
- (4) Battery-charging meter indicating performance of prime mover-driven battery charging means where required by 5.6.3.6.1
- (5) Other instruments as recommended or provided by the prime mover manufacturer where required for maintenance

5.6.3.4 The instruments required in 5.6.3.3(1) through 5.6.3.3(4) shall be placed on an enclosed panel, located in proximity to or on the energy converter, in a location that allows maintenance personnel to observe them readily. The enclosed panel shall be mounted by means of antishock vibration mountings if mounted on the energy converter.

5.6.3.5 All wiring for connection to the control panel shall be harnessed or flexibly enclosed, shall be securely mounted on the prime mover to prevent chafing and vibration damage, and shall terminate at the control panel in an enclosed box or panel. *(For control panel requirements, see 5.6.5.)*

5.6.3.6 The generator set shall be fitted with an integral accessory battery charger, driven by the prime mover and automatic voltage regulator, and capable of charging and maintaining the starting battery unit (and control battery, where used) in a fully charged condition during a running condition.

5.6.3.6.1 A battery charger driven by the prime mover shall not be required for Level 2 generators, provided the automatic battery charger, suitable for the battery technology, is capable of fully charging the starting battery within the time frame required by this standard while powering all loads connected to the starting batteries.

5.6.4 Prime Mover Starting Equipment.

5.6.4.1 Starting Systems. Starting shall be accomplished using either an electric starter or a stored energy starting system.

5.6.4.1.1 Electric starter systems shall start using a positive shift solenoid to engage the starter motor and to crank the prime mover for the period specified in 5.6.4.2 without overheating, at a speed at least equal to that recommended by the manufacturer of the prime mover and at the lowest ambient temperature anticipated at the installation site.

5.6.4.1.2 Other types of stored energy starting systems (except pyrotechnic) shall be permitted to be used where recommended by the manufacturer of the prime mover and subject to approval of the authority having jurisdiction, under the following conditions:

- (1) Where two complete periods of cranking cycles are completed without replacement of the stored energy
- (2) Where a means for automatic restoration from the emergency source of the stored energy is provided
- (3) Where the stored energy system has the cranking capacity specified in 5.6.4.2.1
- (4) Where the stored energy system has a “black start” capability in addition to normal discharge capability

5.6.4.2* Otto or Diesel Cycle Prime Movers. For otto or diesel cycle prime movers, the type and duration of the cranking cycle shall be as specified in Table 5.6.4.2.

Table 5.6.4.2 Starting Equipment Requirements

Starting Equipment Requirements	Level 1	Level 2
(a) Battery unit	X	X
(b) Battery certification	X	NA
(c) Cycle cranking	O	O
(d) Cranking limiter time-outs		
Cycle crank (3 cycles)	75 sec	75 sec
Continuous crank	45 sec	45 sec
(e) Float-type battery charger	X	X
dc ammeter	X	X
dc voltmeter	X	X
(f) Recharge time	24 hr	36 hr
(g) Low battery voltage alarm contacts	X	X

X: Required. O: Optional. NA: Not applicable.

5.6.4.2.1 A complete cranking cycle shall consist of an automatic crank period of approximately 15 seconds followed by a rest period of approximately 15 seconds. Upon starting and running the prime mover, further cranking shall cease.

5.6.4.2.2 Two means of cranking termination shall be utilized so that one serves as backup to prevent inadvertent starter engagement.

5.6.4.2.3 Otto cycle prime movers of 15 kW and lower and all diesel prime movers shall be permitted to use continuous cranking methods.

5.6.4.3* Number of Batteries. Each prime mover that is started with electrochemical batteries shall be provided with both of the following:

- (1) Storage battery units as specified in Table 5.6.4.2
- (2) A storage rack for each battery or battery unit

5.6.4.4* Size of Batteries. The battery unit shall have the capacity to maintain the cranking speed recommended by the prime mover manufacturer through two complete periods of cranking limiter time-outs as specified in Table 5.6.4.2, item (d).

5.6.4.5 Type of Battery. The battery shall be of the nickel-cadmium or lead-acid type.

Δ 5.6.4.5.1* Vented (flooded) and valve-regulated (VRLA) lead-acid batteries shall be furnished as charged unless they are drain-dry or dry-charged.

5.6.4.5.2 When furnished, vented nickel-cadmium batteries shall be filled and charged and shall have listed flip-top, flame arrester vent caps.

5.6.4.5.3 The manufacturer shall provide installation, operation, and maintenance instructions and, for batteries shipped dry, electrolyte mixing instructions.

5.6.4.5.4 Batteries shall not be installed until the battery charger is in service.

5.6.4.5.5 All batteries used in this service shall have been designed for this duty and shall have demonstrable characteristics of performance and reliability acceptable to the authority having jurisdiction.

5.6.4.5.6 Batteries shall be prepared for use according to the battery manufacturer's instructions.

Δ 5.6.4.6* Automatic Battery Charger. In addition to the prime mover-driven charger (alternator), where required by 5.6.3.6 and 5.6.3.6.1, a battery charger(s) shall be installed for maintaining a charge on both the starting and control batteries.

5.6.4.7 All chargers shall include the following characteristics, which are to be accomplished without manual intervention (i.e., manual switch or manual tap changing):

- (1) At its rated voltage, the charger shall be capable of delivering energy into a fully discharged battery unit without damaging the battery.
- (2) The charger shall be capable of returning the fully discharged battery to 100 percent of its ampere-hour rating within the time specified in Table 5.6.4.2, item (f).
- (3) As specified in Table 5.6.4.2, item (e), meters with an accuracy within 5 percent of range shall be furnished.
- (4) The charger shall be permanently marked with the following:
 - (a) Allowable range of battery unit capacity that can be recharged within the time requirements of Table 5.6.4.2
 - (b) Nominal output current and voltage
 - (c) Sufficient battery-type data to allow replacement batteries to be obtained
- (5) The battery charger output and performance shall be compatible with the batteries furnished.
- (6) Battery chargers used in Level 1 systems shall include temperature compensation for charge rate.

5.6.5 Control Functions.

Δ 5.6.5.1 A control panel shall be provided.

N 5.6.5.2 Control panels provided in accordance with 5.6.5.1 shall contain the following:

- (1) Automatic remote start capability
- (2) "Run-off-automatic" switch function
- (3) Shutdowns as required by 5.6.5.4(3)
- (4) Alarms as required by 5.6.5.4(4)
- (5) Controls as required by 5.6.5.4(5)
- (6) Load shed controls for Level 1 systems as required by 5.6.5.4(7)

Δ 5.6.5.3 Where a control panel is mounted on the energy converter, it shall be mounted by means of antivibration shock mounts, if required, to maximize reliability.

Δ 5.6.5.4 An automatic control and safety panel shall be a part of the EPS containing the following equipment or possess the following characteristics, or both:

- (1) Cranking control equipment to provide the complete cranking cycle described in 5.6.4.2 and required by Table 5.6.4.2
- (2) Panel-mounted control switch(es) marked **Run/Off/Automatic** to perform the following functions:
 - (a) *Run*: Manually initiate, start, and run prime mover
 - (b) *Off*: Stop prime mover or reset safeties, or both
 - (c) *Automatic*: Allow prime mover to start or stop by operating a remote contact.
- (3) Controls to shut down and lock out the prime mover under any of the following conditions:
 - (a) Failing to start after specified cranking time

- (b) Overspeed
- (c) Low lubricating-oil pressure
- (d) High engine temperature unless high temperature is due to high lubricating-oil temperature
- (e) Operation of remote manual stop station
- (4) Individual alarm indication to annunciate any of the conditions listed in Table 5.6.5.4 and with the following characteristics:
 - (a) Battery powered
 - (b) Visually indicated
 - (c) Have additional contacts or circuits for a common audible alarm that signals locally and remotely when any of the itemized conditions occurs
 - (d) Have a lamp test switch(es) to test the operation of all alarm lamps
- (5) Controls to shut down the prime mover upon removal of the initiating signal or manual emergency shutdown
- (6) The ac instruments listed in 5.6.9.9
- (7) Controls to shed Level 2 loads and to initiate an overload alarm for EPS that serves both Level 1 and Level 2 loads, per Table 5.6.5.4

5.6.5.5 Engines equipped with a maintaining shutdown device (air shutdown damper) shall have a set of contacts that monitor the position of this device, with local alarm indication and remote annunciation in accordance with Table 5.6.5.4.

5.6.5.6 The control panel in 5.6.5.4(4) shall be specifically approved for either a Level 1 or a Level 2 EPS consistent with the installation.

5.6.5.7 The cranking cycle shall be capable of being initiated by any of the following:

- (1) Manual start initiation as specified in 5.6.5.4(2)(a).
- (2) Loss of normal power at any automatic transfer switch (ATS) as part of the EPSS. Prime mover shall start after appropriate time delays, upon operation of a remote switch or set of contacts.
- (3) Clock exerciser located in an ATS or in the control panel.
- (4) Manually operated (test) switch located in each ATS that simulates a loss of power and causes automatic starting and operation until this switch is reset, to cause the engine circuit to duplicate its functions in the same manner commercial power is restored after a true commercial power failure.

▲ Table 5.6.5.4 Safety Indications and Shutdowns

Indicator Function (at Battery Voltage)	Level 1			Level 2		
	CV	S	RA	CV	S	RA
(a) Overcrank	X	X	X	X	X	O
(b) Low water temperature	X	N/A	X	X	N/A	O
(c) High engine temperature prealarm	X	N/A	X	O	N/A	N/A
(d) High engine temperature	X	X	X	X	X	O
(e) Low lube-oil pressure	X	X	X	X	X	O
(f) Overspeed	X	X	X	X	X	O
(g) Low fuel main tank	X	N/A	X	O	N/A	O
(h) Low coolant level	X	O	X	X	O	X
(i) EPS supplying load	X	N/A	N/A	O	N/A	N/A
(j) Control switch not in automatic position	X	N/A	X	X	N/A	X
(k) High battery voltage	X	N/A	N/A	O	N/A	N/A
(l) Low cranking voltage	X	N/A	X	O	N/A	O
(m) Low voltage in battery	X	N/A	N/A	O	N/A	N/A
(n) Battery charger ac failure	X	N/A	N/A	O	N/A	N/A
(o) Lamp test	X	N/A	N/A	X	N/A	N/A
(p) Contacts for local and remote common alarm	X	N/A	X	X	N/A	X
(q) Audible alarm silencing switch	N/A	N/A	X	N/A	N/A	O
(r) Low starting air pressure	X	N/A	N/A	O	N/A	N/A
(s) Low starting hydraulic pressure	X	N/A	N/A	O	N/A	N/A
(t) Air shutdown damper when used	X	X	X	X	X	O
(u) Remote emergency stop	N/A	X	N/A	N/A	X	N/A
(v) Overload alarm/load shed contact	X	N/A	X	N/A	N/A	N/A

CV: Control panel-mounted visual. S: Shutdown of EPS. RA: Remote audible. X: Required. O: Optional. N/A: Not applicable.

Notes:

- (1) Item (p) shall be provided, but a separate remote audible signal shall not be required when the regular work site in 5.6.6 is staffed 24 hours a day.
- (2) Item (b) is not required for combustion turbines.
- (3) Item (r) or (s) shall apply only where used as a starting method.
- (4) Item (i) EPS ac ammeter shall be permitted for this function.
- (5) All required CV functions shall be visually annunciated by a remote, common visual indicator.
- (6) All required functions indicated in the RA column shall be annunciated by a remote, common audible alarm as required in 5.6.5.2(4).
- (7) Item (g) on gaseous systems shall require a low gas pressure alarm.
- (8) Item (b) shall be set at 11°C (20°F) below the regulated temperature determined by the EPS manufacturer as required in 5.3.1.