Section 10:

Emergency and Standby Power Systems

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Introduction

Emergency and standby power systems are designed to provide an alternate source of power if the normal source of power, most often the serving utility, should fail. As such, reliability of these types of systems is critical and good design practices are essential.

Code and standards

A.) Classification of emergency and standby power systems

The classification of emergency and standby power systems is as follows:

Emergency Power System: Defined in IEEE Std. 446-1995 [1] as "an independent reserve source of electric energy that, upon failure or outage of the normal source, automatically provides reliable electric power within a specified time to critical devices and equipment whose failure to operate satisfactorily would jeopardize the health and safety of personnel or result in damage to property.

The NEC [2] gives a slightly different definition for Emergency Systems as "those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction. These systems are intended to automatically supply illumination, power, or both, to designated areas and equipment in the event of failure of the normal supply or in the event of accident to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life."

Standby Power System: Defined in [1] as "an independent reserve source of electric energy that, upon failure or outage of the normal source, provides electric power of acceptable quality so that the user's facilities may continue in satisfactory operation.

The NEC [2] divides standby power systems into two categories, as follows:

Legally Required Standby Systems: Those systems required and so classed as legally required standby by municipal, state, federal, and other codes or by any governmental agency having jurisdiction. These systems are intended to automatically supply power to selected load (other than those classed as emergency systems) in the event of failure of the normal source. FPN: Legally required standby systems are typically installed to serve loads, such as heating and refrigeration systems, communications systems, ventilation and smoke removal systems, sewage disposal, lighting systems, and industrial processes that, when stopped during any interruption of the normal electrical supply, could create hazards or hamper rescue and fire-fighting operations.

Optional Standby Systems: Those systems intended to supply power to public or private facilities or property where life safety does not depend on the performance of the system. Optional standby systems are intended to supply on-site generated power to selected loads either automatically or manually. FPN: Optional standby systems are typically installed to provide an alternate source of electric power for such facilities as industrial and commercial buildings, farms, and residences and to serve loads such as heating and refrigeration systems, data processing and communications systems, and industrial processes that, when stopped during any power outage, could cause discomfort, serious interruption of the process, damage to the product or process, and the like.

B.) IEEE Standard 446-1995

IEEE Standard 446-1995, *IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications* [1], is a general engineering reference for the design of these systems.

C.) The National Electrical Code

The National Electrical Code [2] contains requirements for emergency systems in Article 700, Legally-Required Standby Systems in Article 701, and Optional Standby Systems in Article 702. In addition, Article 445 (Generators), 517 (Health Care Facilities), 665 (Integrated Electrical Facilities), and 705 (Interconnected Electrical Power Production Sources) are all of particular interest for emergency and standby power systems.

The NEC [2] requirements for emergency and standby power systems are discussed in further detail below.

D.) NFPA 110

NFPA 110 [3], *Standard for Emergency and Standby Power Systems*, defines how emergency and standby power systems are to be installed and tested. It contains requirements for energy sources, transfer equipment, and installation and environmental considerations. It divides emergency power systems into *Types, Classes, and Levels*.

The *Type* refers to the maximum time that an emergency power system can remain unpowered after a failure of the normal source. The Types are listed in table 10-1 [3]:

Table 10-1: NFPA 110 emergency power system types (essentially the same as [3] table 4.1(B))

Type	Power restoration time
U	Basically Uninterruptible (UPS Systems)
10	10 sec
60	60 sec
120	120 sec
M	Manual stationary or nonautomatic – no time limit

The *Class* of an emergency power system refers to the minimum time, in hours, for which the system is designed to operate at its rated load without being refueled or recharged. The Classes for emergency power systems are shown in table 10-2 [3]:

Table 10-2: NFPA 110 emergency power system classes (essentially the same as [3] table 4.1(B))

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

The *Level* of an emergency power system refers to the level of equipment installation, performance, and maintenance requirements. The Levels for emergency power systems are shown in table 10-3 [3]:

Table 10-3: NFPA emergency power system levels

Level	When Installed
1	When failure of the equipment to perform could result in loss of human life or serious injuries
2	When failure of the equipment to perform is less critical to human life and safety and where the authority having jurisdiction shall permit a higher degree of flexibility than that provided by a level 1 system

E.) NFPA 101

NFPA 101 [4], *Life Safety Code*, addresses those construction, protection, and occupancy features necessary to minimize danger to life from fire, including smoke, fumes, or panic. It defines the requirements for what systems the Emergency Power System will supply.

F.) NFPA 99

NFPA 99 defines establishes criteria to minimize the hazards of fire, explosion, and electricity in health care facilities. It defines several specific features of electric power systems for these facilities.

Reasons for application

Emergency and standby power systems are generally designed into the over-all electrical system for one of the following two reasons:

- Legal Requirements – As required by the NEC [2] NFPA 101 [4], NFPA 99 [5], and other local, state, and federal codes and requirements. These are concerned with the safety of human life, protection of the environment, etc.
- Economic Considerations – Continuous process applications often require a continuous source of electrical power to avoid significant economic loss. In some cases even a momentary loss of power can be disastrous.

Co-generation systems which are used to sell power back to the utility as part of an energy management strategy are not discussed in this section.

Power sources

Generators are by far the most prevalent source of power for emergency and standby power systems. For most commercial and industrial power systems these will be engine-generator sets, with the prime-mover and the generator built into a single unit. For reciprocating engines, diesel engines are the most popular choice of prime-mover for generators, due to the cost of the diesel engines as compared to other forms of power and the relative ease of application. Gasoline engine generator sets are also available and are generally less expensive than diesel generator sets, but suffer from the disadvantages of higher operating costs, greater fuel storage hazards, and shorter fuel storage life as compared to diesel. Diesel engines can also run on natural gas, although for maximum efficiency specially-tuned engines for natural gas use are available.

The other alternative for generators is the turbine generator, typically powered by natural gas. Gas-turbine generator sets are generally lighter in weight than diesel engine-generator sets, run more quietly, and generally require less cooling and combustion air, leading to lower installation costs. However, gas-turbine generator sets are more expensive than diesel engine-generator sets, and require more starting time (normally around 30 s compared to the 10-15 seconds for diesels). The long starting-time requirement and lack of available small sizes (< 500 kW) makes the gas-turbine generators infeasible in many applications.

Generator installations must consider the combustion and cooling air required by the generator and prime mover, as well as the provisions for the removal of exhaust gasses. Noise abatement must also be considered. These considerations increase the installation costs, especially for reciprocating-engine units such as diesel or gasoline engines. Further, the fuel supply must be considered; building code and insurance considerations may force the fuel storage tank to be well removed from the generator(s), usually forcing the addition of a fuel transfer tank near the generator(s).

Care must be taken when sizing engine-generator sets for a given application since several ratings exist for the output capability of a given machine. The *continuous rating* is typically the output rating of the engine-generator set on a continuous basis with a non-varying load. The *prime power rating* is typically the continuous output rating with varying load. The *standby rating* is typically the output rating for a limited period of time with varying load. The manufacturer must be consulted to define the capabilities of a given unit.

A second alternative for emergency or standby system power is a second utility source. However, the procurement of a second utility source which is sufficiently independent from the normal service may be economically infeasible.

Solid-state converters that invert DC voltage from a battery system are another alternative, although they can be difficult to apply and generally are not available in the larger sizes that may be needed for a medium to large emergency or standby system.

Because motor starting and block loading can have a big effect on the output voltage and frequency of a small generator such as the engine-generator sets described above, and also because power is not available during the engine starting period, a buffer between the generators and sensitive load equipment is generally required. The Uninterruptible Power Supply (UPS) is usually the buffer of choice for these applications. UPS's are available in several different topologies, but the operational goals are the same regardless of topology: The supply of uninterrupted power to sensitive, critical loads. The most popular topology for a UPS is the double conversion topology, as shown in figure 10-1:

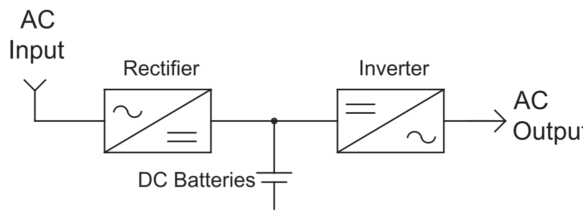

Figure 10-1: Double-conversion UPS topology

So long as the batteries are properly maintained, the AC output should not be affected by change in frequency or voltage, or even a complete loss, at the input, so long as backup time of the UPS is not exceeded. Other topologies exist, including the *line interactive, double-conversion rotary, hybrid rotary, and line-interactive rotary* topologies, each with advantages and disadvantages of application. UPS systems do not alleviate the need for a generator or second utility service power source, but they do serve to buffer critical loads from the effects of generator starting time and voltage and frequency variations.

Switching devices

A means must be provided to switch the critical loads from the normal utility source to the standby power source. Several types of device are available for this.

An *automatic transfer switch* is defined as "self-acting equipment for transferring one or more load conductor connections from one power source to another" [1]. The automatic transfer switch is the most common means of transferring critical loads to the emergency/standby power supply. An automatic transfer switch consists of a switching means and a control system capable of sensing the normal supply voltage and switching over to the alternate source should the normal source fail. Automatic transfer switches are available in ratings from 30-50 A, and up to 600V [1]. Because automatic transfer switches are designed to continuously carry the loads they serve, even under normal conditions, care must be used in sizing these so that the potential for failure is minimized. Automatic test switches with adjustable pickup and dropout setpoints and integral testing capability are generally preferred. An automatic transfer switch is generally an open-transition device that will not allow paralleling of the two sources. Manual versions of transfer switches are also available. A one-line representation of an automatic transfer switch is shown in figure 10-2.

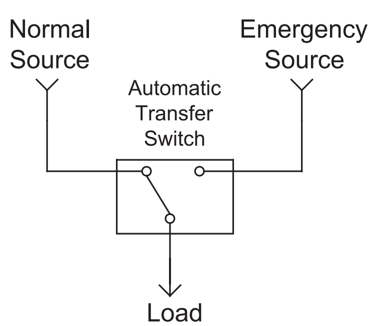

Figure 10-2: Automatic transfer switch one-line diagram representation

Other options for transferring devices include electrically-operated circuit breakers, as described in “System protection” section (section7 in this guide). For medium voltage transfers, medium voltage circuit breakers are generally used. Manual versions of circuit-breaker transferring schemes are, of course, also available.

Bypass/isolation switches, as their name suggests, are used to bypass an automatic transfer switch (or other switching means) and connect the source directly to the load and allow isolation of the transfer switch for maintenance. Figure 10-3 shows a typical bypass/isolation switch arrangement along with the transfer switch:

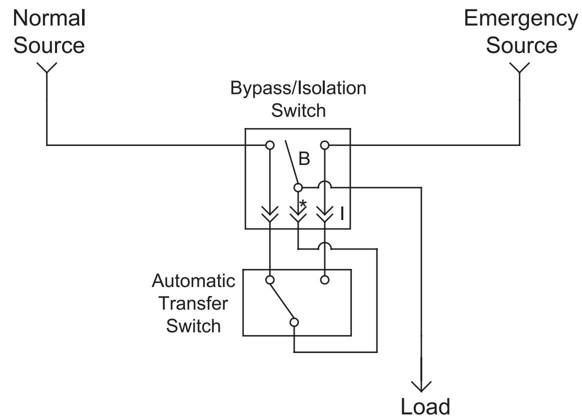

Figure 10-3: Bypass/isolation switch application

In figure 10-3 the bypass blade “B” serves to bypass the automatic transfer switch, and isolating contacts “I” serve to isolate the automatic transfer switch. Bypass/isolation switches are typically manually-operated devices. Bypass/isolation switches are available with a test position in which only the ATS-to-load isolation contact (marked with an asterisk [*] in figure 10-3) is open, allowing the transfer switch to be operated without disconnecting the load.

Static Transfer Switches are typically used when high-speed (~4ms) operation is required. The most common application is to bypass a UPS so that a UPS failure will not result in interruption of service to the load.

System arrangements

Various ways of arranging emergency and standby power systems exist. The most common arrangements are given here.

A.) Basic arrangement – radial system

The most basic arrangement for an emergency or standby power system is shown in figure 10-4. This can be recognized as an extension of the single-source radial system from “System arrangements” section (section 5 of this guide), figure 5-2, with the transformer omitted. The transfer switch transfers the emergency/standby loads to the alternate source upon failure of the normal source. This arrangement extends the same inherent weaknesses of the radial system to the emergency system, since a single failure of one piece of equipment can result in loss of service to the emergency/standby loads. Note that the single generator shown may be several engine-generator sets operating in parallel, if necessary. This simple system may be expanded to the other system types in Section 5.

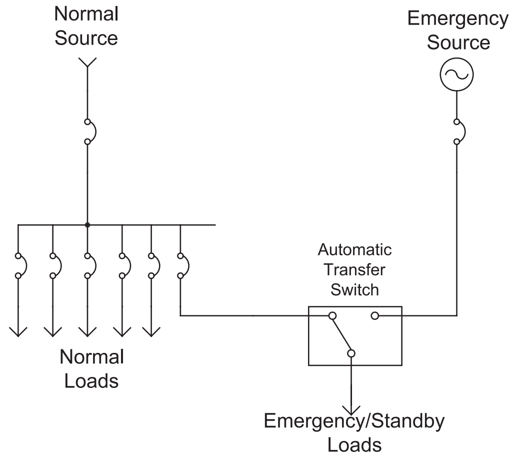

Figure 10-4: Simple emergency/standby system arrangement

B.) More complex systems

The basic arrangement from figure 10-4 may be extended to the other system arrangements shown in Section 5. For example, the secondary-selective system, shown in figure 5-8, could be equipped with an emergency system as shown in figure 10-5:

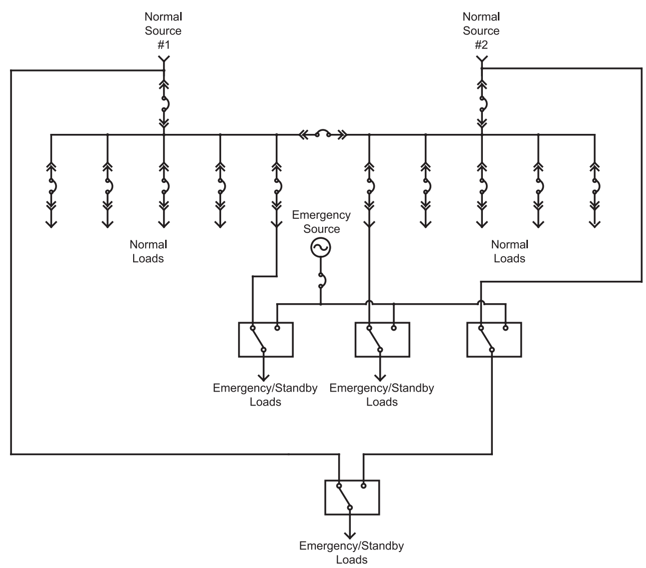

Figure 10-5: Example of a more complex emergency/standby system arrangement

In figure 10-5, the emergency/standby load at the bottom of the figure will always be supplied by one of the normal sources if possible, and by the generator(s) if not. This will avoid the generator starting time for this load if one utility source were to fail. The two emergency/standby loads in the middle of the figure will be supplied by their respective switchboard busses or by the emergency source.

Emergency/standby systems are not limited to the low voltage level. For example, the primary selective/primary loop/secondary selective system shown in figure 5-14 can be expanded to include an emergency system, as shown in figure 10-6:

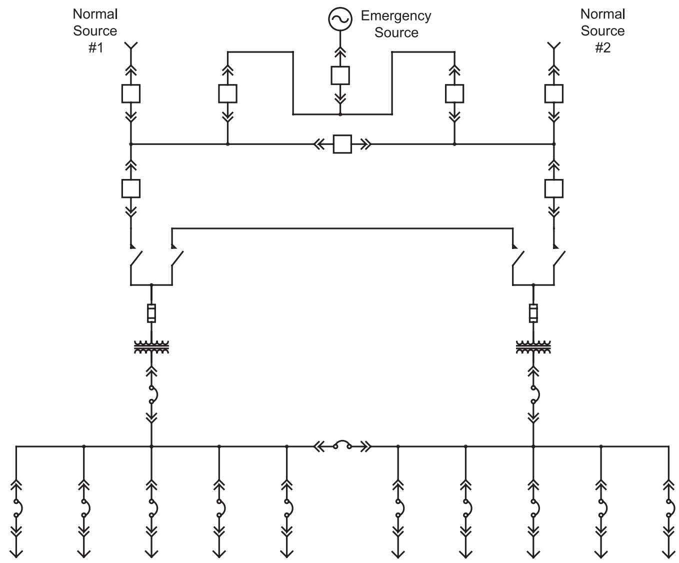

Figure 10-6: Medium voltage emergency/standby system implementation

In figure 10-6 there is a great deal of flexibility in the system operation. However, instead of automatic transfer switches metal-clad switchgear is used increasing the complexity of the system.

C.) Hospital arrangements

NFPA 99 [5] and the NEC [2] have very unique requirements for the design of a hospital emergency system. The emergency system is classified into the essential electrical system, which is comprised of “alternate sources of power and all connected distribution systems and ancillary equipment, designed to ensure continuity of electrical power to designated areas and functions of a health care facility during disruption of disruption of normal power sources,” and the emergency system itself, which is “a system of circuits and equipment intended to supply alternate power to a limited number of prescribed functions vital to the protection of life and safety” [2]. The emergency system is a part of the essential electrical system. The minimum arrangement, for hospitals 150 kVA or less, is shown in figure 10-7. The minimum requirement over 150 kVA is shown in figure 10-8.

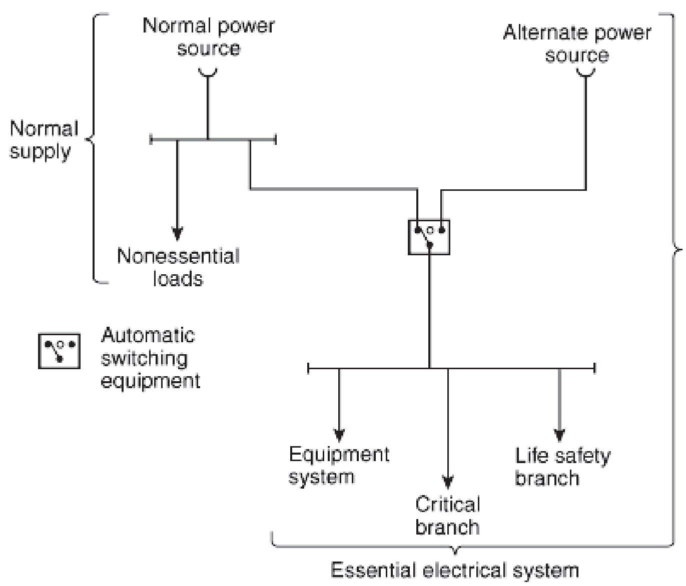

Figure 10-7: Minimum requirement per NEC [2] and NFPA 99 [5] for essential electrical system for hospitals 150 kVA or Less (same as [2] FPN figure 517.30 No.2)

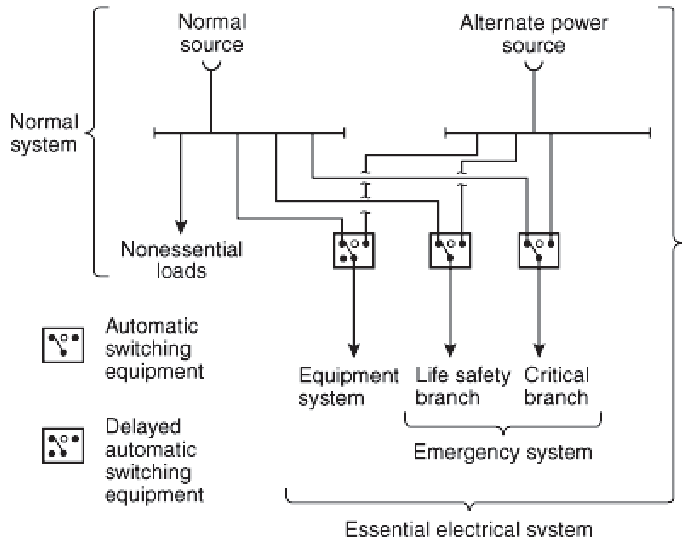

Figure 10-7: Minimum Requirement per NEC [2] and NFPA 99 [5] for Essential Electrical system for Hospitals over 150 kVA (same as [2] FNP figure 517.30 No. 1)

The essential electrical system supplies the *equipment system,* defined as "a system of circuits and equipment arranged for delayed, automatic, or manual connection to the alternate power source and that serves primarily 3-phase power equipment" [2]. The emergency system supplies, which itself part of the essential electrical system, supplies the *life safety branch*, which is "a subsystem of the emergency system consisting of feeders and branch circuits…intended to provide adequate power needs to insure safety to patients and personnel" [2]. The emergency system also supplies the critical branch, which is "a subsystem of the emergency system consisting of feeders and branch circuits supplying energy to task illumination, special power circuits, and selected receptacles serving areas and functions related to patient care" [2]. For hospitals of 150 kVA and less the equipment system, life safety branch, and critical branch may be on the same transfer switch. Note that the transfer switch(es) for the equipment system above 150 kVA is required to be delayed.

NEC requirements

The following are highlights from the NEC [2] requirements for emergency and standby power systems. This is not intended to list all NEC requirements for these systems, but to illustrate the major points that apply in the most common installations and affect the power system design. For the full text of the complete NEC requirements for these systems, consult the NEC.

A.) Emergency systems (Article 700)

The NEC definition for an emergency system was given at the beginning of this section. These requirements apply to those systems meeting this definition:

- Witness Test: The authority having jurisdiction must conduct or witness a test of the complete system and periodically afterward. [700.4 (A)]
- Emergency systems must be tested periodically on a schedule acceptable to the authority having jurisdiction to ensure the systems are maintained in proper operating condition. A written record must be kept of these tests. [700.4 (B), (C), and (D)]
- Battery systems that are part of the emergency system must be periodically maintained. [700.4 (B)]
- A means for testing all emergency lighting and power systems during maximum anticipated load conditions must be provided. [700.4 (E)]
- The alternate power source is required to be sized to supply all emergency loads simultaneously. [700.5 (A)]

- The alternate power source is permitted to supply emergency, legally required standby, and optional standby system loads where the source has adequate capacity or where automatic selective load pickup or load shedding is provided to insure adequate power to the emergency, legally required standby, and optional standby system loads. If these requirements are met the system may also be used for peak load shaving. Peak load shaving operation may satisfy the requirement for periodic testing if acceptable to the authority having jurisdiction. A portable or temporary alternate source must be available if the emergency generator is out of service for repair. [700.5 (B)]
- Transfer equipment must be automatic, identified for emergency use, and approved by the authority having jurisdiction. Automatic transfer switches must be electrically operated and mechanically held. [700.6 (A) and (C)]
- Transfer equipment must supply only emergency loads. [700.6 (D)]
- Audible and visual signal devices must be provided for indication of derangement of the emergency source, that the battery is carrying load, that the battery is not functioning, and to indicate a ground fault in solidly-grounded wye systems of more than 150 V to ground and over 1000 A. The sensor for ground-fault indication must be located at or ahead of the main system disconnecting means for the emergency source. [700.7]
- A sign must be placed at the service entrance equipment, indicating the type and location of on-site emergency power sources. A sign is also required where the grounded circuit conductor connected to the emergency source is connected to a grounding electrode conductor at a location remote from the emergency source. [700.8]
- All boxes and enclosures for emergency circuits must be permanently marked so that they will be readily identified as a component of an emergency circuit or system. [700.9 (A)]
- Wiring from an emergency source or emergency source distribution overcurrent protection to emergency loads must be kept entirely independent of all other wiring and equipment. Exceptions apply where load equipment must have wiring from two sources. [700.9 (B)]
- For occupancies of not less than 1000 persons or in buildings above 75 ft. in height with assembly, educational, residential, detention/correctional, business, or mercantile occupancy class the feeder circuit wiring must be 1.) installed in spaces or areas that are fully protected by an approved automatic fire suppression system, or 2.) be a listed electrical circuit protective system with a 1-hour fire rating, or 3.) be protected by a listed thermal barrier system for electrical system components, or 4.) be protected by a fire-rated assembly listed to achieve a minimum fire rating of 1 hour, or 5.) be embedded in not less than 50mm of concrete. Feeder circuit equipment must be either in spaces fully protected by a approved automatic fire suppression systems or in spaces with a 1-hour fire resistance rating. [700.9 (D)]
- In the event of failure of the normal supply to, or within, the building or group of buildings concerned, emergency lighting, power, or both, must be available within the time required by the application but not to exceed 10 seconds.
- The alternate source of power must be a storage battery, generator set, UPS, separate service, or fuel cell system, each with restrictions on its use. [700.12 (A), (B), (C), (D), and (E)].
- Storage batteries must have sufficient capacity to supply and maintain the total load for a minimum period of one hours, without the voltage applied to the load falling below 87% of nominal. The battery charging means must be automatic. [700.12 (A)]
- Generator sets must have a prime-mover acceptable to the authority having jurisdiction, and means of automatically starting the prime mover on failure of the normal service. If the prime-mover is an internal combustion engine, an on-premises fuel supply must be provided to allow not less than 2 hours full-demand operation of the system. If power is required for operation of fuel transfer pump to deliver fuel to a generator set day tank, this pump must be connected to the emergency power system. Generator sets must not be solely dependent on a public utility gas system for their fuel supply for a municipal water supply for their cooling systems. If dual supplies for these are used, means must be provided to automatically transfer from one supply to the other. If a storage battery is used for control or signal power or as the means of starting the prime mover, it must be equipped with an automatic charging means independent of the generator set. Where power is required for the operation of the dampers used to ventilate the generator set, the dampers must be connected to the emergency system. [700.12 (B) (1), (2), (3), and (4)]

- If a generator set requires more than 10 seconds to develop power, an auxiliary power supply that energizes the emergency system until the generator can pick up the load is permitted. [700.12 (B) (5)]
- Outdoor generator sets do not require an additional disconnecting means where the ungrounded conductors serve or pass through the building or structure, so long as they are equipped with a readily-accessible disconnecting means located within sight of the building or structure supplied. [700.12 (B)(6)]
- UPS's used to provide power for emergency systems must comply with the applicable provisions for battery systems and generators.
- An additional utility service is permitted to be the power source for the emergency system, if acceptable to the authority having jurisdiction. A separate service drop or service lateral and service conductors sufficiently remote electrically and physically from other service conductors to minimize the possibility of simultaneous interruption of supply must be supplied. [700.12 (D)]
- Fuel cell systems must be capable of supplying and maintaining the total load for not less then two hours of full-demand operation. Fuel cell systems must meet the requirements of Parts II through VIII of Article 692 (Fuel Cell Systems). A single fuel cell that serves as the normal source for the building or group of buildings concerned cannot serve as the alternate source. [700.12(E)]
- Individual unit equipment for emergency illumination must have a rechargeable battery, a battery charging means, provisions for one or more lamps mounted on the equipment or terminals for remote lamps, and a relaying device arranged to energize the lamps automatically upon failure of the supply to the unit equipment. The battery must be capable of supplying the lamps for no less than one hours at not less than 60% of the initial illumination level. [700.12 (F)]
- Individual unit equipment for emergency illumination must be fixed in place. Flexible cord-and-plug installation is permitted if the cord is no more than 3ft. in length. The branch circuit feeding the unit equipment must be the same as that serving normal lighting in the area and connected ahead of any local switches, and must be clearly identified at the distribution panel. Alternatively, for areas with at least three normal lighting branch circuits the emergency illumination unit equipment may be supplied by a separate branch circuit with a lock-on feature. [700.12 (F)]
- No appliances or lamps, other than those specified for emergency use, are allowed on emergency lighting circuits. [700.15]
- Emergency illumination must include all required means of egress lighting, illuminated exit signs, and all other lights specified as necessary to provide required illumination. Failure of any individual lighting element must not leave in total darkness any space that requires emergency illumination. If HID lighting is used as emergency illumination, it must operate until normal illumination has been restored. [700.16]
- Emergency lighting must have either an emergency lighting supply, with provisions for automatically transferring the emergency lights upon the event of failure of the general lighting system supply, or two or more separate and complete systems with independent power supplies, each providing sufficient current for emergency lighting purposes. If two systems are used, means must be provided for automatically energizing either system upon failure of the other unless they are both kept lighted. [700.17]
- All branch circuits that supply equipment classed as emergency equipment must have an emergency supply source to which the load will be transferred upon the failure of the normal supply. [700.18]
- Emergency lighting circuits must be arranged so that only authorized persons have control of emergency lighting. Exceptions apply. [700.20]
- Switches in series or 3- and 4-way switches cannot be used in emergency lighting circuits. [700.20]
- Control switches for emergency lighting must be in convenient locations for authorized persons. In assembly occupancies or theaters, audience areas of motion picture studios, and performance areas, a switch for controlling emergency lighting systems must be in the lobby or at a place conveniently accessible thereto. [700.21]
- Emergency lighting on the exterior of a building that is not required for illumination when there is sufficient daylight may be controlled by an automatic light-actuated device. [700.22]

- The branch-circuit overcurrent devices in emergency circuit must be accessible to authorized persons only. [700.25]
- The alternate source for emergency systems is not required to have ground-fault protection of equipment. Ground-fault indication is required. [700.26]
- Emergency system(s) overcurrent devices must be selectively coordinated with all supply-side overcurrent protective devices. [700.27]

B.) Legally required standby systems (Article 701)

- System periodic testing and maintenance requirements are essentially the same as for emergency systems, except that the authority having jurisdiction is only required to witness the test upon installation. [701.5]
- The legally required standby system alternate power source is permitted to supply both legally required standby system and optional standby system loads, provided that it either has enough capacity to handle all connected loads or that automatic selective load pickup and load shedding is provided that will ensure adequate power to the legally required standby circuits. [701.6]
- Requirements for transfer equipment are essentially the same as for emergency systems, except that no restriction is placed upon the use of transfer equipment use for other systems in addition to the legally required standby system. [701.7]
- Audible and visual signal devices must be provided for indication of derangement of the standby source, that the standby source is carrying load, and that the battery charger is not functioning. [701.8]
- Signage requirements are essentially the same as for emergency systems. [701.9]
- Wiring for legally required standby systems is permitted to occupy the same raceways, cables, boxes, and cabinets with other general wiring. [701.10]
- In the event of failure of the normal supply to, or within, the building or group of buildings concerned, legally required standby power must be available within the time required by the application but not to exceed 60 seconds.
- The alternate source of power must be a storage battery, generator set, UPS, separate service, connection ahead of the service disconnecting means, or fuel cell system, each with restrictions on its use. [701.11 (A), (B), (C), (D), (E), and (F)]
- The requirements for storage batteries, generator sets, UPS's, separate utility service, and fuels cells as the standby power source are essentially the same as for emergency systems, except the requirements for fuel transfer pumps and ventilation dampers to be connected to the system for generator sets. [701.11 (A)]
- Where acceptable to the authority having jurisdiction, connections ahead of but not within the same cabinet, enclosure, or vertical switchboard section as the service disconnecting means may serve as the standby power source. This connection ahead of the normal service must be sufficiently separated from the normal main service disconnecting means to prevent simultaneous interruption of supply. [701.11 (D)]
- The requirements for individual unit equipment for legally required standby illumination are essentially the same as for emergency illumination individual unit equipment. [701.11 (G)]
- Legally-required standby system overcurrent protection requirements are essentially the same as for emergency systems, except that ground-fault indication is not required. [701.15, 701.17, 701.18]

C.) Optional standby systems (Article 702)

- Transfer equipment is required, except in the case of temporary connection of a portable generator where conditions of maintenance and supervision ensure that only qualified persons service the installation and where normal supply is physically isolated by a lockable disconnect means or by disconnection of supply conductors. [702.6]
- Audible and visual signal devices must be provided for indication of derangement of the standby source and to indicate that the optional standby source is carrying load. [702.7]

- Signage requirements are essentially the same as for emergency and legally required standby systems. [702.8]
- Wiring for optional standby systems is permitted to occupy the same raceways, cables, boxes, and cabinets with other general wiring. [702.9]
- Where a portable optional standby source is used as a separately derived system, it must be grounded to a grounding electrode in accordance with Article 250.30. Where a portable optional standby source is used as a non-seperately derived system, the equipment grounding conductor must be bonded to the system grounding electrode. [702.10]
- Outdoor generator sets do not require an additional disconnecting means where the ungrounded conductors serve or pass through the building or structure, so long as they are equipped with a readily-accessible disconnecting means located within sight of the building or structure supplied. [702.11]

D.) Health care facility essential electrical systems (Article 517 part III)

- The essential electrical system is required to serve a limited amount of lighting and power service, which is considered essential for life safety and orderly cessation of procedures during the time normal service is interrupted for any reason. This includes clinics, medical and dental offices, outpatient facilities, nursing homes, limited care facilities, hospitals, ad other health care facilities serving patients. [517.25]
- The essential electrical system must meet the requirements of Article 700 (Emergency Systems), except as amended by Article 517. [517.26]
    - **Hospitals (Articles 517.30 – 517.35)**
        - The essential electrical systems for hospitals must comprised of two separate systems: The emergency system and the equipment system. The emergency system must be limited to circuits essential to life safety and to critical patient care, designated as the life safety branch and the critical branch. The equipment system must supply major electrical equipment necessary for patient care and basic hospital operation. [517.30 (B) (1), (2), and (3)]
        - The number of transfer switches used must be based on reliability, design, and load considerations. One transfer switch is permitted to serve one or more branches or systems in a facility with a maximum demand on the essential electrical system of 150 kVA. [517.30 (B) (4)]
        - Other loads not specifically mentioned in Article 517 must be served with their own transfer switches. These loads must not be transferred to the essential electrical system generating equipment if the transfer will overload the equipment, and they must be automatically shed upon generating equipment overloading. [517.30 (B)(5)]
        - The life safety and critical branch circuit wiring must be kept independent of all of other wiring and equipment and must not enter the same raceways, boxes, or cabinets with each other or other wiring. Exceptions apply where transfer or load equipment must have wiring from two sources. Wiring for the equipment system is permitted to occupy the same raceways boxes, or cabinets of other circuits that are not part of the emergency system. [517.30 (C)]
        - All wiring of the emergency system must be mechanically protected. Nonflexible metal raceways, type MI cable, or Schedule 80 rigid nonmetallic conduit are permitted, except that nonmetallic raceways cannot be used for branch circuits that supply patient care areas. Schedule 40 rigid nonmetallic conduit, flexible nonmetallic or jacketed metallic raceways, or jacketed metallic cable assemblies listed for installation in concrete may be used if encased in no less than 2 in. of concrete. Listed flexible metal raceways and listed metal sheathed cable assemblies may be used under certain conditions. Flexible power cords of appliances or other utilization equipment and secondary circuits of Class 2 or Class 3 communications or signaling systems are exempted from being run in metal raceways. [517.30 (C) (3)]
        - Generator sizing may be based upon demand calculations rather than on the entire load operating simultaneously as required in 700.5. [517.30 (D)]
        - All receptacles supplied by the emergency system must have a distinctive color or marking. [517.30 (E)]

- The life safety branch is permitted to supply only illumination of egress means, exit signs, alarm and alerting systems, communications systems used during emergency conditions, task illumination at the generator set location, elevator cab lighting, control, communications, and signal systems, and automatic doors. [517.32]
- The critical branch is permitted to supply task illumination and selected receptacles in critical care areas, isolated power systems in special environments, task illumination and selected receptacles for selected patient care areas, general care beds, selected labs, additional patient care task illumination and receptacles as needed, nurse call systems, blood, bone, and tissue banks, telephone equipment rooms and closets, etc. (complete list given in the NEC text). [517.33]
- The critical branch may be subdivided into two or more branches. [517.33 (B)]
- Delayed automatic connection to the equipment system must be provided for central suction systems, sump pumps, compressed air systems, smoke control and stair pressurizing systems, kitchen hood supply or exhaust systems, and supply, return, and exhaust ventilating systems for selected locations (complete list given in NEC text). [517.34 (A)]
- Delayed automatic or manual connection to the equipment system must be provided for selected heating equipment, selected elevators, hyperbaric and hypobaric facilities, automatically operated doors, selected electrically-heated autoclaving equipment, and other selected equipment. [complete list given in NEC text and NFPA 99:4.2.2.2.3.5(9)] [517.34 (B)]
- Generator accessories, such as the transfer fuel pump, electrically operated louvers, and other accessories essential for generator operation, must be arranged for non-delayed automatic connection to the alternate power source via the equipment system.
- A minimum of two sources of power are required, one normal, one alternate. The alternate source may be generator(s) on the premises, an external utility service if the normal service is a generator(s) on the premises, or a battery system.

◆ **Nursing homes and limited care facilities (Article 517.40 – 517.44)**

- Applicability depends upon the type of care given at the facility. Specific exceptions are listed for certain types of facilities (see NEC text for details). If a nursing home provides inpatient hospital care, it must conform to the requirements for hospitals. Nursing homes and limited care facilities that are contiguous or located on the same site with a hospital are permitted to have their essential electrical systems supplied by the hospital. [517.40]
- The essential electrical system must be comprised of two separate branches: The life safety branch and the critical branch. [517.41 (A)]
- Requirements for transfer switches are essentially the same as for hospitals. [517.41 (C)]
- The life safety branch must be kept entirely independent of all other wiring and equipment and must not enter the same raceways, boxes, or cabinets with other wiring. Exceptions apply where transfer or load equipment must have wiring from two sources. [517.41 (D)]
- Requirements for receptacle identification are essentially the same as for hospitals. [517.41 (E)]
- The life safety branch must be automatically restored via the alternate power source within 10 seconds after interruption of the normal source. [517.42]
- The life safety branch must supply only illumination of means of egress, exit signs, alarm and alerting systems, communications systems used during emergency conditions, dining and recreation areas, task illumination at the generator set location, and elevator cab lighting, control, communications, and signal systems.
- Delayed automatic connection to the critical branch must be provided for task illumination and selected receptacles in selected patient care areas, sump pumps and other equipment required to operate for the safety of major apparatus and associated control systems and alarms, smoke control and stair pressurization systems, kitchen hood supply and/or exhaust systems if required to operate during a fire in or under the hood, and supply, return, and exhaust ventilating systems for airborne infections isolation rooms (complete list given in NEC text). [517.43(A)]

- Delayed automatic connection to the critical branch must be provided for heating equipment to provide heating for patient rooms (exceptions apply), elevator service and additional illumination, receptacles, and equipment. [517.43 (B)]
- The alternate source of power must be a generator(s) located on the premises unless the normal source is a generator(s) on the premises, in which case the alternate source may be either another generator set or external utility service. In certain cases a battery system may be used (see NEC text). [517.44 (B)]

◆ **Other health care facilities (Article 517.45)**

- The essential electrical system must be a battery or generator system, if required per NFPA 99.
- Where electrical life support equipment is required or critical care areas are present, the requirements for hospitals apply.
- The requirements of Article 700 apply to battery systems. Generator systems must be as described for hospitals.

References

[1] IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications, IEEE Std. 446-1995, December 1995.

[2] The National Electrical Code, NFPA 70, The National Fire Protection Association, Inc., 2005 Edition.

[3] Standard for Emergency and Standby Power Systems, NFPA 110, The National Fire Protection Association, 2005 Edition.

[4] Life Safety Code, NFPA 101, The National Fire Protection Association, 2003 Edition.

[5] Standard for Health Care Facilities, NFPA 99, The National Fire Protection Association, 2005 Edition.