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OUTLINE OF INVESTIGATION
FOR
CONTROLS FOR STATIONARY ENGINE DRIVEN ASSEMBLIES

ISSUE NO: 1

JUNE 8, 2012

Summary of Topics:

This is the first issue of the Outline of Investigation for Controls for Stationary Engine Driven Assemblies.

This Outline of Investigation covers engine and engine generator or engine driven fire pumps and similar equipment control panels and assemblies that operate, control and supervise an engine or generator's operational functions. These units perform primary functions, such as engine control, overspeed control, fuel-flow control, ignition control, throttle control, engine temperature and low-oil indication, etc. These control panels and assemblies may additionally perform other secondary functions, such as battery charging, generator voltage regulation, transfer switch control, overcurrent (overload) protection, stand-alone and utility interactive protective relay functions (such as over, under, voltage and frequency, phase loss, phase reversal), ground-fault protection, generator rotor and stator field control, and thermal protection.

This issue becomes effective June 8, 2012, except for Sections 6.5, 19, 21, 22, 28, 29, 31 – 42, 57 – 66, paragraphs 68.4 – 68.13, paragraphs 69.14 and 69.15, paragraphs 69.33 – 69.61, and paragraph 69.66, which become effective June 8, 2015.

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INTRODUCTION

1 Scope

1.1 These requirements apply to control panels, control units, and other various electrical circuits employed within a control circuit device for use in a Stationary Engine Driven Assembly or similar equipment applications.

1.2 These requirements cover controls operating at 600 Volts maximum with sensing and measurement circuits of 1000 Volts AC and 1500 Volts DC maximum.

1.3 These requirements apply only to electrically operated control equipment.

1.4 These requirements apply to equipment intended to be operated and installed by skilled personnel in the field.

1.5 These requirements do not apply to devices in the power circuit, but may apply to pilot devices that would control switching devices in the power circuit and devices that include circuits that monitor a power circuit.

1.6 These requirements do not apply to controls for the propulsion engine of a vehicle.

1.7 These requirements apply to control equipment used in or with Movable engine driven assemblies that are otherwise constructed the same as Stationary engine driven assemblies.

1.8 These requirements do not apply to independent equipment that does not perform any control function of an engine driven assembly.

1.9 These requirements may supplement but do not cover equipment or devices for use in or connected to hazardous (Classified) locations.

2 General

2.1 Units of measurement

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Undated references

2.2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

2.3 Verification

2.3.1 Labels and literature intended to accompany a product, such as installation, rating, operation, and user-maintenance instructions or manuals shall be reviewed in the investigation of the product.

2.4 Environmental conditions

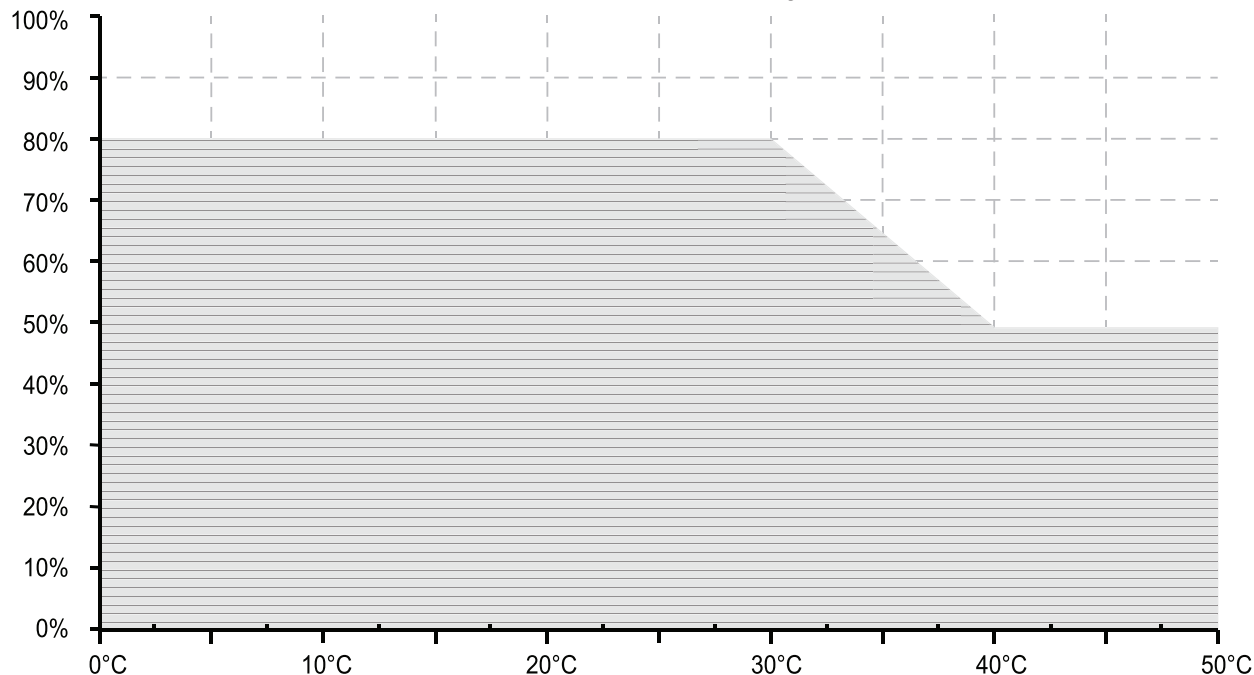
2.4.1 This standard applies to equipment designed for use under the following conditions:

- a) Indoor or outdoor use;
- b) Altitude 0 to 2000 m;
- c) Ambient temperature per Table 2.1;
- d) Maximum relative humidity in that does not exceed the levels charted in Figure 2.1;
- e) Voltage fluctuation of 90 percent to 110 percent of the nominal rated voltage for mains connected equipment and 75 percent to 120 percent of the nominal rated voltage for battery connected circuits;
- f) Overvoltage Level III based on direct connection to distribution circuits and local to the generator assembly; and
- g) Pollution degree 3 macro environment.

Table 2.1
Ambient temperatures

	Minimum		Maximum			
	Enclosed/open equipment		Enclosed equipment		Open equipment	
	°C	°F	°C	°F	°C	°F
Indoor	0	(32)	40	(104)	55	(131)
Outdoor	minus 35	(minus 31)	55	(131)	70	(158)

Figure 2.1
Maximum relative humidity



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2.5 Components

2.5.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components typically used in the products covered by this standard.

2.5.2 A Component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this document, or
- b) Is superseded by a requirement in this document.

2.5.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.5.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.5.5 If the manufacturer assigns a rating or an intended use to a component of a device (for example, an integral auxiliary switch intended to control an external circuit) the component is to be evaluated for that rating or use or both.

3 Glossary

3.1 General

3.1.1 AMBIENT TEMPERATURE – The temperature of the air medium into which the heat of the equipment is dissipated. See Table 1 for standard ambient temperature conditions.

3.1.2 AMBIENT TEMPERATURE RATING – A rating assigned to equipment that refers to the maximum ambient temperature of the room or space outside of the device enclosure or intended enclosure.

3.1.3 SURROUNDING AIR TEMPERATURE RATING – A rating assigned to open type equipment that refers to the maximum ambient temperature of air immediately surrounding the equipment inside of the ultimate enclosure.

3.1.4 HAZARDOUS (CLASSIFIED) LOCATIONS – Locations where fire or explosion hazards may exist due to flammable gases, flammable liquid–produced vapors, combustible liquid–produced vapors, combustible dusts, or ignitable fibers/flyings. Per NFPA 37, Engine rooms or other (related) locations shall not be classified as hazardous locations solely by reason of that engine fuel, lubricating oil, or hydraulic fluid are there.

3.1.5 BRANCH CIRCUIT – The portion of the building wiring system beyond the final overcurrent protective device in the power-distribution panel that protects the ac output of the field-wiring terminals in a permanently connected unit.

3.1.6 CONTROL CIRCUIT – A circuit that carries the electric signals directing the performance of a device, but which does not carry the main power. A control circuit is generally limited to 15 amperes.

3.1.7 PILOT DEVICE – An auxiliary mechanism that actuates, energizes, governs, or regulates another mechanism.

3.1.8 PILOT DUTY – The rating assigned to the output of a Pilot Device or similar circuit to control the energizing of the coil of a relay, contactor, solenoid, or similar coil operated mechanism.

3.1.9 PILOT LIGHT – A lamp that indicates when a pilot device is operating.

3.1.10 LOAD DEVICE – The solenoid, relay, contactor, circuit breaker, motor, heater, or other device controlled by the output circuit of a controller.

3.1.11 CONTROLLER – A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

3.1.12 CONTROL SYSTEM – An assembly of two or more engine and/or generators control circuit components such as engine control modules and voltage regulators in combination with push-button, pilot lights, selector switches, timers, switches, and/or control relays. Generator Control Systems may be provided with a complete enclosure, partial enclosure for flat surface panel mounting, or open type for mounting totally within an ultimate enclosure such as the engine generator assembly enclosure.

3.1.13 SNUBBER CIRCUIT – A device or circuit used to suppress (“snub”) voltage transients in electrical systems. Snubber circuits are frequently used in electrical systems with an inductive load where the sudden interruption of current flow often leads to a sharp rise in voltage across the device creating the interruption. This sharp rise in voltage is a transient and can damage and lead to failure of the controlling device. A spark is likely to be generated (arcing), which can cause electrical breakdown of a switching device or electromagnetic interference in other circuits. The snubber prevents this undesired voltage by conducting transient current around the device.

3.1.14 ENGINE DRIVEN ASSEMBLY – Includes the engine, the engine load equipment, and associated electrical equipment.

3.1.15 STATIONARY ASSEMBLY – Permanently placed or mounted assembly not intended to be relocated under normal circumstances.

3.1.16 MOVABLE ASSEMBLY – An assembly mounted on skids, wheels (trailer), or other arrangement that allows the assembly to be relocated as the required service dictates.

3.1.17 DRY LOCATIONS – Indoor-use units or provided within an enclosure that prevent ingress of water. Wet contact is not likely.

3.1.18 WET LOCATIONS – Location where water or another conductive liquid may be present and is likely to cause reduced human body impedance due to wetting of the contact between the human body and the equipment, or wetting of the contact between the human body and the environment. Circuits, including wiring and connections, exposed to outdoor or spraying, splashing, or dripping water, oil, or coolant (such as within the engine compartment) are considered to be in wet locations.

3.2 Personnel

3.2.1 AUTHORIZED PERSONNEL – For the purpose of this document, personnel that have appropriate training to understand any risks and hazards associated with the equipment so that access to the equipment is authorized by facility management.

3.2.2 ENGINEER IN CHARGE – A Skilled Licensed Professional Engineer (PE) responsible for the proper installation of a generator or fire pump system in a facility.

3.2.3 OPERATOR – Trained Personnel responsible for day to day operation of the system.

3.2.4 SERVICE PERSONNEL – Skilled personnel authorized by the facility to perform maintenance on the equipment.

3.2.5 TECHNICIAN – Skilled personnel authorized by the equipment manufacturer to install the equipment.

3.2.6 TRAINED – Having undergone an informal course or supervised instruction related to the specified tasks.

3.2.7 SKILLED – Having undergone formal instruction and/or educational program related to the specified tasks.

3.2.8 UNAUTHORIZED PERSONNEL – Personnel who do not have sufficient training to have access to specified parts of the equipment.

3.3 Enclosures

3.3.1 ENCLOSURE – The portion of a unit that:

- a) Reduces the accessibility of a part that involves a risk of fire, electric shock or injury to persons, or
- b) Reduces the risk of propagation of flame, sparks, and molten metal initiated by an electrical disturbance occurring within.

3.3.2 ENCLOSURE TYPE RATINGS – Enclosed control equipment is identified with an enclosure type designation and is intended for use as indicated in Table 110.28 of NFPA 70.

3.3.3 ASSEMBLY ENCLOSURE – The enclosure provided and evaluated with the end product assembly that houses the generator, prime mover, and associated electrical equipment. Engine and generator controls may be housed in the engine or generator assembly enclosure or in a separate attached or remote enclosure.

3.3.4 WEATHER ENCLOSURE – An Assembly Enclosure that is intended to protect from exposure to environmental conditions of an outdoor application. Weather Enclosures are normally rated “rainproof”, which is equivalent to the ingress protection provided by the Enclosure Type rating of 3R, and “raintight”, which is the same as rainproof excepted no entrance of water is allowed under the rain test.

3.3.5 ENCLOSED EQUIPMENT – Equipment provided with complete enclosures and marked with one or more specific Enclosure Type ratings.

3.3.6 PANEL MOUNT – Equipment with partial or incomplete enclosures intended for mounting through the exterior wall in an opening provided in an enclosure. Panel mount equipment investigated for mounting through the wall specific enclosure types are marked “Suitable for use on a flat surface of a Type ____ enclosure,” or the equivalent, and are provided with instructions and mounting hardware. Panel mount equipment has aspects of both enclosed and open type equipment.

3.3.7 RACK MOUNT – A 19-inch rack is a standardized frame or enclosure for mounting multiple equipment modules. Each full width rack mount module has a front panel that is 482.6 mm (19 inches) wide, including edges or ears that protrude on each side which allow the module to be fastened to the rack frame with screws. The dimensions for standard racks and front panels of rack mounted devices are defined in IEC 60297-100. The height of a rack mounted device is defined in units, U. A unit is a multiple of 44.45 mm. Therefore the height of a 1U device is 44.45 mm, a 2U device is 88.90 mm, 10U is 444.50 mm, etc.

3.3.8 OPEN-TYPE – Unless otherwise specified in the instructions or markings on the product, open-type equipment is intended for installation completely within enclosures supplied in the field.

3.4 Power

3.4.1 ISOLATED CIRCUIT – A circuit having an isolation transformer or isolating components such as optically or magnetically coupled devices.

3.4.2 NOMINAL SYSTEM VOLTAGE – The voltage by which a portion of the system is designated, and to which certain operating characteristics of the system are related. Each nominal system voltage pertains to a portion of the system bounded by transformers or utilization equipment. The nominal voltage of a system is near the voltage level at which the system normally operates. To allow for operating contingencies, systems generally operate at voltage levels about 5–10 percent below the maximum system voltage for which system components are designed.

3.4.3 MAXIMUM SYSTEM VOLTAGE – The highest system voltage that occurs under normal operating conditions and the highest system voltage for which equipment and other components are designed for satisfactory continuous operation without derating of any kind.

3.4.4 MINIMUM SYSTEM VOLTAGE – The lowest system voltage that occurs under normal operating conditions, and the lowest system voltage for which equipment and other components are designed for satisfactory continuous operation without derating of any kind.

3.4.5 RATED INSULATION VOLTAGE – (U_i) The value of voltage to which dielectric tests, clearance distances, and creepage distances are referred. In no case shall the maximum value of the rated operational voltage exceed that of the rated insulation voltage.

3.4.6 RATED IMPULSE VOLTAGE – (U_{imp}) The peak value of an impulse voltage of prescribed form and polarity that the equipment is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred. The rated impulse withstand voltage of an equipment shall be equal to or higher than the values stated for the transient overvoltage's occurring in the circuit in which the equipment is fitted.

3.4.7 WITHSTAND VOLTAGE – Voltage to be applied to a specimen under prescribed test conditions that does not cause breakdown and/or flashover of a satisfactory specimen.

3.4.8 WORKING VOLTAGE – Highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation that can occur when the equipment is supplied at rated voltage. Both open-circuit conditions and normal operating conditions are taken into account. Transients are disregarded.

3.4.9 OPERATING VOLTAGE – The nominal voltage that a circuit component needs in order to function properly. The value of the voltage under normal conditions, at a given instant and a given point of the system. This value may be expected, estimated or measured.

3.4.10 RATED SUPPLY VOLTAGE – (U_s) The value of voltage assigned by the manufacturer to the equipment and to which operation and performance characteristics are referred.

3.4.11 OVERVOLTAGE – Any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions.

3.5 Insulation coordination

3.5.1 ELECTRICAL INSULATION – That part of an electrotechnical product that separates the conducting parts at different electrical potentials.

3.5.2 SPACINGS – Any combination of clearance distances, creepage distances, and distances through insulation.

3.5.3 CLEARANCE – Shortest distance through air between two conductive parts.

3.5.4 CREEPAGE DISTANCE – Shortest distance along the surface of the insulating material between two conductive parts.

3.5.5 COMPARATIVE TRACKING INDEX (CTI) – (CTI) Numerical value of the maximum voltage at which a material withstands 50 drops of NH_4Cl solution (ammonia chloride) without tracking.

3.5.6 OPERATIONAL INSULATION – Insulation between live parts which have a potential difference between them, and which insulation is necessary:

- a) For the correct operation of the control or controlled equipment and/or
- b) Where the failure of the insulation can lead to risk of fire but not a risk of electric shock (example across the line or opposite polarity spacings).

3.5.7 BASIC INSULATION – Insulation of hazardous live parts which provides basic protection from electric shock.

3.5.8 DOUBLE INSULATION – Insulation comprising equivalent of a combination of both Basic Insulation and Supplementary Insulation for fault protection and a greater degree of protection against electric shock.

3.5.9 REINFORCED INSULATION – Insulation which provides protection against electric shock not less than that provided by Double Insulation. It may comprise several layers which cannot be tested singly as Supplementary Insulation or Basic Insulation. . For the purposes of this document, Reinforced Insulation is not treated separately but is evaluated in as a combination of multiple Insulations when Double Insulation is required.

3.5.10 SUPPLEMENTARY INSULATION – Independent insulation applied in addition to Basic Insulation in order to provide protection against electric shock in the event of a failure of Basic Insulation. For the purposes of this document, Supplementary Insulation is not treated separately but is evaluated in combination with Basic Insulation when Double Insulation is required.

3.6 Wiring methods

3.6.1 FIELD WIRING – The connection of a wire, which is made in the field and that is subjected to the requirements for a terminal for field wiring as specified in this standard and the National Electrical Code, NFPA 70.

3.6.2 FACTORY WIRING – The connection of a wire in the end application under controlled conditions, usually at a manufacturer's location.

3.6.3 APPLIANCE WIRING MATERIAL (AWM) – Appliance wiring material are evaluated to the requirements of UL 758 solely for use as factory-installed wiring either within the overall enclosure of appliances and other equipment (internal wiring) or as external interconnecting cable for appliances (external wiring), or for further processing as components in multi-conductor cables.

3.6.4 CM CABLE – Cable that is evaluated in accordance with UL 444 for use in communication circuit applications in accordance with Article 800 of NFPA 70. For the purposes of this document there is no differentiation between types CM, CMG, CMP, CMR, CMX, and CMUC since the installation requirements in an engine driven assembly is the same for all types. CM Cables may be used as a substitute for CL2 or CL3 Cable when these circuits are reclassified as communication circuits. CM cable is rated 300V but is not suitable for use for other than communication, Class 2, Class 3, or equivalent circuits as determined by NFPA 70.

3.6.5 CL2 CABLE – Cable that is evaluated in accordance with UL 13 for use in Class 2 applications in accordance with Article 725 of NFPA 70. For the purposes of this document there is no differentiation between types CL2, CL2P, CL2R, and CL2X since the installation requirements in an engine driven assembly is the same for all types. CL2 cable is rated 150V but is not suitable for use for other than Class 2 or equivalent circuits as determined by NFPA 70.

3.6.6 CL3 CABLE – Cable that is evaluated in accordance with UL 13 for use in Class 3 applications in accordance with Article 725 of NFPA 70. For the purposes of this document there is no differentiation between types CL3, CL3P, CL3R, and CL3X since the installation requirements in an engine driven assembly is the same for all types. CL3 may be substituted for CL2 cable. CL2 cable is rated 300V but is not suitable for use for other than Class 2, Class 3, or equivalent circuits as determined by NFPA 70.

3.6.7 POWER LIMITED TRAY CABLE (PLTC) – PLTC Cable is evaluated in accordance with UL 13 for Class 2 and Class 3 cable tray installations in accordance with NFPA 70. PLTC cable is rated 300V but is not suitable for use for other than Class 2, Class 3, or equivalent circuits as determined by NFPA 70. PLTC cable permitted to be exposed between cable trays and utilization equipment is marked “-ER”. PLTC that is marked for sunlight resistance, wet locations, and with a temperature of “-30°C” or less is suitable for outdoor locations.

3.7 Ground

3.7.1 GROUND – The earth.

3.7.2 GROUNDED (GROUNDING) – Connected (connecting) to ground or to a conductive body that extends the ground connection.

3.7.3 GROUNDED CONDUCTOR – A system or circuit conductor that is intentionally grounded.

3.7.4 GROUNDING CONDUCTOR, EQUIPMENT (EGC) – The conductive path(s) installed to connect normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.

3.7.5 GROUNDING ELECTRODE – A conducting object through which a direct connection to earth is established.

3.7.6 GROUNDING ELECTRODE CONDUCTOR – A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

3.8 Circuits – general

3.8.1 LIVE PART – Conductor or conductive part intended to be energized in normal operation, including a neutral but by convention not a grounding conductor, bonding conductor, or grounded part.

3.8.2 DEAD METAL – A conductive part that has Galvanic Isolation to Live Parts, Grounded Parts, and accessible conductive parts.

3.8.3 HAZARDOUS LIVE – A circuit capable of rendering an electric shock or electric burn in normal condition or single-fault condition.

3.8.4 HAZARDOUS VOLTAGE – A Hazardous Live circuit exceeding 30 V r.m.s., 42.4 V peak, or 60 V d.c. and the available current exceeds 0.5 mA r.m.s., 0.7 mA peak, or 2 mA d.c., in normal condition or single-fault condition.

3.8.4.1 NON-HAZARDOUS SECONDARY CIRCUIT – A circuit that is not capable of rendering an electric shock, electric burn, or fire in normal condition and single-fault condition.

3.8.4.2 ACCESSIBLE CIRCUIT – A circuit that is subject to inadvertent user contact or does not meet spacings requirements to exposed conductive parts.

3.8.4.3 ACCESSIBLE NON-HAZARDOUS SECONDARY CIRCUIT – An Accessible Circuit that meets the requirements of Non-Hazardous Secondary Circuit to the extent that directly touching any Live Part has no risk of rendering an electric shock, electric burn under both open or short circuit conditions and there is no risk of fire when a direct short is applied across the circuit or to conductive and/or grounded parts.

3.8.4.4 INACCESSIBLE NON-HAZARDOUS SECONDARY CIRCUIT – A Non-Hazardous Secondary Circuit that is completely contained within the equipment, not subject to inadvertent user contact, and meets minimum Basic Insulation spacings requirements to exposed conductive and grounded parts.

3.8.5 ISOLATED CIRCUIT – A circuit having an isolation transformer or isolating components such as optically or magnetically coupled devices.

3.8.5.1 OPPOSITE POLARITY – The relationship between two Live Parts such that an interconnection between them allows a flow of current which is limited by the impedance of the electrical supply circuit.

3.8.6 MAINS – Power distribution system external to the equipment for supplying power to a facility. These power sources include public or private utilities and equivalent sources such as motor-driven generators and uninterruptible power supplies.

3.8.7 PRIMARY CIRCUIT – Circuit that is directly connected to the mains supply. It includes, for example, the means for connection to the mains supply, the primary windings of transformers, motors and other loading devices.

3.8.8 SECONDARY CIRCUITS – A circuit that has no direct connection to a primary circuit and derives its power from a transformer, converter or equivalent isolation device, or from a battery.

3.9 Generators

3.9.1 GENERATOR – A machine by which mechanical energy is changed into electrical energy usually by electromagnetic induction. Generators are often referred to as DC machines while alternators are AC machines. In the context of this document, the term generators shall be understood to apply to both AC and DC machines.

3.9.2 GENERATOR FAMILY – A group of generators from the same manufacturer that have:

- a) Similar stator construction,
- b) Similar rotor construction,
- c) Similar excitation system construction,
- d) The same number of poles,
- e) The same number of phases, and
- f) The same output voltage rating.

3.9.3 NAMEPLATE CURRENT – The maximum rated output current of the engine driven generator assembly as specified by the manufacturer. The nameplate current for generators rated in kilowatts only is 1000 times the kilowatt rating divided by the generator nominal output voltage rating (for example a 480 V, 120 kilowatt generator will have a nameplate current of 250 Amps).

3.9.4 EXCITATION CONTROLLER – Controls the output voltage of a generator by controlling its excitation (field) current. The excitation current is directly proportional to the magnetic field strength of the stator windings. The terminal voltage of the generator is proportional to the magnetic field strength until the stator field coil nears saturation.

3.9.5 POWER MODULE – A Semiconductor based switching assembly that is controlled by an external signal. Power modules are typically thyristor (SCR, Triac) or transistor based. For the purposes of this document a power module is controlled by a low level signal from the excitation controller for an AVR that is rated greater than 15 amps output.

3.9.6 AUTOMATIC VOLTAGE REGULATOR (AVR) – An excitation controller that is provided with voltage feedback from the output of a generator output and directly controls the field coil current.

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3.9.6.1 EXCITATION – The process of generating a magnetic field by means of an electric current. An electric generator that uses field coils rather than permanent magnets will require a current flow to be present in the field coils for the device to be able to work. This construction is often referred to as an alternator. If the field coils are not powered, the rotor in a generator can spin without producing any usable electrical energy.

3.9.6.2 EXCITER FIELD – The field electromagnet of a generator.

3.9.6.3 FIELD COIL – The magnetic field component of an alternator, generator, dynamo, motor, or rotary converter. The phrase is also often used in the plural form, as field coils. The field coils can be mounted on either the rotor or the stator, depending on whichever method is the most cost-effective for the device design.

3.9.6.4 PMG SUPPLY – A separate permanent magnet generator used to power the AVR and excite the field coil. Very large power generators often utilize a separate smaller generator to excite the field coils of the larger.

3.9.6.5 SHUNT SUPPLY – A branch from the main generator output circuit is used to power the AVR and excite the field coil.

3.9.6.6 DIRECT PHASE EXCITATION (DPE) SUPPLY – A separate (usually stator) winding of the generator used to power the AVR and excite the field coil. The DPE winding is electrically isolated from the main generator output winding and does not connect to loads external to the generator assembly.

3.9.7 FIELD CURRENT REGULATOR (FCR) – A controller that maintains a constant field current independent of the generator output voltage.

3.9.8 FIELD FLASHING – The application of a separate source to magnetize the stator or rotor field of a generator that does not utilize permanent magnets. When there is insufficient residual magnetism in the exciter and generator fields the generator will not produce an output voltage. In some cases, a generator that has been out-of-service for an extended period may lose its residual magnetism. Residual magnetism can be restored by flashing the field thereby causing a current surge in the generator.

3.9.9 MANUAL FLASHING – Field flashing may be conducted manually by temporary connection to the AVR output circuit or the excitation coil.

3.10 Equipment – general

3.10.1 SERVICE EQUIPMENT – The necessary equipment, usually consisting of a circuit breaker or switch and fuses and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means to cut-off the supply.

3.10.2 TERMINAL VOLTAGE – The potential difference measured across the terminals of the generator under an open circuit condition.

3.10.3 OPEN DEVICE OR EQUIPMENT – Open-type equipment are intended for installation within enclosures supplied in the field.

3.10.4 PILOT DUTY RATING – A rating assigned to a relay or switch that controls the coil of a solenoid or coil of another relay or electromagnetic switch.

3.10.5 POWER CIRCUIT – Conductors and components of branch and feeder circuits.

3.10.6 SAFETY CIRCUIT – A primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, injury to persons, operation of controlled equipment that is capable of resulting in a risk of fire, electric shock, or injury to persons. Examples include an interlock circuit, a circuit which limits leakage current to accessible parts, a circuit which limits the wattage to a limited-energy circuit, or a phase control or other circuit designed to limit temperatures or fault current in the end-use product to acceptable levels.

3.10.7 SURROUNDING AIR TEMPERATURE RATING – A rating assigned to open type equipment that refers to the maximum ambient temperature of air immediately surrounding the equipment inside of the ultimate enclosure.

3.10.8 TRANSFER SWITCH – A switching device that disconnects a load from a primary source and connects the load to another separately derived source. Automatic Transfer Switches operate without human intervention when power is lost in the primary source.

3.10.9 TRANSFER SWITCH CONTROLLER – A device that remotely causes an Automatic Transfer Switch to operate.

3.10.10 INTERNAL POWER TRANSFER – A circuit allowing more than one source to power an internal circuit but only one source is connected at a time. See also Transfer Switch.

3.10.11 SURGE PROTECTIVE DEVICE – A component or assembly that limits the transient voltage such as an overvoltage protective device, a transformer with isolated windings, or damping impedance suitably located.

3.10.12 UTILIZATION VOLTAGE – The output potential difference measured on the line side of the load supplied by the generator. The utilization voltage is often not the same as the terminal voltage due to internal reactive impedance variance dependent on load current and load power factor. A higher load current and/or lower load power factor will result in a greater difference between the utilization voltage and terminal voltage.

3.11 Engine controls

3.11.1 PRIME MOVER – The engine or rotating equipment driving the generator, pump, or other mechanical load. Typical examples of prime movers are, internal combustion and external combustion engines, wind and water driven turbines, and electric motors.

3.11.2 ENGINE – A machine for converting energy (in such forms as heat, chemical energy, radiation energy, and potential energy) into mechanical force and motion.

3.11.3 INTERNAL COMBUSTION ENGINE – Any heat driven engine in which the working medium consists of the products of combustion of the air and fuel supplied. This combustion usually is affected within the working cylinder but can take place in an external chamber. Typical examples of internal combustion engines are otto cycle, diesel cycle, and gas turbine engines. Engine controls for internal combustion engines control the engine starting motor, air flow, and fuel flow.

3.11.4 STARTER CONTACTOR – A high current battery contactor used to energize the Starter Solenoid. Typical starter contactor coil power is 8 to 25 watts.

3.11.5 STARTER SOLENOID – A dual function, two coil operated device used to mechanically engage the starter motor to the engine and to energize the windings of the starter motor. The two coils will have the same number of turns. However the positioning coil has larger winding conductors and will typically draw up to 25 Amps. The holding coil has smaller winding conductors and will typically draw up to 10 Amps. The two coils operate in parallel for 50 ms for a total current draw of up to 35 Amps. After 50 ms the positioning coil circuit will open and the holding coil continues to be energized with the current reduced to 10 Amps maximum.

3.11.6 CRANKING – The energizing of an electric (or hydraulic, or pneumatic) starter motor (or starter) for rotating an internal-combustion engine so as to initiate the engine's operation under its own power. The cranking operation in engine driven assemblies is usually initiated by manually actuating a momentary switch or automatically energizing a relay coil that controls the operation of the starter contactor. The term originated from the hand operated crank mechanism used to start internal combustion engines used in early automobiles.

3.11.7 ENGINE CRANKING SEQUENCE – The sequence of Cranking Cycles repeated until the Crank Limit time is reached or the engine has started. Also includes the sequence of continuously cranking the engine until the Crank Limit time is reached or the engine has started.

3.11.8 CRANK (DUTY) CYCLE – The part of the engine cranking sequence that consists of single iteration of crank time plus the rest time. A cranking duty cycle for emergency standby applications per NFPA 110 and fire pump applications per NFPA 20 is 15 seconds crank time followed by 15 seconds rest time.

3.11.9 CRANKING TIME LIMIT (CRANK LIMIT) – The maximum time that the engine cranking sequence is allowed to operate without the engine starting. A failure to start is indicated after the crank limit has been reached.

3.11.10 ENGINE CONTROLLER – Device, such as governor device and engine control unit that control the operation of the prime mover.

3.11.11 GOVERNOR – Controls the rotational speed of the prime mover. The rotational speed can affect the driven generator terminal voltage; for AC generators, the frequency; or the driven pump output line pressure and/or flow rate. Electronic governors are often referred to as electronic control units or ECU's.

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3.12 Emergency control systems

3.12.1 EMERGENCY POWER SUPPLY SYSTEM (EPSS) – A complete functioning emergency power supply 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. There are two Levels of equipment installation, performance, and maintenance recognized by NFPA 110. Unless otherwise specified by the specific level, any reference in this document to Emergency Standby means both Levels of EPSS.

3.12.1.1 LEVEL 1 EPSS – System installed when failure of the equipment to perform could result in loss of human life or serious injuries. Standby generator systems for fire pumps and critical equipment in a hospital are examples. A control for an emergency system as defined in NFPA 70 Article 700 shall be evaluated to the requirements of a Level 1 EPSS.

3.12.1.2 LEVEL 2 EPSS – System installed when failure of the equipment to perform is less critical to loss of 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. A control for a legally required standby system as defined in NFPA 70 Article 701 shall be evaluated to the requirements of a Level 2 EPSS.

3.12.1.3 ESSENTIAL LOAD – A load of an EPSS in which the failure could result in serious injury or loss of life. An example of an essential load is an electric motor driven fire pump and emergency room lighting in a hospital. An optional standby system may treat some loads as “essential” when it is determined to be important to keep energized in a particular installation even though these loads cannot be properly defined as essential. For example a sump pump or refrigerator may be considered to be “essential” in a residential application.

3.12.1.4 NON-ESSENTIAL LOAD – A load of an emergency standby system in which the failure is not likely to result in serious injury or loss of life. All loads of an optional standby system would be considered to be non-essential. However an optional standby system may treat a load as “non-essential” when it is determined to be less important to keep energized than the loads determined to be “essential” for a particular installation.

3.12.1.5 LOAD SHED – The act or process of disconnecting the electric current to specific non-essential loads when the demand becomes greater than the supply so that sufficient power can be maintained for essential loads.

3.13 Annunciators

3.13.1 ANNUNCIATOR – An audio or visual indicator that announces which electrical circuit has become active. For the purposes of this outline the electrical circuits typically being monitored include engine sensors, engine starting battery, transfer switch, air damper control, and/or generator output. The visual indicators range from pilot lights and panel meters to panel mounted displays.

3.13.2 INDIVIDUAL ALARM SIGNALS – An annunciator indicating an emergency condition requiring immediate action. For the purpose of this document the alarms are panel mounted or signaling circuit to remote equipment providing an electrically operated visual or audible or other means determined to be the equivalent in which each indication provides status information about a circuit, condition, and/or location. Signaling functions covered by these requirements are categorized as Safety Indications and Shutdowns and/or Emergency-Signaling.

3.13.3 SAFETY INDICATIONS AND SHUTDOWNS – For Emergency Power Supply System (EPSS) the control functions required to be incorporated into the control panel by NFPA 110. The requirements vary by if the control is intended for a Level 1 or Level 2 EPPS installation. There are primarily three types of Safety Indications and Shutdowns: CV: Control panel-mounted visual; S: Shutdown of the prime mover; and RA: Remote audible. Safety indications and Shutdowns for Fire Pump applications are the same as Level 1 EPPS installations unless otherwise indicated in NFPA 20.

3.13.4 EMERGENCY SIGNALING – Individual Alarm Signals categorized as indicated below, that are associated with property and/or life safety and are of a non-fire/non-security alarm nature. These products are evaluated with regard to product safety and to appropriateness of signaling.

- a) Type UM (User-Monitored) devices or systems are intended to be monitored and tested by the user. These devices are intended for household use. Emergency signals for engine driven assemblies are not evaluated as UM Signaling devices.
- b) Type SM (Self-Monitored) devices or systems are intended to be self-monitoring. These devices are intended for, but not restricted to, commercial and hospital use.
- c) Type AM (Attendant-Monitored) devices or systems are intended to be constantly operated and maintained by competent and experienced personnel, either locally or at a remote station.
- d) Type NM (Non-Monitored) are non-emergency-signaling devices and systems that are not associated with property and/or life safety, and are only evaluated relative to fire and shock hazards. Signals for non-critical and optional standby engine driven assemblies are evaluated as NM Signaling devices to the basic fire and shock requirements of this document and are not considered to be functional safety circuits.

3.14 Cogeneration controls

3.14.1 CONGENERATION – Includes tri-generation or poly-generation applications. Also has been referred to as Combined Heat and Power (CHP) and/or Combined Cooling Heat and Power (CCHP). Applied to equipment intended to utilize heat from an engine or a power station to simultaneously generate both electricity and useful heat. The reject heat from an engine driven generator is most often used for space heating but is sometimes used in absorption chillers and industrial processes.

3.14.2 HEAT RECOVER MEDIUM – A fluid which conducts heat from one or more heat sources and transports it to a heat exchanger, where the heat is removed and disposed of or transferred to another fluid for spacing heating or other purposes.

3.15 Parallel generation systems

3.15.1 MULTIPLE GENERATOR SYSTEM (MGS) – A generator system where the two or more generator outputs are connected to the load for parallel operation. The systems are intended for applications requiring load sharing, power system expansion, redundant operation for Level 1 systems, and system reliability.

3.15.2 SYNCHRONIZATION – Matching the voltage amplitude, phase angle, and frequency of the output of a generator with the amplitude, phase angle, and frequency of the system bus.

3.15.3 ELECTRIC POWER SYSTEM (EPS) – Facilities that deliver electric power to a load.

3.15.4 DISTRIBUTED RESOURCES (DR) – Sources of electric power that are not directly connected to a bulk power transmission system. DR includes both generators and energy storage technologies.

3.15.5 INTERCONNECTION SYSTEM (ICS) – The collection of all equipment and functions, taken as a group, used to interconnect a distributed resources (DR) unit to an area electric power system (EPS).

3.15.6 POINT OF COMMON COUPLING (PCC) – The point where a local electric power system (EPS) is connected to an area EPS.

3.15.7 PARALLELING DEVICE – A device (e.g., circuit breaker) operating under the control of a synchronizing function to electrically connect two energized power sources together.

3.15.8 UTILITY-INTERACTIVE – A separately derived source intended for use in parallel with an electric utility to supply common loads and sometimes deliver power to the utility.

3.15.9 DESIGN TEST – Test of one or more devices made to a certain design to demonstrate that the design meets certain specifications. Also referred to as Type Test.

3.15.9.1 COMMISSIONING TEST – A test conducted when the equipment is installed to verify correct operation.

3.15.9.2 PRODUCTION TEST – A test conducted on every unit of equipment prior to shipment.

3.16 Protective controls

3.16.1 ELECTRONIC PROTECTION – Equipment that provide various types of electronic protection by detecting abnormal conditions and isolating them from the rest of the electrical system. For the purpose of this document, this term may apply to equipment that causes the circuit breaker to open, disconnect to open, engine to shut down, or generator to stop production of power.

3.16.2 INTERRUPTING DEVICE – A device capable of being opened and reclosed whose purpose is to interrupt faults and restore service or disconnect loads. These devices can be manual, automatic, or motor-operated. Examples include circuit breakers, motor-operated switches, and electronic switches.

3.16.3 DETECTION TIME – The minimum length of time from the inception of the abnormal condition to the change in state of the device or function dedicated to controlling the interrupting device. Also referred to as Processing or Trip Time.

3.16.4 CLEARING TIME – The time between the start of the abnormal condition and the distributed resources' (DR's) ceases to energize the area electric power system (EPS). It is the sum of the detection time, any adjustable time delay, the operating time for any interposing devices (if used), and the operating time for the interrupting device (used to interconnect the DR with the area EPS).

3.16.5 SIGNAL INJECTION TEST METHODS – Test methods where signals are injected into the sense terminals of the equipment under test (EUT). These methods include both primary injection test methods and secondary injection test methods.

3.16.6 ABNORMAL FREQUENCY – Any frequency either over or under the acceptable tolerance for the equipment or system. An under or over frequency condition can cause motors to operate above or below rated speed and/or overheat. When two or more power sources are connected to a system bus an out of phase and thereby an overvoltage condition will likely result from an abnormal frequency condition.

3.16.7 ABNORMAL VOLTAGE – Any continuous or temporary overvoltage or undervoltage condition with a value outside acceptable tolerance for the equipment or system.

3.16.7.1 UNDERVOLTAGE – Any voltage having a peak value below the corresponding peak value of minimum steady-state voltage at normal operating conditions. A continuous undervoltage condition can cause equipment, such as motors, to severely overheat and systems to shut down. An undervoltage condition on generator system that is connected in parallel with other power sources can cause reverse power to the generator.

3.16.7.2 OVERVOLTAGE – Any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions. A continuous overvoltage condition on generator system that is connected in parallel with other power sources can cause reverse power to other sources.

3.16.8 LOSS OF SIGNAL – A condition where a signal from a local or remote device is interrupted long enough to effect the operation of equipment. Safety and other critical signal inputs need to be provided with a means to ensure that an unsafe condition of the equipment does not result from the Loss of Signal.

3.16.9 LOSS OF FIELD – When the magnetic field generated by the excitation fails to exist and thereby the voltage generated which is directly related to this magnetic field and also fails to exist. Upon Loss of field the generator could absorb or import power from the system bus and motoring possible. There is a high potential for generator overheating and prime mover damage.

3.16.10 OVER EXCITATION – A condition when the excitation system is providing too much field current and as a result, the rotor of the generator will over heat. If the excitation system is equipped with an over excitation limiter, this limiter acts to reduce the excitation current if this condition exists.

3.16.11 UNDER EXCITATION – A condition where the generator is not getting enough excitation current. If the generator does not get enough excitation current, it can be un-synchronized with the grid. This is referred to as slipping a pole. If this occurs, the generator can be severely damaged.

3.16.12 MOTORING – The rotation of a generator from reverse electrical power instead from the prime mover.

3.16.13 OVERCURRENT – Any current in excess of the rated current of the equipment, generator, or ampacity of the conductors. It may result from overloads, short circuits, and faults to ground.

3.16.14 CURRENT LIMITING – Equipment designed to limit the current to a predetermined value. Current limiting may be accomplished by controlling the prime mover speed or the excitation field current.

3.16.15 OVERLOAD – Operation of equipment or generator in excess of the full load rating or of a conductor in excess of rated ampacity when it persists for a sufficient time to cause damage or damage of the equipment or generator. A fault such as short circuit and ground fault is not an overload.

3.16.16 GROUND FAULT – Denotes an unintentional electrical path between a part operating normally at some potential to ground, and ground. Ground fault protection of a generator is intended to interrupt equipment damaging line-to-ground currents. Ground fault protection of personnel is intended to interrupt excessive leakage currents to protect from risk of electric shock. Ground fault protection will operate at current levels lower than current levels required to protect from overload or short circuit conditions.

3.16.17 REVERSE POWER – Electrical power provided to the generator from the electric power system or load that causes motoring of the generator after loss or reduction of rotational power from the prime mover.

3.16.18 REVERSE REACTIVE POWER – Leading power from the local electric power system that can cause under-excitation of the alternator field coil.

3.16.19 SHORT CIRCUIT – A fault current is caused by direct line-to-line short across a load or the generator terminals. The symmetrical short circuit fault current is a function of the terminal voltage divided by the sum of transformer or generator impedance, line-side series equipment impedance, and the conductor impedance at the location of the fault.

3.16.20 THERMAL SENSING – Sensing of the temperature of an engine, generator, heating device, the equipment, or other devices or systems for monitoring, recording, protection, and/or regulation of the thermal condition.

3.17 Current sensing

3.17.1 CURRENT TRANSFORMER – A type of instrument transformer used to measure AC current. It is intended to be able to measure the current through an isolated secondary winding where the ratio of primary turns to secondary turns is inversely proportional to the ratio of the primary current to the secondary current up to the knee-point. A burden resistor is connected across the secondary winding to convert the current measurement to a voltage measurement in a similar way as a current shunt. The burden resistor is sized so that all the secondary current passes through it.

3.17.2 CURRENT SHUNT – An accurately known resistance placed in series with the load so that the entire load current passes through it. The voltage drop across the shunt is proportional to the current flowing through it and since its resistance is known, a millivolt meter or similar analog measurement circuit connected across the shunt can be scaled to directly display the current value.

3.17.3 CURRENT TRANSDUCER – A device used to measure AC and DC current based on the hall effect. The hall effect is the production of a voltage difference across an electrical conductor transverse to the electric current and a magnetic field perpendicular to the current. An analog input circuit is used to measure the voltage and the controller converts the measured voltage to current based on the ratings of the transducer.

3.17.4 MAIN CURRENT TRANSFORMER – A current transformer in which the primary winding is the feeder or branch circuit conductor or is in series with the feeder or branch circuit conductor. The secondary is typically rated 5 Amps or 1 Amp.

3.17.5 AUXILIARY CURRENT TRANSFORMER – A current transformer in which the primary winding is intended to be supplied by the secondary of the main current transformer. The primary is typically rated 5 Amps or 1 Amp and the secondary is rated 1 Amp or less.

3.17.6 PASS-THROUGH TYPE CURRENT TRANSFORMER – A bushing or window type current transformer in which the primary conductor is passed through an opening in the core of the transformer and the secondary windings. The pass-through type CT is not provided with primary terminals. The secondary may be provided with terminals or leads.

3.17.7 KNEE-POINT – The point that indicates saturation of the current transformer. The knee-point voltage of a current transformer is the magnitude of the secondary voltage after which the output current ceases to follow linearly the input current. This means that the one-to-one or proportional relationship between the input and output is no longer within declared accuracy.

3.18 Fire pump controls

3.18.1 FIRE PUMP UNIT – An assembled unit consisting of a fire pump, pump driver, controller, and accessories used in fire suppression sprinkler systems. Additional functional safety requirements apply to engine controllers and generator controllers utilized in a fire pump unit due to the need for high reliability in the application.

3.18.2 ENGINE DRIVEN FIRE PUMP – A fire pump unit in which the pump driver is an internal combustion engine.

3.18.3 PUMP DRIVER – The designation given to the prime mover in an engine driven pump application.

3.18.4 VARIABLE PRESSURE CONTROL (VPC) – Control of the pressure of the fluid in system under varying conditions through regulating the speed of the pump driver.

3.18.5 REDUNDANT CONTROL SYSTEM (RCS) – A system that utilizes two or more controls that have equivalent functions to increase the reliability of the equipment. A redundant control system includes provisions to manually or automatically select between the primary and alternate controls so that upon failure of the primary control the alternate control will take over the operation. A typical redundant control system is for engine driven fire pump applications that require multiple engine control modules.

3.19 Fire detection and alarm systems

3.19.1 FIRE DETECTION AND ALARM SYSTEMS – A system that includes smoke flame detectors intended to activate an alarm when a fire is detected. For engines installed in a building NFPA 37 requires fuel shut-off valves to be installed that close when the fire detection system activates the alarm.

3.20 Functional safety

3.20.1 FUNCTIONAL SAFETY – Functional safety applied to the overall safety of a system or piece of equipment that depends on the system or equipment operating correctly in response to its inputs, including the safe management of likely operator errors, hardware failures, and environmental changes. The objective of functional safety is freedom from unacceptable risk of physical injury or of damage to the health of people either directly or indirectly (through damage to property or to the environment). For the purposes of these guidelines, this applies to functions that:

- a) Limit the effects abnormal voltage, frequency, and/or power;
- b) Limit the effects of an overcurrent condition;
- c) Maintain line pressure of an engine driven fire pump system;
- d) Monitor critical system sensors for safety indications and shutdowns in emergency power systems and fire pump applications;
- e) Control the detection time of a transfer switch or paralleling device controller;
- f) Control the detection time of electronic protection of the engine, generator, pump, and other components of the system;

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- g) Provide a means to remove output power from a generator system from the load upon actuation of an emergency stop device;
- h) Provide a means to shut down the prime mover upon actuation of an emergency stop device;
- i) Control the synchronization of a generator system of a distributed resource to an electric power system; and
- j) Incorporate signal and communication circuits that interconnect systems or devices to provide the functions described above.

3.20.2 SUPPLEMENTARY FUNCTION – A function is considered supplementary when the primary protection or control is provided by a separate device evaluated for the application. Examples of a Supplementary Function are:

- a) Overload protection provided by the controller is supplementary when a separate fuse or circuit breaker is to be provided to protect the generator and generator output conductors.
- b) Software controlled interlock of a transfer switch controller is supplementary when the transfer switch is mechanically interlocked.

3.20.3 PROGRAMMABLE SAFETY-RELATED SYSTEMS – Systems and controls relying on software or firmware for Functional Safety.

CONSTRUCTION

4 General

4.1 Engine and generator control equipment shall:

- a) Be constructed so that it complies with the rules for installation and use of such equipment as given in:
 - 1) The National Electrical Code, ANSI/NFPA 70; and
 - 2) The Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA 37; and
 - 3) The Standard for the Installation of Stationary Pumps for Fire Protection, NFPA 20 for Fire Pump applications; or
 - 4) The Standard for Emergency and Standby Power Systems, NFPA 110 for Emergency Power Supply System applications.
- b) Employ materials that are acceptable for the use.

5 Personnel Protection

5.1 An enclosure, a frame, a guard, a handle, or the like shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use.

5.2 Any uninsulated live part involving a potential of more than 30 volts r.m.s (42.4 volts peak) mounted to the inside of a door shall be guarded, recessed, or enclosed to provide protection against unintentional contact when the door is open. A mechanical obstacle, such as a barrier, cover or guard, relied upon to comply with this requirement is able to be removed without the use of tools.

5.3 Equipment incorporating a fuse holder and the location of fuses, the normal function of which requires renewal, shall be so constructed that the fuses are readily accessible when the switch contacts are open so that a person is not required to touch any live part when replacing a fuse. The electrical arrangement of a single-throw switch shall be such that when it is connected as intended and the contacts are open, the fuse terminals are not energized.

5.4 A control-circuit fuse arrangement is not required to comply with the 5.3 requirement when the fuse and control-circuit load - other than a fixed control-circuit load, such as a pilot lamp - are within the same enclosure.

5.5 As an alternative a door shall be interlocked with the disconnecting means such that:

- a) The door is not able to be opened unless the disconnecting means is in the open (OFF) position; and
- b) The door is required to be latched before the disconnecting means is able to be switched to the closed (ON) position.

5.6 The interlocking means required by 5.5 is able to have a defeat mechanism that requires the use of tools to open the door and that is self-restoring when the door is closed.

5.7 Enclosed equipment with a door and containing a display, reset button, routine adjustment, or operating handle of a switch or circuit breaker shall be constructed so the display, button, adjustment or operating handle is readily accessible so that a person is not required to touch any live part in order to perform any operation or adjustment or monitor the display. When a barrier is relied upon to comply with this requirement, the barrier shall require the use of a key or tools for removal.

6 Enclosures

6.1 General

6.1.1 An enclosure or partial enclosure provided as part of the equipment shall comply with the control circuit requirements from UL 508.

6.2 Panel mounted displays

6.2.1 The frame and covering of LCD, cathode-ray, and similar displays that are panel mounted or part of a panel mounted device shall comply with UL 508 requirements for observation windows.

6.2.2 A backlight circuit shall be considered a hazardous live part when determining compliance with Impact and Crush Tests unless the backlight circuit complies with the requirements for Class 2, Limited Impedance, or Limited Current secondary circuits evaluated to determine if a risk of shock is present.

6.3 Specific enclosures

6.3.1 An enclosure or panel mount component rated other than Type 1 shall also be evaluated to UL 50E.

6.3.2 A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material employed to comply with the requirements for a Type 2, 3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 5, 6, 6P, 12, 12K, or 13 enclosure shall comply with the Gasket Tests in UL 50E.

6.3.3 Enclosed or partially enclosed equipment to be attached to or used with stationary engine driven assemblies marked "Rainproof" shall comply with the requirements for Type 3, 3R, 3RX, 3S, 3SX, 3X, 4, or 4X.

Exception: Equipment to be completely installed within the assembly weather enclosure need not be so rated.

6.3.4 Enclosed or partially enclosed equipment to be attached to stationary engine driven assemblies marked "Raintight" shall comply with the requirements for Type 3, 3S, 3SX, 3X, 4, or 4X.

Exception: Equipment to be completely installed within the Assembly weather enclosure need not be so rated.

6.3.5 Enclosed or partially enclosed equipment to be installed within 1 meter (39 inches) of the engine shall comply with the requirements for Type 12 or Type 13.

Exception: Equipment protected by barriers from splashing coolant or oil from the engine need not be so rated.

6.3.6 Enclosed or partially enclosed equipment used in fire pump applications shall comply with the requirements for Type 2, 3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 5, 12, 12K, or 13.

6.3.7 Equipment and enclosures that comply with the ingress protection requirements of IEC 60529 may additionally be marked with IP ratings.

6.4 Equipment with incomplete or partial enclosures

6.4.1 Equipment with incomplete or partial enclosures shall comply with the requirements of Sections 6.1 through 6.3 for the parts that complete the integrity of the intended enclosure.

6.4.2 Equipment, such as a display, a human machine interface device (HMI), or similar component, with an incomplete or partial enclosure intended for use with a type designated environmental enclosure, meets the requirements for use with a specific type enclosure when all of the following are met:

- a) The component has been evaluated for its intended use installed on a representative enclosure;
- b) All hardware, gaskets, or other parts needed to complete the installation are provided with the component;

Exception: Hardware, gaskets, or other parts are not required to be provided with the component when they are available from the component manufacturer in the form of a kit and the component is marked as specified in 71.1.

- c) Installation instructions are provided in accordance with 69.13; and
- d) The component, its carton, or accompanying instruction sheet is marked in accordance with the requirement in 69.12.

6.5 Rack mounted equipment

6.5 effective June 8, 2015

6.5.1 Equipment intended for use in a standard 482.6 mm (19 inch) rack, shall comply with the following:

- a) The component has been evaluated for its intended use installed on a representative rack and cabinet;
- b) All hardware, gaskets, or other parts needed to complete the installation are provided with the equipment.

Exception: Hardware, gaskets, or other parts are not required to be provided with the component when they are available from the component manufacturer in the form of a kit and the component is marked as specified in 71.1.

- c) Installation instructions are provided in accordance with 69.14.
- d) The component, its carton, or accompanying instruction sheet is marked in accordance with the requirement in 69.12.

6.5.2 Rack mounted equipment shall comply with the applicable requirements of Sections 6.1 through 6.3.

Exception: Rack mounted equipment intended to be installed completely within a cabinet or enclosure and marked in accordance with 69.15 able to be evaluated as open type devices.

6.5.2.1 Rack mounted equipment that can also be panel mounted in the wall of an enclosure shall additionally comply with Section 6.4.

6.5.2.2 A subrack intended to be used with plug-in equipment that can have the subrack backplane energized while the plug-in equipment is withdrawn shall comply with accessibility of live parts with the plug-in units withdrawn.

6.5.3 Rack mounted equipment provided with slides/rails allowing equipment to slid away from the rack for installation, service, maintenance, and the like shall:

- a) Be provided with end stops that prevent the equipment from unintentionally sliding off the mounting means; and
- b) Comply with the mechanical strength tests from UL 60950 with the slide/rail mounted equipment in the maximum extended position.

ELECTRICAL SYSTEM

7 Separation of Circuits

7.1 Separation of circuits shall comply with the requirements of UL 508.

8 Grounding

8.1 Grounding and Bonding shall comply with the grounding and bonding requirements of UL 508.

9 Electrical Connections

9.1 General

9.1.1 Except as modified by Sections 9.2 through 12 all electrical connections shall comply with UL 508 requirements for internal wiring, external interconnection, and supply connection requirements for control circuits from UL 508.