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NATIONAL STANDARD

ANSI/CAN/UL/ULC 6200:2019

STANDARD FOR SAFETY

Controllers for Use in Power Production

Approved American National Standard
ANSI
ANSI/UL 6200-2019

Standards Council of Canada
Conseil canadien des normes

SCC FOREWORD

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UL Standard for Safety for Controllers for Use in Power Production, ANSI/CAN/UL/ULC 6200:2019

First Edition, Dated May 31, 2019

Summary of Topics

The First Edition of ANSI/CAN/UL/ULC 6200 has been issued to reflect the ANSI and SCC approval dates, and to incorporate the proposals dated August 24, 2018 and February 22, 2019.

The requirements are substantially in accordance with Proposal(s) on this subject dated August 24, 2018 and February 22, 2019.

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ANSI/UL 6200-2019

MAY 31, 2019

ANSI/CAN/UL/ULC 6200:2019

Standard for Controllers for Use in Power Production

First Edition

May 31, 2019

This ANSI/CAN/UL/ULC Safety Standard consists of the First Edition.

The most recent designation of ANSI/UL 6200 as an American National Standard (ANSI) occurred on May 31, 2019. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This standard has been designated as a National Standard of Canada (NSC) on May 31, 2019.

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Preface

This is the First Edition of the ANSI/CAN/UL/ULC 6200, Standard for Controllers for Use in Power Production.

UL is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. ULC Standards is accredited by the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

Annex A, identified as Normative, forms a mandatory part of this Standard.

Annex B, identified as Informative, is for information purposes only.

This ANSI/CAN/UL/ULC 6200 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

To purchase UL Standards, visit the UL Standards Sales Site at http://www. shopulstandards. com/ HowToOrder.aspx or call tollfree 1-888-853-3503.

This Edition of the Standard has been formally approved by the UL Standards Technical Panel (STP) on Controls for Stationary Engine Driven Assemblies, STP 6200.

This list represents the STP 6200 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

STP 6200 Membership

Name	Representing	Interest Category	Region
Abrams, Michael	Aquatec Maxcon	Supply Chain	Australia
Allen, Blake K.	Marex Canada Ltd	AHJ	Canada
Basler, Michael	Basler Electric Co.	Producer	USA
Belcher, Steven	FM Gernerator	Supply Chain	USA

STP 6200 Membership Continued on Next Page

STP 6200 Membership Continued

Name	Representing	Interest Category	Region
Bush, Ken	Maryland State Fire Marshal's Office	AHJ	USA
Ching, Yonghan	Cummins Power Generation Inc	Producer	USA
Day, Rick	State of Michigan Fire Marshal Office	AHJ	USA
Dollard, James	IBEW Local 98	General Interest	USA
Dona, Mario	Self	General Interest	Australia
Eifrid, Brady	Kohler Co.	Producer	USA
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George, Rick	Intertek	Testing and Standards	USA
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Jonas, Jeff	Generac Power Systems Inc.	Producer	USA
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Kovacik, John	UL LLC	Testing and Standards	USA
Martin, Derrick	Underwriters Laboratories Inc.	Project Manager (Non-Voting)	USA
Niclaus, Mike	NEC Power LLC	Commercial/Industrial User	USA
Sahota, Santokh	Simson Maxwell Ltd.	Producer	Canada
Sappington, Steven	Caterpillar Inc.	Producer	USA
Watt, Glen	Glenergy Services	AHJ	Australia
Young, Eddie	IRED Thermal Group Ltd	General Interest	Canada

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For further information on UL standards, please contact:

Underwriters Laboratories Inc.
171 Nepean Street, Suite 400
Ottawa, Ontario K2P 0B4
Phone: 1-613.755.2729
E-mail: cec@ul.com
Web site: ul.com

This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE.

INTRODUCTION

1 Scope

1.1 These requirements apply to control panels, control units, and other various electrical circuits employed within a control circuit device intended for support functions, maintain operation and limiting safety control features for use in a Stationary Engine Driven Assembly or similar power production equipment control applications.

1.2 These requirements cover controls operating at 600 Volts a.c. or d.c maximum with sensing and measurement circuits without the use of isolation devices and 36 kV a.c. or d.c. maximum with the use of isolation devices.

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 qualified personnel in the field.

1.5 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.

1.6 These requirements do not cover:

a) Distribution equipment which sole function is the automatic or nonautomatic transferring of one or more load conductor connections from one power source to another. In Canada the Standard for Transfer Switch Equipment is CSA C22.2 No. 178.1. In the United States it is the Standard for Transfer Switch Equipment, UL 1008.

b) Devices in the output power circuit, but would apply to pilot devices that monitor or control switching devices that control loads in power circuits.

c) Controls for the propulsion engine of a vehicle.

d) Independent equipment that does not perform any control function of an engine driven assembly or similar power production equipment control applications.

e) Equipment or devices for use in or connected to hazardous (Classified) locations.

f) Industrial Control Equipment for general use. In Canada the Standard for Industrial Control Equipment is CSA C22.2 No. 14. In the United States it is the Standard for Industrial Control Equipment, UL 508.

g) General Use Industrial Control Panels and Industrial Control Panel Assemblies other than power production. In Canada the Standard for Industrial Control Panels and Assemblies is CSA C22.2 No. 286. In the United States it is the Standard for Industrial Control Panels, UL 508A.

h) Equipment or devices for use in mobile applications.

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 Verification

2.2.1 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.

2.3 Environmental conditions

2.3.1 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 as declared by manufacturer or 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 utility/mains connected equipment and 75 percent to 120 percent of the nominal rated voltage for battery connected circuits;

f) Overvoltage Level III as defined in Insulation Coordination, CSA C22.2 No. 0.2 for Canada and Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States based on direct connection to distribution circuits and local to the generator assembly; and

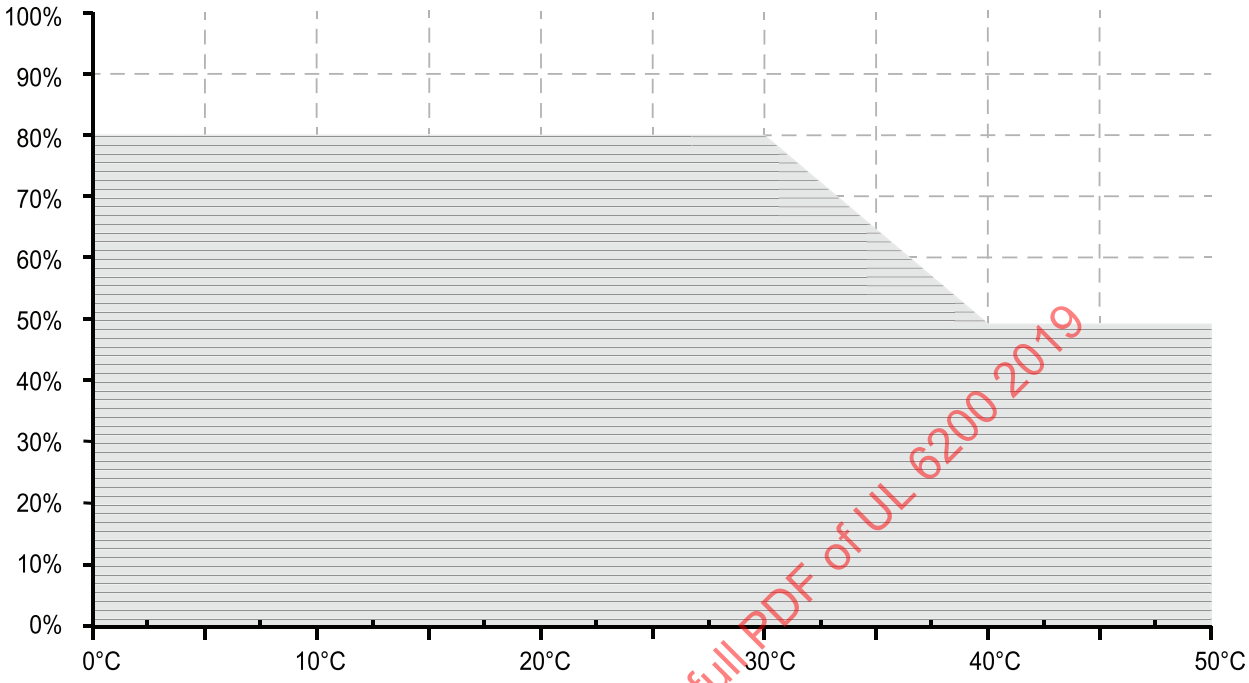
g) Pollution degree 3 as defined in Insulation Coordination, CSA C22.2 No. 0.2 for Canada and Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States.

h) Altitudes greater than 2000 m. See Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests, IEC 60664-1 Table A.2.

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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2.4 Components

2.4.1 Except as indicated in 2.4.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Annex A for a list of Standards covering components generally used in the products covered by this Standard. A component shall comply with the Standards of UL or ULC or CAN/CSA Standards as appropriate for the country where the product is to be used.

Exception: PCB mounted components, such as resistors, capacitors, surface mounted inductors, semiconductor switches, and microprocessors are not evaluated as components but as an assembly feature of a PCB.

2.4.2 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 standard, or

b) Is superseded by a requirement in this standard.

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

2.4.4 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.

2.4.5 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 2.1 for standard ambient temperature conditions.

3.1.2 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.

3.1.3 CONTROL SYSTEM – An assembly of two or more engine and/or generators control circuit components such as engine control modules, paralleling modules, fuel 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.

3.1.4 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.

3.1.5 ENGINE DRIVEN ASSEMBLY – Includes the engine and any machine designed to convert energy; thermal energy, rotating mechanical work, electrical power generation.

3.1.6 LARGE SCALE AUTOMATIC VOLTAGE REGULATOR (AVR) – Cabinet enclosed network of control equipment with multiple circuit boards and field excitation current greater than 75 A.

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

3.1.8 MECHANICAL GUARD – A part or barrier that reduces the risk of access to a component or prevents the splashing, dripping or spraying of coolant, oil or fuel that has the potential of causing an electrical, fire hazard or injury to persons.

3.1.9 MOBILE – An engine driven assembly intended to produce power while in motion.

3.1.10 MOVABLE – An engine driven assembly other than stationary or mobile installations intended to produce power while it is not in motion.

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

3.1.12 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.

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

3.1.14 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.

3.1.15 SOLID-STATE RELAY/SWITCHING DEVICES – Electrical relay/switching devices in which the intended response is produced by electronic, magnetic, optical or other components without mechanical motion.

3.1.16 STATIONARY – An engine driven assembly that is intended to be hard-wired and/or permanently installed.

3.1.17 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.

3.1.18 UTILITY-INTERACTIVE DEVICE – An individual or multiple devices (example: programmable control) used in an interconnection system intended for use in parallel with an electric utility to supply common loads and sometimes deliver power to the utility.

3.1.19 WET LOCATION – Location where occasional or continuous exposure to water or other liquids is anticipated. Circuits, including wiring and connections, exposed to outdoor environments 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 OPERATOR – Trained Personnel responsible for day to day operation of the system.

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

3.3 Enclosures

3.3.1 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.

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

3.3.3 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.

3.3.4 ENCLOSURE TYPE RATINGS – Enclosed control equipment identified with an enclosure type designation and is intended for use as indicated in:

a) Table 110.28 of the National Electrical Code (NEC), NFPA 70 for the United States and

b) Table 65 of the Canadian Electrical Code, CSA C22.1 for Canada.

3.3.5 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.

3.3.6 PANEL MOUNT – Equipment with partial or incomplete enclosures intended for mounting through the exterior wall in an opening provided in an enclosure.

3.3.7 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.

3.4 Power sources

3.4.1 OVERVOLTAGE – Any voltage that exceeds its rated or intended value. A continuous overvoltage condition on generator system that is connected in parallel with other power sources can cause reverse reactive power to other sources.

3.5 Insulation coordination

3.5.1 CLEARANCES– Through-air spacing – The shortest distance measured through air between conductive parts.

3.5.2 CREEPAGE DISTANCES (CREEPAGE) – Over-surface spacings – The shortest distance measured over the surface of insulation between conductive parts.

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

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

3.6 Wiring methods

3.6.1 FACTORY WIRING – The connection of a wire in the end application under controlled condition.

3.6.2 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:

a) The National Electrical Code (NEC), NFPA 70 for the United States and

b) The Canadian Electrical Code, CSA C22.1 for Canada.

3.7 Ground

3.7.1 GROUND – The earth, unless otherwise specified.

3.7.2 GROUNDED CONDUCTOR – A system or circuit conductor intentionally connected to ground at the building supply source, also referred to as "common" or "neutral."

3.7.3 GROUNDING – The act of establishing a conductive connection, whether intentional or otherwise, between an electrical circuit or electrical equipment and earth.

3.7.4 GROUNDING CONDUCTOR, EQUIPMENT (EGC) – In the United States, the definition is in Article 100 of the National Electrical Code (NEC), NFPA 70. In Canada, the definition for Bonding Conductor is in Section 0 of the Canadian Electrical Code, CSA C22.1.

3.8 Circuits – general

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

3.8.2 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.

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

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

3.8.5 HAZARDOUS VOLTAGE – A Hazardous Live circuit exceeding the following available electrical parameters under normal condition or single-fault condition:

a) (30 V rms) 42.4 V peak for sinusoidal or non-sinusoidal AC;

b) 60 V for continuous DC, or 60 V peak for interrupted DC outside the range of 10 – 200 Hz;

c) 5 A; or

d) 100 VA.

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

3.8.7 LIVE PART – Denotes metal or conductive parts that, during intended use, have a potential difference with respect to ground or any other conductive part.

3.8.8 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.

3.8.9 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.

3.8.10 PRIMARY CIRCUIT – Circuit that is directly connected to the external supply mains or other equivalent source (such as a motor-generator set) that supplies the electric power. It includes the primary windings of transformers, motors, other loading devices, and the means of connection to supply mains.

3.8.11 SECONDARY CIRCUITS – Those circuits supplied from transformer secondary windings or the output of a power supply that are electrically separated from the primary windings or input to a power supply.

3.8.12 SUPPLY MAINS – Permanently installed power source which may also be used to supply electrical apparatus that is outside the scope of this standard.

3.9 Generators

3.9.1 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.

3.9.2 EXCITATION – The process of generating a magnetic field on the field coils of an alternator by means of an electric current.

3.9.3 EXCITATION CONTROLLER – Controls the output voltage of a generator by controlling its excitation (field) current.

3.9.4 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.

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

3.9.6 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.

3.10 Equipment – general

3.10.1 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.

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

3.10.3 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.

Note: Functional safety (3.18.1) applies to safety circuits.

3.10.4 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.

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

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

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

3.11 Engine controls

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

3.11.2 ENGINE CONTROLLER – Device, such as governor device and engine control unit that control the operation of the prime mover. Engine controls for external and internal combustion engines control the engine starting motor, air flow, and fuel flow.

3.11.3 ENGINE STARTING SEQUENCE – The sequence of Starting Cycles repeated until the number of Start Attempts Limit is reached or the engine has started. Also includes the sequence of continuously starting the engine until the Start Attempt Limit time is reached or the engine has started.

3.11.4 INTERNAL AND EXTERNAL 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 Brayton cycle (gas turbine engines). Typical examples of external combustion engines are steam or similar design engine.

3.11.5 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.

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

3.11.7 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.

3.11.8 STARTING – The energizing of an electric (or hydraulic, or pneumatic) starter motor (or starter) for rotating an engine so as to initiate the engine's operation under its own power. The starting 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 or solenoid valve.

3.11.9 STARTING (DUTY) CYCLE – The part of the engine starting sequence that consists of single iteration of start time plus the rest time.

3.11.10 STARTING TIME LIMIT (CRANK/CYCLE LIMIT) – The maximum time that the engine starting sequence is allowed to operate without the engine starting. A failure to start is indicated after the start limit has been reached.

3.12 Annunciators

3.12.1 ANNUNCIATOR – An audio or visual indicator that announces which electrical circuit has become active. For the purposes of this standard 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 Cogeneration controls

3.13.1 Reserved.

3.14 Parallel generation systems

3.14.1 SYNCHRONIZATION – The matching of the voltage amplitude, phase angle, and frequency of the output of a generator with the amplitude, phase angle, and frequency of the local area system bus or utility.

3.15 Protective controls

3.15.1 CURRENT LIMITING – Equipment designed to limit the current to a predetermined value.

3.15.2 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.

3.15.3 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.

3.15.4 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.

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

3.15.6 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.

3.15.7 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.

3.15.8 OVERLOAD – In the United States, the definition is in Article 100 of the National Electrical Code (NEC), NFPA 70. In Canada, the definition is in Section 0 of the Canadian Electrical Code, CSA C22.1.

3.15.9 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.

3.15.10 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.

3.15.11 TYPE 1 ACTION – Automatic action of an operating control for which the manufacturing deviation and the drift of its operating value, operating time or operating sequence have not been declared and evaluated.

3.15.12 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 Current sensing

3.16.1 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.

3.16.2 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.

3.16.3 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 Fire detection and alarm systems

3.17.1 FIRE DETECTION AND ALARM SYSTEMS – A system that includes smoke flame detectors intended to activate an alarm when a fire is detected.

3.18 Functional safety

3.18.1 FUNCTIONAL SAFETY – Safety of a Stationary Engine Driven Assembly or similar Power Production equipment, which depends on the correct operation of control functions, which in turn depends on the integrity of the control circuits implementing these control functions. Such control circuits are identified as Safety Circuits (3.10.3 and Safety Circuits, Section 37).

3.18.2 PROGRAMMABLE ELECTRONIC SAFETY-RELATED SYSTEMS – Safety Circuits that include, and rely on programmable electronics and software.

3.18.3 SUPPLEMENTARY FUNCTION – A function is considered supplementary when the primary protection or control is provided by a separate device evaluated for the application.

3.19 Test

3.19.1 PERFORMANCE 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.

3.19.2 PRODUCTION-LINE TEST – A test conducted on every unit of equipment prior to shipment. Also referred to as Routine Test.

4 Reference Publications

4.1 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.

4.2 Throughout this Standard, the CSA and ULC standard references apply to products intended for use in Canada, while the UL standard references apply to products intended for use in the United States. Combined references are commonly separated by a slash (“ / ”).

4.3 The following publications are referenced in this Standard:

Canada	United States
CSA C22.2 No. 107.3, Uninterruptible Power Systems	UL 1778, Uninterruptible Power Systems
CSA C22.2 No. 66-1, Low Voltage Transformers – Part 1: General Requirements	UL 5085-1, Low Voltage Transformers – Part 1: General Requirements
CSA C22.2 No. 66.3, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers	UL 5085-3, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers
CSA C22.2 No. 61010-2-030, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits	UL 61010-2-030, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 2-030: Particular Requirements for Testing and Measuring Circuits
CSA C22.2 No. 94.1, Enclosures for Electrical Equipment, Non-Environmental Considerations	UL 50, Enclosures for Electrical Equipment, Non-Environmental Considerations
CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	UL 746C, Polymeric Materials – Use in Electrical Equipment Evaluations
No equivalent	UL 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
No equivalent	UL 723, Test for Surface Burning Characteristics of Building Materials
CSA C22.2 No. 18.1, Metallic Outlet Boxes	UL 514A, Metallic Outlet Boxes
CSA C22.2 No. 18.3, Conduit, Tubing, and Cable Fittings	UL 514B, Conduit, Tubing, and Cable Fittings
No equivalent	UL 1439, Tests for Sharpness of Edges on Equipment
CSA C22.2 No. 178.1, Transfer Switch Equipment	UL 1008, Transfer Switch Equipment
CSA C22.2 No. 111, General-Use Snap Switches	UL 20, General-Use Snap Switches
CSA C22.2 No. 14, Industrial Control Equipment	UL 508, Industrial Control Equipment
CSA C22.2 No. 100, Motors and Generators	UL 1004-4, Electric Generators
CSA C22.2 No. 0.19, Requirements for Service Entrance Equipment	UL 869A, Reference Standard for Service Equipment
CSA C22.2 No. 18.2, Nonmetallic Outlet Boxes	UL 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
No equivalent	UL 746A, Polymeric Materials – Short Term Property Evaluations
CSA C22.2 No. 75, Thermoplastic-Insulated Wires and Cables	UL 83, Thermoplastic-Insulated Wires and Cables
CSA C22.2 No. 153, Electrical Quick-Connect Terminals	UL 310, Electrical Quick-Connect Terminals
CSA C22.2 No. 198.1, Extruded Insulating Tubing	UL 224, Extruded Insulating Tubing
CSA C22.2 No. 197, PVC Insulating Tape	UL 510, Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
CSA Component Acceptance Service Notice No. 5, Component Acceptance Service for Optocouplers and Related Devices	UL 1577, Optical Isolators
CSA C22.2 No. 66.1, Low Voltage Transformers – Part 1: General Requirements	UL 5085-1, Low Voltage Transformers – Part 1: General Requirements
CSA C22.2 No. 66-2, Low Voltage Transformers – Part 2: General Purpose Transformers CSA C22.2 No. 66-3, Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers	UL 506, Specialty Transformers
CSA C22.2 No. 47, Air-Cooled Transformers (Dry Type)	UL 1561, Dry-Type General Purpose and Power Transformers
CSA C22.2 No. 5, Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures	UL 489, Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
ULC-S111, Standard Method of Fire Tests for Air Filter Units	UL 900, Air Filter Units
CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	UL 796, Printed-Wiring Boards
No equivalent	UL 1446, Systems of Insulating Materials – General
No equivalent	UL 746B, Polymeric Materials – Long Term Property Evaluations
CSA C22.2 No. 46, Electric Air Heaters	UL 499, Electric Heating Appliances

Canada	United States
CSA C282, Emergency Electrical Power Supply for Buildings	NFPA 110, Emergency and Standby Power Systems
CSA C22.2 No. 107.2, Battery Chargers	UL 1236, Battery Chargers for Charging Engine-Starter Batteries
ULC/ORD-C558, Guide for the Investigation of Internal Combustion Engine-Powered Industrial Trucks	UL 558, Industrial Trucks, Internal Combustion Engine-Powered
CSA C22.2 No. 223, Power Supplies with Extra-Low-Voltage Class 2 Outputs	UL 1310, Class 2 Power Units
CSA 8.3, Thermoplastic Hose And Hose Couplings For Conducting Propane And Natural Gas CGA-8.1, Elastomeric Composite Hose and Hose Couplings for Conducting Propane and Natural Gas	UL 21, LP-Gas Hose
CSA C22.2 No. 0.15, Adhesive Labels	UL 969, Marking and Labeling Systems
CSA C22.2 No. 65, Wire Connectors	UL 486A-486B, Wire Connectors
CSA C22.2 No. 65, Wire Connectors	UL 486E, Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
No equivalent	UL 157, Gaskets and Seals
CSA C22.2 No. 14, Industrial Control Equipment	UL 508, Industrial Control Equipment
CSA C22.2 No. 107.1, Power Conversion Equipment	UL 1012, Power Units Other Than Class 2
CSA C22.2 No. 60529, Degrees of Protection Provided by Enclosures (IP Code)	IEC 60529, Degrees of Protection Provided by Enclosures (IP Code)
No equivalent	IEEE C37.40, Service Conditions and Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories
CSA C22.2 No. 144.1, Ground-Fault Circuit-Interrupters	UL 943, Ground-Fault Circuit-Interrupters
CSA C22.2 No. 144, Ground Fault Circuit Interrupters	UL 943C, Outline for Special Purpose Ground-Fault Circuit-Interrupters
CSA C22.2 No. 26, Construction and Test of Wireways, Auxiliary Gutters, and Associated Fittings	UL 870, Wireways, Auxiliary Gutters, and Associated Fittings
CSA C22.2 No. 190, Capacitors for Power Factor Correction	UL 810, Capacitors
CSA-E60384-14, Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains	UL 60384-14, Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains
CSA C22.2 No. 8, Electromagnetic Interference (EMI) Filters	UL 1283, Electromagnetic Interference Filters
CSA C22.2 No. 141, Emergency Lighting Equipment	UL 924, Emergency Lighting and Power Equipment
CSA C22.2 No. 29, Panelboards and Enclosed Panelboards	UL 67, Panelboards
CSA C22.2 No. 250.0, Luminaires	UL 1598, Luminaires
CSA C22.2 No. 250.0, Luminaires CSA C22.2 No. 9.0, General Requirements for Luminaires	UL 2108, Low Voltage Lighting Systems
National Building Code of Canada – Emergency Lighting	NFPA 101, Life Safety Code
CSA C22.2 No. 31, Switchgear Assemblies	IEEE 1247, IEEE Standard for Interrupter Switches for Alternating Current Rated Above 1000 Volts IEEE C37.20.3, Metal-Enclosed Interrupter Switchgear (1 kV – 38 kV) IEEE C37.20.4, Indoor AC Switches (1 kV to 38 kV) for Use in Metal-Enclosed Switchgear NEMA C37.54, For Indoor Alternating Current High-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear – Conformance Test Procedures NEMA C37.57, For Switchgear – Metal-Enclosed Interrupter Switchgear Assemblies – Conformance Testing

Canada	United States
	NEMA C37.58, For Switchgear – Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear – Conformance Test Procedures
CSA C22.2 No. 253, Medium-Voltage AC Contactors, Controllers, and Control Centres	UL 347, Medium-Voltage AC Contactors, Controllers, and Control Centers
CSA C22.2 No. 0.22, Evaluation Methods for Arc Resistance Ratings of Enclosed Electrical Equipment	IEEE C37.20.7, Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults
C22.2 No. 0.2, Insulation Coordination	UL 840, Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment
CSA C22.2 No. 139, Electrically Operated Valves	UL 429, Electrically Operated Valves UL 428A, Electrically Operated Valves for Gasoline and Gasoline/Ethanol Blends with Nominal Ethanol Concentrations Up to 85 Percent (E0 – E85) UL 428B, Electrically Operated Valves for Diesel Fuel, Biodiesel Fuel, Diesel/Biodiesel Blends with Nominal Biodiesel Concentrations Up to 20 Percent (B20), Kerosene, and Fuel Oil
CSA B51, Boiler, pressure vessel, and pressure piping code ASME B31.3, Process Piping	ASME B31.3, Process Piping
CSA-B149.6, Code for digester gas, landfill gas, and biogas generation and utilization	No equivalent
ULC/ORD-C536, Flexible Metallic Hose	UL 536, Flexible Metallic Hose
ANSI Z21.21/ CSA 6.5, Automatic Valves for Gas Appliances	ANSI Z21.21/ CSA 6.5, Automatic Valves for Gas Appliances
ANSI Z21.18/ CSA 6.3, Gas Appliance Pressure Regulators	ANSI Z21.18/ CSA 6.3, Gas Appliance Pressure Regulators
ULC/ORD-C959, 540 Degrees C and 760 Degrees C Industrial Chimneys	UL 2561, 1400 Degree Fahrenheit Factory-Built Chimneys
ULC-S629, 650 Degrees C Factory-Built Chimneys	UL 103, Factory-Built Chimneys for Residential Type and Building Heating Appliances
CSA C22.2 No. 236, Heating and Cooling Equipment	UL 1995, Heating and Cooling Equipment
CSA C22.2 No. 165, Electric Boilers	UL 834, Heating, Water Supply, and Power Boilers – Electric
CSA CAN1-3.1, Industrial and Commercial Gas-Fired Packaged Boilers	UL 795, Commercial-Industrial Gas Heating Equipment
ANSI Z21.13/ CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers	ANSI Z21.13/ CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers
CSA B149.1, Natural Gas and Propane Installation Code	UL 181, Factory-Made Air Ducts and Air Connectors
CSA B51, Boiler, Pressure Vessel, and Pressure Piping Code	ASME Boiler and pressure vessel Code VIII Rules for Construction of Pressure Vessels, Division 1
CAN/CGSB 12.1-M90, Tempered or Laminated Safety Glass	ANSI Z97.1, Safety glazing Materials Used in Buildings – Safety Performance Specifications and Methods of Test
IEC 60695-2-13, Glow-wire ignition temperature (GWIT) test method for materials	IEC 60695-2-13, Glow-wire ignition temperature (GWIT) test method for materials
ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process	ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A90, Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings	ASTM A90, Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM D1525, Standard Test Method for Vicat Softening Temperature of Plastics	ASTM D1525, Standard Test Method for Vicat Softening Temperature of Plastics
ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers Tension	ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers Tension
ASTM E230/E230M, Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples	ASTM E230/E230M, Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

Canada	United States
ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus	ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus
ANSI C37.55, Switchgear – Medium-Voltage Metal-Clad Assemblies – Conformance test procedures	ANSI C37.55, Switchgear – Medium-Voltage Metal-Clad Assemblies – Conformance test procedures
NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines	NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
ASME B31.1, Power Piping	ASME B31.1, Power Piping
ASME B1.20.1, Pipe Threads, General Purpose (Inch)	ASME B1.20.1, Pipe Threads, General Purpose (Inch)
NFPA 54/ANSI Z223.1, National Fuel Gas Code	NFPA 54/ANSI Z223.1, National Fuel Gas Code
ASME B36.10M, Welded and Seamless Wrought Steel Pipe	ASME B36.10M, Welded and Seamless Wrought Steel Pipe
ISO 10380, Pipework – Corrugated metal hoses and hose assemblies	ISO 10380, Pipework – Corrugated metal hoses and hose assemblies
ASTM F1120, Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications	ASTM F1120, Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications
ASME B36.19M, Stainless Steel Pipe	ASME B36.19M, Stainless Steel Pipe
ASME B31.11, Slurry Transportation Piping Systems	ASME B31.11, Slurry Transportation Piping Systems
IEEE 4, High-Voltage Testing Techniques	IEEE 4, High-Voltage Testing Techniques
NFPA 79, Electrical Standard for Industrial Machinery	NFPA 79, Electrical Standard for Industrial Machinery
ISO 7000, Graphical symbols for use on equipment – Registered symbols	ISO 7000, Graphical symbols for use on equipment – Registered symbols
ISO 7010, Graphical symbols – Safety colours and safety signs – Registered safety signs	ISO 7010, Graphical symbols – Safety colours and safety signs – Registered safety signs
IEC 60417 Database, Graphical Symbols for Use on Equipment	IEC 60417 Database, Graphical Symbols for Use on Equipment
ISO 19372, Microturbines applications – Safety	ISO 19372, Microturbines applications – Safety
IEC 61508, Functional safety of electrical/electronic/ programmable electronic safety-related systems	IEC 61508, Functional safety of electrical/electronic/ programmable electronic safety-related systems
IEEE C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	IEEE C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

CONSTRUCTION

5 General

5.1 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 for the United States, and the Canadian Electrical Code, CSA C22.1 for Canada; and

2) The Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA 37; and

3) The Standard for Stationary Engine Generator Assemblies, UL 2200.

6 Protection of Users and Service Personnel

6.1 The controller shall comply with the requirements of Sections 8 and 39 of the Standard for Stationary Engine Generator Assemblies, UL 2200.

7 Enclosures

7.1 General

7.1.1 A complete enclosure shall comply with the requirement of:

a) The Standard for Industrial Control Panels, UL 508A for the United States and

b) Industrial Control Equipment, CSA C22.2 No. 14 for Canada.

A partial enclosure provided as part of the end product equipment shall comply with the requirements of the Standard for Stationary Engine Generator Assemblies, UL 2200. Field wiring requirements shall comply with the requirements of UL 2200.

7.2 Panel mounted displays

7.2.1 Exposed frames and coverings of LCD, and similar displays that are panel mounted or part of a panel mounted device and observation windows or a part, such as a dial, membrane or face plate, that serves as a functional part of the end product enclosure shall comply with the requirements of the Standard for Stationary Engine Generator Assemblies, UL 2200, Section 7.6.

7.2.2 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.

7.2.3 Outdoor use LCD displays shall be suitable for UV exposure or provided with provisions for protection from UV exposure.

7.2.4 Panel mount equipment evaluated 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.

7.3 Specific enclosures

7.3.1 An enclosure or panel mount component rated other than Type 1 shall also be evaluated to:

a) The Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E for the United States and

b) Enclosures for electrical equipment, environmental considerations, CSA C22.2 No. 94.2 for Canada.

7.3.2 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:

a) The Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E for the United States and

b) Enclosures for electrical equipment, environmental considerations, CSA C22.2 No. 94.2 for Canada.

7.3.3 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.

7.3.4 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.

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

Exception: Equipment protected from splashing fuel, coolant or oil from the engine by mechanical guards, evaluated in the end product application need not be so rated.

7.3.6 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.

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

7.4 Equipment with incomplete or partial enclosures

7.4.1 Equipment with incomplete or partial enclosures shall comply with the requirements of 7.1 – 7.3 for the parts that complete the integrity of the intended enclosure.

7.4.2 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 type rating use while installed on a representative type rated enclosure during testing;

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 47.13.

c) Installation instructions are provided in accordance with 49.3; and

d) The component, its carton, or accompanying instruction sheet is marked in accordance with the requirement in 49.2.

ELECTRICAL SYSTEM

8 Separation of Circuits

8.1 General

8.1.1 Separation of circuits shall comply with these requirements and shall comply with the end product standard in the installation instructions.

8.2 Factory wiring

8.2.1 Insulated conductors of different circuits (see 8.2.2) within an engine generator assembly, including wires in a terminal box or compartment, shall be either separated by barriers or segregated and shall be so separated or segregated from uninsulated live parts connected to different circuits.

Exception: For insulated conductors of different circuits other than class 2 or low-voltage, limited energy (LVLE), when each conductor is provided with insulation intended for the highest of the circuit voltages, no barriers or segregation are required.

8.2.2 For the purpose of the requirement in 8.2.1, different circuits include those separated in Table 8.1.

Table 8.1
Circuit characteristics

Hazardous Voltage Circuits		Non – hazardous Low Voltage Circuits (Accessible Non-Hazardous Secondary Circuit)	
Characteristics	**Examples**	**Characteristics**	**Examples**
>30 V_{rms} (sinusoidal)	output power circuit	≤ 30 V_{rms} (sinusoidal)	Limited Energy circuit
>30 V_p (non sinusoidal)-	power supply to control circuit	≤30 V_p (non-sinusoidal)	Limited Voltage circuit, starting battery[b]
>42.4 V_p (non sinusoidal)-	output/sense/monitor/control/ feedback circuits (non-sinusoidal) (or output side of these circuits, when isolation[a] provided to low voltage circuits)	≤42.4V_p (non-sinusoidal)	low voltage side of output feedback circuits, when isolation[a] provided
>60 V_{DC} (if >10% ripple, composite voltage, subject to 42.2 V_p limit)	supply voltage for AC/DC starter battery charger, when provided	≤ 60 V_{DC}	low voltage side of AC/DC starter battery charger, when provided
Any circuit not isolated from a hazardous voltage circuit, regardless of working voltage (e.g., a 5V control circuit is hazardous when referenced to a 240V output circuit: 5V across circuit, and 240V to ground)	AC convenience receptacles, when provided, engine ignition coil output, gas turbine ignition exciter output		control/signal circuits accessible to the user/ operator, or intended for external or remote connections (e.g., Class 2 Remote-Control, Signaling Circuits – Article 725 of the NEC)

[a] Isolation that meets applicable requirements including construction, spacings, electrical strength, abnormal operation.

[b] See 14.2 for fusing requirements, source may have amperage potential of up to 300 A – 1000 A.

8.2.3 Segregation of insulated conductors is to be accomplished by clamping, routing, or an equivalent means that maintains permanent separation from insulated and uninsulated live parts and from conductors of a different circuit.

8.3 Separation barriers

8.3.1 A barrier used to provide separation between the wiring of different circuits shall be:

a) Grounded metal or insulating material complying with the requirements in Solid Insulating Materials, Section 12, and no less than 0.71 mm (0.028 inch) thick, and

b) Supported so that it is not capable of being readily deformed so as to defeat its purpose.

8.3.2 A barrier used to provide separation between field wiring and parts of a different circuit (field wiring, factory wiring, or uninsulated live parts) shall be spaced no more than 1.6 mm (1/16 inch) from the enclosure walls and interior mechanisms, component-mounted panels, and other parts that serve to provide separated compartments.

8.4 Field wiring

8.4.1 The equipment shall be constructed so that a field-installed conductor of a circuit shall be separated by barriers as specified in 8.3.1 and 8.3.2 or be separated by segregation as specified in 8.4.2 from:

a) Factory-installed conductors connected to any other circuit, unless the conductors of both circuits are insulated for the maximum voltage of either circuit,

b) An uninsulated live part of another circuit and from an uninsulated live part where short circuit with it results in a risk of fire, electric shock, electrical energy involving high current levels, or injury to persons, and

c) Field-installed conductors connected to any other circuit unless:

1) Both circuits are Class 2 or Class *3, or

2) Both circuits are other than Class 2 or Class *3, and both circuits are insulated for the maximum voltage of either circuit.

Note: *In Canada, Class 3 not recognized.

8.4.2 Field installed conductors and the live parts of different circuits as indicated in 8.4.1, may be separated by a minimum of 6.4 mm (0.25 inch). When evaluating the separation requirements the field installed conductors are to be wired as in service and each conductor shall have 152 mm (5.98 inch) of slack. No more than average care is to be exercised in routing the wiring and stowing the conductor slack into the wiring compartment. The field installed conductors are to be wired as follows:

a) When each opening is located opposite a set of terminals, it is to be assumed that a conductor entering an opening is to be connected to the terminal opposite that opening.

b) When each opening is located other than the one opposite the terminal to which it is intended to be connected the potential for it to contact insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be evaluated.

9 Grounding

9.1 Grounding and Bonding shall comply with the grounding and bonding requirements of the Standard for Stationary Engine Generator Assemblies, UL 2200.

10 Electrical Connections

10.1 External connections

10.1.1 External connections that exit the enclosure or partial enclosure shall comply with the requirements of the Standard for Stationary Engine Generator Assemblies, UL 2200, Section 16 for output connection and Section 26 for accessible signal circuits.

10.2 Receptacles and equipment mounted connectors

10.2.1 Receptacles and equipment mounted connectors shall comply with Sections 16.4 and 28 of the Standard for Stationary Engine Generator Assemblies, UL 2200.

10.2.2 Male and female connectors, shall be provided with a design feature to prevent misalignment.

10.2.3 Controls with non-standard equipment mounted connectors shall be provided with a wiring harness assembly complying with 10.3.

10.2.4 Receptacles that are mounted through the walls of an enclosure shall comply with applicable requirements from Sections 16.4 and 28 of the Standard for Stationary Generator Assemblies, UL 2200.

10.2.5 Receptacles and equipment mounted connectors insulating materials shall comply with requirements in Solid Insulating Materials, Section 12.

Exception: When all circuits are from non-hazardous secondary sources the insulating materials need not comply with electrical insulation requirements for:

a) Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada and

b) The Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C for the United States.

10.2.6 Receptacles and equipment mounted connectors that carry any hazardous voltage circuits shall comply with spacings requirements Section 24 of the Standard for Stationary Engine Generator Assemblies, UL 2200.

10.2.7 Receptacles and equipment mounted connectors that may be energized when disconnected, such as an outlet, shall comply with Accessibility of live parts from the Standard for Stationary Engine Generator Assemblies, UL 2200 when disconnected from the mating plug.

10.2.8 Overcurrent protection shall be provided and shall have a current rating not exceeding the ampacity of receptacles and equipment mounted connector.

Exception: When the available current from a source complying with non-hazardous secondary circuit requirements does not exceed the ampacity of the connector then overcurrent protection need not be provided for that circuit.

10.3 Plugs and connectors within the enclosure

10.3.1 Attachment plugs and connectors, wiring assemblies, and cable assemblies shall comply with the appropriate standard from Annex A.

10.3.2 Plugs and connectors shall be selected for designs that prevent the misalignment of male and female connectors, insertion of a multi-pin male connector in a female connector other than the one intended to receive it, and other manipulations of parts that are accessible to the operator shall not result in mechanical damage or a risk of fire, electric shock, or injury to persons.

10.3.3 Insulating materials of attachment plugs and cable attached connectors shall comply with requirements in Solid Insulating Materials, Section 12.

Exception: When all circuits are from non-hazardous secondary sources the insulating materials need not comply with electrical insulation requirements of:

a) Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada and

b) The Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C for the United States.

10.3.4 Attachment plugs and cable attached connectors that carry any hazardous voltage circuits shall comply with Section 38 spacings requirements.

10.3.5 Attachment plugs and cable attached connectors that carry any hazardous voltage circuits shall be subjected to the Production-Line Dielectric Voltage-Withstand test in 45.1.

10.3.6 The ampacity of the attachment plugs and cable attached connectors shall be greater than or equal to the ampacity of the largest conductor of the cord it is attached to.

Exception No. 1: The ampacity of the plug or connector may alternatively be greater than or equal to the available current from a non-hazardous secondary source.

Exception No. 2: When the ampacity of the plug or connector is less than the ampacity of the cord, overcurrent protection shall be provided with a current rating not exceeding the ampacity of attachment plug or cord attached connector.

Exception No. 3: When the plug or connector is used in a current transformer secondary circuit the ampacity shall be sufficient to handle the expected current transformer secondary current for continuous and overload/short circuit conditions.

11 Secondary Circuits

11.1 Non-hazardous secondary circuits shall neither involve a risk of electric shock nor involve a risk of fire.

See Table 7.1 and Sections 25 and 26 of the Standard for Stationary Engine Generator Assemblies, UL 2200 for secondary circuits.

11.2 The following applications shall comply with requirements for non-hazardous secondary circuits:

a) User accessible circuits;

b) Communication circuits;

c) Sensor circuits connected to the Engine;

d) Sensor circuits connected to the output windings of a generator;

e) Analog circuits connected to remote potentiometers;

f) Remote signal circuits to be connected external to the generator or engine driven assembly.

11.3 Spacings between two different secondary circuits need not comply with Spacings, Section 38 when:

a) Neither circuit is associated with a safety circuit function and

b) It can be determined that under single fault condition the combined circuits meet the requirements for non-hazardous secondary circuits.

11.4 Circuits are considered to involve a risk of electric shock unless they comply with:

a) The Standard for Stationary Engine Generator Assemblies, UL 2200 limited voltage limited energy (LVLE) requirements;

b) UL 2200 Accessible Signal Circuits

c) UL 2200 or the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3 for the United States and Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, CSA C22.2 No. 66.3 Class 2 requirements for Canada; or

d) Battery supplied circuits operating at not greater than 60 V dc.

11.5 Circuits are considered to involve a risk of fire unless they comply with:

a) The Standard for Stationary Engine Generator Assemblies, UL 2200 limited voltage limited energy requirements;

b) UL 2200 or the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3 for the United States and Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, CSA C22.2 No. 66.3 Class 2 requirements for Canada;

c) UL 2200 limited impedance requirements of control circuits;

d) UL 2200 Accessible Signal Circuits

11.6 Accessible non-hazardous secondary circuits that are not inherently limited (overcurrent protection required) to 100 VA maximum shall be protected by an impedance that limits the available power before overcurrent protective device to:

a) 350 VA for a source of 15 volts or less; and

b) 250 VA for a source of more than 15 volts but not greater than 60 volts.

11.7 Controllers shall be protected externally against exposure to voltages exceeding 600 V ac or 750 V dc due to insulation failure of RTDs and other devices embedded in generator windings.

ELECTRICAL COMPONENTS

12 Solid Insulating Materials

12.1 General

12.1.1 Solid insulating materials shall be evaluated to the requirements in:

a) The Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C for the United States and

b) Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada.

Exception No. 1: The generic materials from Table 12.1 are suitable for direct support of live parts.

Exception No. 2: The generic materials from Table 12.2 are suitable for use as an insulating barrier when they do not directly support live parts.

Exception No. 3: Solid insulation used as a coating, potting, encapsulation, or cemented joint to create a pollution degree 1 micro environment for reduced creepage distances per Table 12.1 and Table 12.2 or in lieu of the required creepage and clearance distances shall alternatively comply with the Test for Pollution Degree 1 Environment and for Insulating Compound or Test for Cemented Joint from:

a) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 for the United States and

b) Information Technology Equipment – Safety – Part 1: General Requirements, CAN/CSA C22.2 No. 60950-1 for Canada.

Table 12.1
Minimum material characteristics for the direct support of uninsulated live parts

Generic material	Minimum thickness		RTI, °C
Beryllium Oxide	No limit		No limit
Ceramic, Porcelain and Slate	No limit		No limit
Diallyl Phthalate	0.71 mm	(0.028 inch)	105
Epoxy	0.71 mm	(0.028 inch)	105
Melamine	0.71 mm	(0.028 inch)	130
Melamine-Phenolic	0.71 mm	(0.028 inch)	130
Phenolic	0.71 mm	(0.028 inch)	150
Unfilled Nylon	0.71 mm	(0.028 inch)	105
Unfilled Polycarbonate	0.71 mm	(0.028 inch)	105
Urea Formaldehyde	0.71 mm	(0.028 inch)	100
NOTE: Each material shall be used within its minimum thickness and its RTI value shall not be exceeded during the Temperature Test, Section 40.			

Table 12.2
Generic materials suitable as a barrier

Generic material	Minimum thickness, mm	(inch)	RTI, °C
Aramid Paper	0.25	(0.010)	105
Cambric	0.71	(0.028)	105
Electrical Grade Paper	0.71	(0.028)	105
Epoxy	0.71	(0.028)	105
Mica	0.15	(0.006)	105
Mylar (PETP)	0.18	(0.007)	105

Table 12.2 Continued on Next Page

Table 12.2 Continued

Generic material	Minimum thickness, mm	(inch)	RTI, °C
RTV	0.71	(0.028)	105
Silicone	0.71	(0.028)	105
Treated Cloth	0.71	(0.028)	105
Vulcanized Fiber	0.71	(0.028)	105
NOTE – Each material shall have at least the minimum thickness specified and its Relative Thermal Index (RTI) value shall not be exceeded during the Temperature Test.			

12.2 Printed circuit boards

12.2.1 Printed Circuit Boards shall comply with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94 for the United States and Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada for a flammability classification of:

a) V-0, V-1, or V-2 for printed circuit boards totally within non-hazardous secondary circuits;

b) V-0 when the printed wiring board assembly is to be evaluated as a flame barrier; or

c) V-0 or V-1 for generator output voltage sensing circuits; or

d) V-0, V-1, or V-2 for all other applications.

12.2.2 Except for use in the conditions described in 12.2.1(a), Printed Circuit Boards shall comply with the requirements for direct support in:

a) The Standard for Printed-Wiring Boards, UL 796 for the United States and

b) Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada.

12.2.3 Permanent printed wiring board coatings applied to printed circuit boards shall comply with requirements of the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used In Printed-Wiring Boards, UL 746E.

13 Disconnection Device

13.1 Disconnect devices shall comply with:

a) The Standard for Industrial Control Panels, UL 508A and

b) Industrial Control Equipment, CSA C22.2 No. 14 or with

c) Section 14 of the Standard for Stationary Engine Generator Assemblies, UL 2200

based on the intended application.

14 Overcurrent Protective Device

14.1 Overcurrent protective devices shall comply with:

a) The Standard for Industrial Control Panels, UL 508A and

b) Industrial Control Equipment, CSA C22.2 No. 14 or

c) Section 29.2 of the Standard for Stationary Engine Generator Assemblies, UL 2200.

14.2 A Class 1 power-limited circuit, in accordance with:

a) The National Electrical Code (NEC), NFPA 70 for the United States and

b) The Canadian Electrical Code, CSA C22.1, for Canada

used to supply a programmable control circuit shall be supplied from a source having a rated output of no more than 30 volts and 1000 volt-amperes. When the source is other than a transformer, the circuit shall be protected by an overcurrent protection device rated no more than 167 percent of the volt-ampere rating divided by the rated voltage.

15 Surge Protection Devices

15.1 Surge protective device shall comply with the requirements in:

a) The Standard for Surge Protective Devices, UL 1449 for the United States and

b) Surge protective devices, CSA C22.2 No. 269 Series for Canada,

for circuits rated not greater than a 1000 volts nominal and be used within the appropriate surge protective device "Type".

15.2 Metal oxide varistors for circuits in circuits rated higher than 1000 V shall comply with Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV), IEEE C62.11. All other types of surge arresters in circuits rated higher than 1000 V shall comply with IEEE C62.1.

15.3 Surge protective device shall additionally comply with the requirements in:

a) The Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and

b) Insulation coordination, CSA C22.2 No. 0.2 for Canada

when used to reduce clearance distance requirements.

16 Transformers

16.1 Transformers shall comply with the relevant component standards in Annex A.

17 Battery Circuits

17.1 Battery charging circuits for the engine starting battery shall comply with the requirements of:

a) The Standard for Battery Chargers for Charging Engine-Starter Batteries, UL 1236 for the United States and

b) Battery chargers, CSA C22.2 No. 107.2 for Canada.

Exception: Spacings shall be evaluated to the requirements of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and Insulation Coordination, C22.2 No. 0.2 for Canada as an alternative to the spacings requirements of UL 1236 and CSA C22.2 No. 107.2.

17.2 Battery circuits other than specified in 17.1 shall comply with the applicable requirements from:

a) The Standard for Uninterruptible Power Systems, UL 1778 for the United States and

b) Uninterruptible Power Systems, CSA C22.2 No. 107.3 for Canada.

Exception: Spacings shall be evaluated to the requirements of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and Insulation Coordination, C22.2 No. 0.2 for Canada as an alternative to the spacings requirements of UL 1778 and CSA C22.2 No. 107.3.

18 Capacitors

18.1 A capacitor used for electromagnetic interference elimination or power-factor correction that is oil filled shall comply with:

a) The Standard for Capacitors, UL 810 for the United States and

b) Capacitors for power factor correction, CSA C22.2 No. 190 for Canada.

18.2 A capacitor connected across an input/output ac circuit that is connected to a utility shall comply with the requirements for across-the-line capacitors in:

a) The Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14 for the United States and

b) Fixed capacitors for use in electronic equipment – Part 1: Generic specification, CAN/CSA-E60384-1 for Canada.

19 Enclosure Cooling Fans

19.1 Enclosure cooling fans shall comply with the applicable requirements of:

a) The Standard for Industrial Control Panels, UL 508A for the United States and

b) Industrial control equipment, CSA C22.2 No. 14 for Canada.

20 Visual Indicators

20.1 A pilot light (indicator) shall comply with:

a) The Standard for Industrial Control Equipment, UL 508 or

b) The Standard for Low-Voltage Switchgear and Controlgear – Part 5-1: Control Circuit Devices and Switching Elements – Electromechanical Control Circuit Devices, UL 60947-5-1 for the United States and

c) Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices, CAN/CSA-C22.2 No. 60947-5-1 for Canada.

20.2 A miscellaneous lamp holder shall:

a) Comply with the applicable requirements of:

1) The Standard for Lampholders, UL 496 for the United States and

2) Lampholders, CSA C22.2 No. 43 for Canada;

b) Fill an opening in an enclosure of not more than 650 mm^2 (1 $inch^2$); and

c) Be covered by a lens with a flammability rating in accordance with:

1) The Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94 for the United States and

2) Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17 for Canada

of HB minimum.

20.3 A panel meter (monitoring devices only) shall comply with:

a) The Standard for Electrical Equipment For Measurement, Control, and Laboratory Use – Part 1: General Requirements, UL 61010-1 for the United States and

b) Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements, CAN/CSA-C22.2 No. 61010-1 for Canada.

20.4 A panel mount display shall comply with 7.2 and other applicable requirements of this standard.

21 Audible Indicators

21.1 An audible signaling appliance including a horn, bell, or buzzer shall comply with the applicable requirements of:

a) The Standard for Audible Signaling Devices for Fire Alarm and Signaling Systems, Including Accessories, UL 464 for the United States and

b) Signal equipment, CSA C22.2 No. 205 for Canada.

22 Switching Devices

22.1 General

22.1.1 An emergency stop button switch shall comply with the requirements of Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function, IEC 60947-5-5.

22.1.2 An emergency stop button switch intended to control the operation of the prime mover or excitation circuit shall have a key operated reset or have another means for locking in the latched “Off” state.

22.1.3 An emergency stop button switch and the circuit it controls shall be connected so that it cannot be bypassed by another local or remote control.

22.1.4 Panel mounted start, run, on, stop, off, or test switches shall be evaluated to:

a) The Standard for Industrial Control Equipment, UL 508;

b) The Standard for Low-Voltage Switchgear and Controlgear – Part 5-1: Control Circuit Devices and Switching Elements – Electromechanical Control Circuit Devices, UL 60947-5-1 for the United States and;

c) Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices, CAN/CSA-C22.2 No. 60947-5-1 for Canada or;

d) The Standard for Switches for Appliances – Part 1: General Requirements, 61058-1 for the United States and

e) Switches for Appliances – Part 1: General Requirements, CAN/CSA-C22.2 No. 61058-1 for Canada.

Note: If the switching device does not directly cut/disconnect critical power, but only does so by means of interconnected devices such as electromechanical relays or programmable logic, then the emergency stop circuit shall be considered a safety circuit and comply with functional safety requirements per Safety Circuits, Section 37.

22.1.5 Relays shall comply with the applicable requirements of:

a) The Standard for Industrial Control Equipment, UL 508 for the United States;

b) The Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1 for the United States; and

c) Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters, CAN/CSA C22.2 No. 60947-4-1 for Canada;

d) The Standard for Low-Voltage Switchgear and Controlgear – Part 5-1: Control Circuit Devices and Switching Elements – Electromechanical Control Circuit Devices, UL 60947-5-1 for the United States; and

e) Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices, CAN/CSA-C22.2 No. 60947-5-1 for Canada; or

f) The Standard for Electromechanical Elementary Relays – Part 1: General Requirements, UL 61810-1 for the United States; and

g) Automatic electrical controls for household and similar use – Part 2-10: Particular requirements for motor-starting relays, CAN/CSA-E60730-2-10 for Canada.

22.1.6 Solid-state output switching devices shall comply with the applicable performance requirements of:

a) 22.2;

b) 22.3; or

c) The Standard for Low-Voltage Switchgear and Controlgear – Part 5-1: Control Circuit Devices and Switching Elements – Electromechanical Control Circuit Devices, UL 60947-5-1 for the United States; and

d) Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices, CAN/CSA-C22.2 No. 60947-5-1 for Canada.

The testing shall be conducted at the manufacturer's specified maximum ambient temperature. The solid-state switching device/component shall be identified by manufacturer, model, type or part number and the devices declared voltage, current and temperature ratings.

Exception: A solid-state switching device intended to control a fuel safety shutoff valve shall comply with the requirements for safety circuits (functional safety) per Section 37, and with 22.3 endurance test with the following conditions:

a) A inductive load adjusted for 100 percent of the declared rated current shall be switched;

b) The switching cycle rate shall be 1 s on 9 s off (may be faster cycle rate per manufactures declared recommendations); and

c) The test shall be conducted for 100,000 cycles of operation.

The solid-state switching device output shall be rated in volt-amperes, pilot duty, continuous amperes and inrush amperes, or amperes and "Pilot Duty" or with Pilot duty code designation.

22.1.7 Battery contactors located within the control panel for control of start solenoids of the starting systems of internal combustion engines shall comply with:

a) The Standard for Battery Contactors for Use in Diesel Engines Driving Centrifugal Fire Pumps, UL 218A for the United States; and

b) Fire pump controllers, CSA C22.2 No. 263 for Canada or

c) The Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1 for the United States; and

d) Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters, CAN/CSA-C22.2 No. 60947-4-1 for Canada.

22.1.8 Switching devices intended to control a glow plug of a diesel engine or a heater load may be rated general use or resistive.

22.1.9 Switching devices intended to control an electromechanical relay, contactor, shunt trip of circuit breaker, solenoid, or similar coil loads shall be rated for pilot duty.

Exception No. 1: A switching device intended to control the shunt trip of a circuit breaker may alternatively be evaluated for protective relay functionality in the end product application. Make, carry, and interrupt rating performance requirements apply when the output rating is specified for circuit breaker shunt trip control. Switching device outputs evaluated for make only and not evaluated for a carry and/or interrupt current rating shall be identified as tripping duty only.

Exception No. 2: A switching device with a general use rating may be used to control a coil load when all of (a) – (c) below apply:

a) The load voltage is not greater than 50 V;

b) The load current rating is 10 percent of the switching device ampere rating; and

c) The load is connected in parallel with a snubber circuit. The snubber circuit shall be one of the below:

1) A reverse biased (flywheel) diode with a minimum forward current rating of 110 percent of load current and minimum reverse (blocking) voltage rating of 300 percent of the maximum rated load voltage for direct current loads,

2) A varistor complying with the Standard for Surge Protective Devices, UL 1449 for the United States and Surge protective devices – Type 1 – Permanently connected, CSA C22.2

No. 269.1 and Surge protective devices – Type 2 – Permanently connected, CSA C22.2 No. 269.2 for Canada with a voltage protection rating of not greater than 200 percent of the maximum rated load voltage; or

3) A 100 ohm non-inductive resistor in series with a 0.1 micro-farad, or larger, capacitor rated 50 V minimum.

22.1.10 Switching devices intended for starting of fans, blowers, pumps, vents, and other motor loads shall be rated in horsepower or FLA and LRA.

22.2 Overload Test

22.2.1 The programmable controller employing a solid-state relay or semiconductor switch for an output device shall be required to establish an ON-state, to commutate, to carry designated levels of load and, if applicable, overload currents, and to establish and sustain an OFF-state condition without failure or any type of damage to the circuit, when tested in accordance with 22.2.2.

22.2.2 The programmable control shall be operated for 50 operations, ON-state and OFF-state at a circuit supply voltage of 100 to 110 percent of the maximum rated voltage. The load is to consist of a manufacture specified load type representative of the load that the device is intended to control. The load types are to be those specified in Table 46.2.

Note: Alternately if the system solid-state relay or semiconductor switch supply voltage cannot be increased, the overload test can be conducted at 110 percent of the rated inductive load or 150 percent of the rated resistive load.

22.2.3 The device is to be thermally operated at the manufacturer's specified maximum ambient temperature.

22.2.4 The test cycle rate is to be 1 second ON-state and 9 s OFF-state if the operation of the device is such that the test can be so conducted.

Exception: May be faster cycle rate per manufactures declared recommendations, minimum 1 s OFF-state.

22.2.5 The load is to be set to conform with Table 46.2 at the rated potential and then the voltage/current is to be increased 10 percent without further adjustment of the load. After the completion of the overload test verify the criteria:

a) No loss of commutating capability.

b) No loss of blocking capability.

c) No loss of functionality.

d) No visual evidence of damage.

22.3 Endurance Test

22.3.1 During the endurance test described in this section, there shall be no electrical or structural breakdown of the solid-state relay. After the test, the device shall comply with the requirements of the Dielectric Voltage-Withstand Test, Section 41.

22.3.2 The conditions for the endurance test shall be the same as the conditions for the overload test as specified in 22.2, except as described in this section.

22.3.3 The programmable control shall be operated for 6000 cycle operations; rate is to be 1 s ON-state and 9 s OFF-state if the operation of the device is such that the test can be so conducted. The closed circuit supply voltage of 100 to 110 percent of the maximum rated voltage.

Note: See the Exception to 22.1.6 for a control for a fuel safety shutoff valve.

23 Motor Controllers and Large Scale Automatic Voltage Regulators (AVR)

23.1 Motor controllers incorporated as part of the overall product shall comply with the requirements of:

a) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1 for the United States and

b) Adjustable speed drives, CSA C22.2 No. 274 for Canada.

23.2 Large scale AVR power circuits shall comply with:

a) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1 for the United States and Adjustable speed drives, CSA C22.2 No. 274 for Canada for construction requirements and

b) The Standard for Medium-Voltage AC Contactors, Controllers, and Control Centers, UL 347 for the United States and Medium-voltage ac contactors, controllers, and control centres, CSA C22.2 No. 253 for Canada for control spacings.

23.3 Large scale AVR power circuit bus bars shall comply with:

a) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1 for the United States and Adjustable speed drives, CSA C22.2 No. 274 for Canada for construction requirements;

b) The Standard for Medium-Voltage AC Contactors, Controllers, and Control Centers, UL 347 for the United States and Medium-voltage ac contactors, controllers, and control centres, CSA C22.2 No. 253 for Canada for control spacings; and

c) The Standard for Stationary Engine Generator Assemblies, UL 2200 requirements for the United States for bus bar construction.

24 Overtemperature Protection Devices

24.1 Thermal cut-outs switches shall comply with:

a) The Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9 for the United States and

b) Automatic electrical controls for household and similar use – Part 2-9: Particular requirements for temperature sensing controls, CAN/CSA-E60730-2-9 for Canada

as limiting devices.

24.2 Thermistors that are utilized for integral thermal protection shall comply with:

a) The Standard for Thermistor-Type Devices, UL 1434 for the United States; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 for the United States and

c) Automatic electrical controls – Part 1: General requirements, CAN/CSA-E60730-1 for Canada

and shall be suitable for use in a safety circuit (i.e., are suitable as a limiting device).

25 Heating Device Controls

25.1 Fuel system heater control circuits shall comply with:

a) the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 for the United States and

b) Automatic electrical controls – Part 1: General requirements, CAN/CSA-E60730-1 for Canada

for operating controls "Type 1 Action" and shall incorporate limiting type over-temperature protection devices complying with Overtemperature Protection Devices, Section 24.

26 Internal Power Transfer

26.1 An internal power transfer circuit shall not control power supply circuits connected external to the equipment.

Exception: Power supply circuits may be connected external to the equipment that are:

a) From the secondary of an isolation transformer connected on the load side of the power transfer circuit or

b) In a flashing circuit of an excitation control.

26.2 Internal power transfer switching devices shall comply with the component requirements in 26.5 and shall be mechanical or electromechanical. Solid-state switching devices shall not be used for internal power transfer.

26.3 The internal power transfer circuits shall be designed to control all lines, including the grounded conductor, of both normal and alternate sources.

26.4 If separate electromechanical controls are provided for each source, an interlock circuit shall be provided that prevents the contacts from being closed on both sources at the same time.

26.5 Internal power transfer switching circuits shall comply with the applicable performance requirements from the Standard for Transfer Switch Equipment, UL 1008 for the United States and Transfer switch equipment, CSA C22.2 No. 178.1 for Canada based on the intended application. The UL 1008 and CSA C22.2 No. 178.1 Withstand test is not required for control circuits. The normal and alternate sources used in the test shall be representative of the intended sources with the:

a) Highest voltage;

b) Highest current; and

c) Highest power.

26.6 The loads used for the tests may be simulated or the integral loads of the equipment. Power supply and battery charger loads shall be loaded to the maximum rated output current for the endurance test.

27 Isolation Components

27.1 Optical isolators and non-optical isolators relied on to provide isolation between different circuits (isolation circuit) shall comply with:

a) The Standard for Electrically Isolated Semiconductor Devices, UL 1557 for the United States and

b) CSA Component Acceptance Service Notice No. 5 for Canada

requirements and shall have a dielectric isolation-voltage rating of at least 1000 plus 2 times the maximum nominal voltage rating for circuits rated greater than 50 volts or 500 volts for circuits with a maximum nominal voltage rating of 50 volts or less.

27.2 Optical isolator components that provide isolation between primary circuits and accessible circuits shall comply with:

a) The Standard for Electrically Isolated Semiconductor Devices, UL 1557 for the United States and

b) CSA Component Acceptance Service Notice No. 5 for Canada

requirements for double-protection and shall have a dielectric isolation-voltage rating of at least 1600 plus 3 times the maximum nominal voltage rating.

27.3 Power switching semiconductors that are relied on to provide isolation to a grounded part such as an enclosure or heat sink shall comply with:

a) The Standard for Electrically Isolated Semiconductor Devices, UL 1557 for the United States and

b) CSA Component Acceptance Service Notice No. 5 for Canada

requirements and shall have a dielectric isolation voltage rating of at least 1000 plus 2 times the maximum nominal voltage rating for circuits rated greater than 50 volts or 500 volts for circuits with a maximum nominal voltage rating of 50 volts or less.

27.4 An Impedance network consisting of one or more resistors relied on to provide isolation between different circuits shall comply with the dielectric isolation-voltage rating of 27.1 and the spacings shall comply with:

a) The Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and

b) Insulation coordination, CSA C22.2 No. 0.2 for Canada.

Exception: Power switching semiconductors that are used in secondary circuits complying with Section 11 need not comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557 for the United States and CSA Component Acceptance Service Notice No. 5 for Canada.

28 Fuel System Control Circuits

28.1 Engine and fuel control equipment shall comply with the requirements for Safety Circuits, Section 37:

a) That are intended when installed in a building to control automatic fuel stop valves when fire detection and alarm systems are activated per the Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA 37;

b) That are relied on to shut off pumps or valves to prevent spillage of liquid fuel or venting of gaseous fuel; and/or

c) That are relied on to shut off fuel to the engine when used in combination with an electronic protection system.

28.2 Engine and fuel control circuits intended to control automatic fuel safety shutoff valves shall comply with 22.1.6.

29 Engine Start Control

29.1 General

29.1.1 Equipment provided with automatic start control and/or exercise control shall also be provided with manual start control. The manual start control shall over-ride the operation of the automatic start control.

29.1.2 The start control circuits shall be supplied by the engine starting battery.

29.1.3 The start control circuit shall be arranged so that the “run” or fuel solenoid control circuit is energized during and after the starting circuit has been energized.

29.1.4 A start control circuit shall be arranged so that the “run” or fuel solenoid control circuit is deenergized if the engine fails to start.

29.1.5 A start control circuit shall be arranged so that upon starting and running of the engine the starting control circuit is de-energized.

29.2 Manual engine start

29.2.1 A manual start control switch shall be provided with a momentary type actuator for the start cycle.

29.2.2 A digital input circuit used to initiate a remote control manual start sequence shall comply with Switching Devices, Section 22 and 29.3.2 – 29.3.4.

29.3 Automatic engine start

29.3.1 An automatic start control shall be arranged so that prime mover cannot start when an emergency stop circuit has been activated.

29.3.2 A complete engine starting duty cycle of an automatic start control shall consist of an automatically repeating starting duty cycle consisting of a 15 s start time followed by 15 s rest time in accordance with one of the following:

a) For emergency standby applications in Canada is Emergency electrical power supply for buildings, C282;

b) For emergency standby applications in the United States is the Standard for Emergency and Standby Power Systems, NFPA 110;

c) For fire pump applications in Canada is Fire pump controllers, CSA C22.2 No. 263;

d) For fire pump applications in the United States is the Standard for the Installation of Stationary Pumps for Fire Protection, NFPA 20 or the Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems NFPA 25.

Exception: A programmable start control may be able to be set for additional starting cycle rates.

29.3.3 An automatic start control that is used in an emergency standby system or automatic start control that is used in fire pump applications shall be configured per the requirements specified in 29.3.2.

Exception: A programmable start control may be able to be set for additional starting time limits.

29.3.4 An automatic engine start control shall have an engine run sensing circuit and shall cease further starting operation when the engine starts.

29.3.5 An automatic engine start control used in emergency standby applications or fire pump applications shall comply with the functional safety requirements per Section 37.

29.3.6 An automatic engine start control used in emergency standby or fire pump applications shall be provided with an indicator or alarm signal output to indicate failure to start the engine.

29.3.7 A loss of mains automatic start control shall be able to operate by each of the following means:

a) Test switch;

b) Interrupting each conductor of the mains supply;

c) Low mains supply voltage of:

1) 85 percent of the nominal sensing voltage rating for AC;

2) 80 percent of the nominal sensing voltage rating for DC; or

3) The marked trip voltage limits specified by the manufacturer if other than (1) or (2).

29.3.8 A loss of mains automatic start control shall additionally operate by an under frequency condition if so declared by the manufacturer.

29.3.9 An analog input circuit used to initiate the start sequence shall comply with Audible Indicators, Section 21 and shall initiate the start sequence at the voltage or current value specified by the manufacturer.

Exception: An analog input circuit intended to be used with a specific transducer shall be evaluated for compatibility with that transducer.

29.3.10 A digital input circuit used to initiate a remote control start sequence shall additionally comply with Switching Devices, Section 22.

29.3.11 An automatic engine start control for fire pump applications shall have provisions to switch to a second battery set for three additional starting cycles if the engine has not started in the first three starting cycles.

29.3.12 The maximum number of starting attempts shall be defined by the manufacturer and factory set in accordance with the end-use application. The maximum number of starting attempts shall be permitted

to be adjusted by qualified service personnel. Once the maximum number of starting attempts has been reached, the controls shall be capable of manual reset.

29.4 Automatic exercise control

29.4.1 An automatic exercise control shall comply with 29.3.1 – 29.3.4.

29.4.2 An automatic exercise control shall be arranged so that the exercise control is over-ridden when the engine is under control of the automatic start or manual start system.

29.4.3 The automatic exercise control equipment for fire pump and emergency standby systems shall have adjustable exercise time durations to comply with the installation codes specified in 29.3.2.

Exception: A programmable exercise control may be able to be set for additional run durations.

29.4.4 The automatic exercise control shall comply with the end product standards and installation codes specified in 29.3.2.

30 Engine Speed Control

30.1 General

30.1.1 An engine speed control circuit shall be provided with overspeed protection or limiting that complies with the Overspeed test requirements of the Standard for Stationary Engine Generator Assemblies, UL 2200.

30.1.2 An overspeed control that is the primary means to protect from mechanical hazard from expelled parts of the engine shall comply with the requirements for electronic protection described in 32.1 and the requirements for safety circuits described in 37.1.

30.2 Frequency regulation

30.2.1 An Engine Speed control that provides frequency regulation shall comply with the Output Voltage and Frequency Fluctuation Test from the Standard for Stationary Engine Generator Assemblies, UL 2200.

30.3 Voltage regulation

30.3.1 An Engine Speed control that provides voltage regulation shall comply with the Output Voltage and Frequency Fluctuation Test from the Standard for Stationary Engine Generator Assemblies, UL 2200.

31 Automatic Transfer Switch Control

31.1 An automatic transfer switch control shall comply with the Normal Operation test from:

a) The Standard for Transfer Switch Equipment, UL 1008 for the United States and

b) Transfer switch equipment, CSA C22.2 No. 178.1 for Canada or

c) *The Standard for Solid-State Transfer Switches, UL 1008S for the United Sates.

Note: *In Canada not recognized.

Exception: An automatic transfer switch control that is not intended for a specific transfer switch shall verify the detection time only at the normal source (utility) and alternate source (generator) control terminals.

31.2 A solid-state output circuit or solid-state interlock circuit shall comply with the requirements for Safety Circuits, Section 37.

32 Electronic Protection

32.1 Electronic protection circuits shall be evaluated in the end product.

32.2 A programmable controller incorporating electronic thermal protection shall comply with the Solid-State Circuitry-Protected Motors Tests of:

a) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 for the United States and

b) Automatic electrical controls – Part 1: General requirements, CAN/CSA-E60730-1 for Canada.

32.3 Programmable controllers evaluated as a current limiting device in a short circuit condition shall be evaluated with a specific interrupting device, AVR and generator series construction in the end product. Current limiting may be accomplished by controlling the prime mover speed or the excitation field current.

32.3.1 The generator is to be connected and operated as in the normal temperature test. While operating the AC output is to be shorted. Shorting is to include from line to line and line to neutral (when applicable).

32.3.2 When shorting the unit, the output is to be disconnected by a relay or similar device.

32.3.3 With reference to the Standard for Stationary Engine Generator Assemblies, UL 2200 Section 67.1 Ratings, Item (d), the maximum generator output fault current (peak and RMS) and short circuit current duration are to be measured immediately after the short is applied.

32.3.4 The short-circuit test is to be performed a total of four times so the short occurs in different portions of the line cycle for single phase units.

32.3.5 For a unit with a 3-phase output, the test is to be performed with shorts applied from phase to phase and from phase to neutral.

33 Synchronization Control – Utility Interactive Device

33.1 A programmable controller that provides synchronization control of utility interactive shall comply with the requirements of the Standard for Stationary Engine Generator Assemblies, UL 2200, Section 40.2, and the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.

34 Multiple Generator Paralleling Control Equipment

34.1 The paralleling controls with other generator sets or with another source of supply other than the utility, shall demonstrate that at the moment of the paralleling-device closure, all three parameters; frequency, voltage, and phase angle are within the manufacturers stated tolerance ranges. This test shall also demonstrate that if any of the parameters are outside of the ranges stated in the manufacturers declared range, the paralleling-device shall not close. This is to be evaluated in the end product application. The online generator is designated as the area EPS (Electrical Power System) that the oncoming generator shall parallel to within the following parameters:

a) Frequency: ± 0.1%;

b) Voltage: ± 5%; and

c) Phase angle: ± 10 degree

34.2 Power production paralleling control equipment shall be tested using the synchronization requirements and applicable test method in the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547 and the Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1. Where the test specifies the manufacturer's unique EPS parameters; the generators and paralleling control equipment may require unique parameters for voltage, frequency and phase angle and are required to be tested with these unique limits.

Exception: Power production paralleling controls relying on indirect voltage, frequency and or phase angle sensing communication methods shall comply with the parameters of 33.1 and the magnitude of the synchronization current recorded.

Note: Synchronization current is used with area EPS impedance at a specific location to estimate the maximum voltage fluctuation related to synchronization.

34.3 The paralleling controls shall demonstrate multiple generator balanced load paralleling. When running in parallel with other generator sets or with another source of supply other than the utility, means shall be provided to ensure stable operation and correct sharing of reactive power. This is to be evaluated in the end product application.

35 Excitation Control

35.1 A current limiting control function shall be evaluated in the end product application.

35.2 An excitation control system that provides generator protection shall comply with the applicable requirements for electronic protection.

35.3 An automatic voltage regulator function shall be evaluated in the end product application.

36 Annunciators

36.1 An Annunciator shall not be used as a primary safety control.

37 Safety Circuits

37.1 A safety risk assessment based on the end product application shall be conducted to identify safety circuits performing functions that are the primary means to mitigate risk of fire, electric shock, or other hazards that could cause personal injury. The risk assessment shall take into account hardware failures, design faults, operator errors, and environmental impacts. Guidelines for the safety risk assessment are provided in Safety of machinery – General principles for design – Risk assessment and risk reduction, ANSI/ISO 12100, Sections 5.4, 5.5 and 6. These requirements apply to circuits implementing functions that:

a) Limit the effects of abnormal voltage and/or power for standalone power applications;

b) Limit the effects of an overcurrent condition or current limiting in a short circuit condition for standalone power applications;

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 and energy parameters of a paralleling device controller for closing permissive for standalone power applications;

f) Control the detection time of electronic protection of the engine, fuel, generator, pump, and other components of the system;

g) Provide a means to remove output power to 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 (see 37.3); and

j) Incorporate signal and communication circuits that interconnect systems or devices to provide the safety functions described above.

37.2 Solid-state switching circuitry relied on for safety circuit fuel flow control functions per 37.1, shall be evaluated for reliability per the Exception to 22.1.6.

37.3 Systems that include utility interactive circuits shall comply with the requirements of the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547 and the surge requirements of Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus, IEEE C37.90.1 for the intended application.

37.4 Signal and communication circuits permanently connected to Utility interactive devices shall comply with the requirements of the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547 and the surge requirements of Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus, IEEE C37.90.1 for the intended application.

37.5 Safety circuits that rely on embedded software or firmware shall be identified by microprocessor model and firmware/software version. In addition, that software/firmware shall comply with one of the following functional safety standards:

a) IEC 61508-3, Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements (minimum of SIL 1);

b) UL 60730-1, Automatic Electrical Controls – Part 1: General Requirements for the United States and/or CAN/CSA-E60730-1 Automatic electrical controls – Part 1: General requirements (Annex H.11.12 only) (minimum of Software Class B) for Canada;

c) UL 1998, Software in Programmable Components (minimum of Software Class 1) for the United States; and/or

d) CSA C22.2 No. 0.8, Safety functions incorporating electronic technology (minimum of Software Class B) for Canada.

Exception No. 1: Software/firmware that is performing a supplementary function supported by external and independent limiting protection is not required to comply with functional safety requirements.

Exception No. 2: Safety Control circuits that meet the requirements of proven in use elements in Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 2:

Requirements for electrical/electronic/programmable electronic safety-related systems, IEC 61508-2, are not required to comply with (a) – (d).

37.6 Control circuits become supplementary functions when supported by external and independent limiting protection. Some examples include, but are not limited to:

a) Overload protection provided by the programmable controller when a separate fuse or circuit breaker is provided to protect the generator and generator output conductors.

b) Software controlled interlock of a transfer switch controller when the transfer switch is mechanically interlocked.

c) Additional software-based limiting device that meets the requirements of 37.5.

SPACINGS

38 General

38.1 General

38.1.1 Clearance and creepage distances between circuits shall comply with the requirements of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and Insulation coordination, CSA C22.2 No. 0.2 for Canada on printed circuit boards and the Standard for Stationary Engine Generator Assemblies, UL 2200 for the United States in all other areas. The minimum standalone application field wiring terminal spacings are determined in accordance with UL 840 and CSA C22.2 No. 0.2, per the applicable pollution degree environment, and overvoltage CAT III environment.

38.1.2 The minimum utility interactive application field wiring terminal spacings are determined in accordance with:

a) The Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and

b) Insulation coordination, CSA C22.2 No. 0.2 for Canada

per the applicable pollution degree environment, and overvoltage CAT IV environment or CAT III if provided with current and voltage limiting devices per UL 840.

38.2 Printed-wiring board assembly guidance

38.2.1 The use of coating or encapsulation intended on printed wiring boards as an alternative to providing required creepage distances under the coating shall comply with:

a) The Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, Section 11 for the United States and

b) Insulation coordination, CSA C22.2 No. 0.2 for Canada.

Generic encapsulation materials suitable as a barrier may be found in Table 38.2 . Clearances and creepage distances provided on printed-wiring board assemblies may be less than indicated in UL 840, Tables 8.1 and 9.1, and CSA C22.2 No. 0.2, provided that they comply with 38.2.2 – 38.2.8.

38.2.2 All printed-wiring board assemblies shall apply the Table 38.3 Pollution Degree 3 requirements except as noted in 38.2.3 and 38.2.4.

38.2.3 Pollution Degree 2 shall be considered to exist on a printed-wiring board where a conformal coating provides an uninterrupted covering of the conductive material for at least one of two conductive materials and covers the entire space between the two conductive materials for which the spacing is being evaluated.

38.2.4 Pollution Degree 1 shall be considered to exist on a printed-wiring board where a potting barrier as specified in 12.1 and Table 38.2 or conformal coating that complies with:

a) The Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and

b) Insulation coordination, CSA C22.2 No. 0.2 for Canada

is provided.

38.2.5 A printed-wiring board or other solid insulation shall be considered to be Material Group IIIb (CTI of 100 to 175) without further investigation. For printed-wiring boards or other solid insulation of Material Groups I, II, or IIIa, the requirements of:

a) The Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C for the United States and

b) Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada

shall apply.

38.2.6 For those areas of printed-wiring boards in Pollution Degree 3, clearances and creepage distances shall be no less than the values in:

a) The Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and

b) Insulation coordination, CSA C22.2 No. 0.2 for Canada.

38.2.7 For those areas of printed-wiring boards where Pollution Degree 1 or 2 are provided by a coating, creepage distances shall be no less than the values in:

a) The Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and

b) Insulation coordination, CSA C22.2 No. 0.2 for Canada.

The existence of recurring voltages shall be evaluated in accordance with UL 840 and CSA C22.2 No. 0.2.

38.2.8 Spacings are not specified for a circuit involving a potential of not more than 30 V and supplied by a primary battery or by a Class 2 transformer or by a combination of transformer and fixed impedance having output characteristics in compliance with those required for a Class 2 transformer.

Table 38.1
Minimum acceptable spacings in millimeters (inches) for other than on the PWB

Potential involved, in volts		Power circuits rated 400 A maximum and control circuits					
		51 – 150		151 – 300		301 – 600	
Between any uninsulated live part and an uninsulated live part of opposite polarity	Through air (clearance)	3.2[a]	(1/8)[a]	6.4	(1/4)	9.5	(3/8)
	Over surface (creepage)[d,e]	6.4	(1/4)	9.5	(3/8)	12.7	(1/2)
Between any uninsulated live part and an uninsulated grounded part, other than the enclosure, or exposed metal part	Through air (clearance)	3.2[a]	(1/8)[a]	6.4	(1/4)	9.5	(3/8)
	Over surface (creepage)[d,e]	6.4	(1/4)	9.5	(3/8)	12.7	(1/2)
Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable	Shortest distance (clearance and creepage)[d,e]	12.7	(1/2)	12.7	(1/2)	12.7	(1/2)
Potential involved, in volts		**Power circuits rated over 400 A**					
		50 – 150		**151 – 300**		**301 – 600**	
Between any uninsulated live part and an uninsulated live part of opposite polarity	Through air (clearance)	12.7	(1/2)	19.1	(3/4)	25.4	(1)
	Over surface (creepage)[d,e]	19.1	(3/4)	31.8	(1-1/4)	50.8	(2)
Between any uninsulated live part and an uninsulated grounded part, exposed metal part, or walls of a metal enclosure, including fittings for conduit or armored cable[b]	Through air (clearance)	12.7	(1/2)	19.1	(3/4)	25.4[c]	(1)[c]
	Over surface (creepage)[d,e]	12.7	(1/2)	12.7	(1/2)	25.4	(1)

[a] The spacing between wiring terminals of opposite polarity and the spacing between a wiring terminal and a grounded part shall not be less than 6.4 mm (1/4 inch) if short-circuiting or grounding of such terminals can result from projecting strands of wire.

[b] For the purpose of this requirement, a metal piece attached to the enclosure shall be considered a part of the enclosure if deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts.

[c] A through-air spacing of not less than 12.7 mm (1/2 inch) is acceptable:

1) At the main terminals, and

2) Between grounded dead metal and the neutral of a 277/480 V, or 347/600 V, 3-phase, 4-wire transfer switch.

[d] In measuring over-surface spacings, any slots, grooves, and the like, 0.33 mm (0.013 inch) wide or less in the contour of insulating material shall be disregarded.

[e] An air space of 0.33 mm (0.013 inch) or less between a live part and an insulating surface shall be disregarded and the part shall be considered in contact with the insulating material when measuring spacings.

Table 38.2
Generic materials suitable as a potting barrier

Generic material	Minimum thickness,		RTI, °C
	mm	(Inch)	
Epoxy	0.71	(0.028)	105
RTV	0.71	(0.028)	105
Silicone	0.71	(0.028)	105
NOTE – Each material shall have at least the minimum thickness specified and its Relative Thermal Index (RTI) value shall not be exceeded during the Temperature Test.			

Table 38.3
Control board pollution degree for application of UL 840

Generator location	Pollution degree
Areas Exposed To Brush Dust	4
Inside Sealed Nonventilated Enclosures and Enclosures with Filtered Air	2
Generator Engine Compartment	3
Generator Intake Plenum	3
Inside Hermetically Sealed Enclosures and Potted Equipment	1
Conformal Coating rated for PWB material[a]	1
Generic or Conformal Coating not rated for PWB material	2
[a] Only applies to the PWB surfaces covered by conformal coating. Does not apply to components mounted on PWB, PWB locations under components, component leads (above and below the PWB).	

39 Field Wiring Terminal Spacings

39.1 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Spacings, Section 38.

Exception: If the design of the field wiring terminals is such that it will preclude the possibility of reduced spacing due to stray strands or improper wiring installation, clearances and creepage distances at the field wiring terminal may be evaluated in accordance with:

a) The Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 for the United States and

b) Insulation coordination, CSA C22.2 No. 0.2 for Canada.

39.2 The following information should be used when determining if the terminals "will preclude the possibility of reduced spacing due to stray strands or improper wiring installation":

a) Terminals which are rated for solid wire only comply with this requirement.

b) Terminals which are marked to indicate use with a type of "prepared conductor" comply with this requirement.

Note: Prepared conductor are conductors, the strands of which are soldered or tinned; or the end of which is fitted with a cable lug, eyelet, quick-connect, ring terminal, spade terminal, or similar component, prior to insertion into the terminal.

c) Terminals with design features such as recessed terminal pockets comply with this requirement.

39.3 Terminal blocks shall comply with:

a) The Standard for Terminal Blocks, UL 1059 for the United States and

b) Terminal blocks, CSA C22.2 No. 158 for Canada

usage group C spacing and shall be suitable for the intended voltage, current and temperature.

Exception: Terminals blocks complying with UL 1059 and CSA C22.2 No. 158 usage group D spacing which are have been investigated as part a system to be suitable for the intended voltage, current and temperature.

PERFORMANCE DESIGN TEST

40 Temperature Test

40.1 The unit shall be operated at the manufacturer's declared rating for input and output current-voltage characteristics as specified per Table 46.1. The unit is to be energized from a supply that simulates the current-voltage characteristics and time response of the input source.

Exception: Circuits that operate only during the engine starting sequence need not be energized during the temperature test.

40.2 A unit shall not attain a temperature at any point so as to result in a risk of fire, to damage any material used, to result in the operation of a protective device, or to exceed the maximum temperatures specified in 40.4 and Table 40.1 and Table 40.2:

a) When the unit is delivering maximum rated output power in an ambient temperature as specified in 40.5, and

b) For a unit marked for operation at a higher ambient at reduced output power, the test is to also be performed at the specified higher ambient and the associated reduced output power.

Table 40.1
Surface temperature limits

Location[c]	Composition of surface[a]	
	Metal	Nonmetallic
Handles or knobs that are grasped for holding	50°C (122°F)	60°C (140°F)
Handles, buttons or knobs that are contacted and do not involve holding; and other surfaces subject to contact and user maintenance	60°C (140°F)	85°C (185°F)
Surfaces subject to casual contact	70°C (158°F)	95°C (203°F)

[a] A handle, knob, or similar device, made of a material other than metal that is plated or clad with metal having a thickness of 0.127 mm (0.005 inch) or less is judged as the underlying material.

Table 40.2
Maximum temperature

Materials and Components	Degrees °C	Degrees (°F)
1. Capacitors:		
a.Electrolytic types	65[b]	(149)[b]
b.Other than electrolytic	90[b]	(194)[b]
2. Field wiring terminals	75[c]	(167)[c]
3. Vulcanized fiber employed as electric insulation	90	(194)
4. Relays, solenoids, and similar components		
a.Class 105 (Class A) coil insulation systems:		
Thermocouple method	90[a]	(194)[a]
Resistance method	110	(230)
b.Class 130 (Class B) coil insulation systems:		
Thermocouple method	110[a]	(230)[a]
Resistance method	120	(248)
5. Transformer insulation systems:		
a.Class 105 (Class A):		
Thermocouple method	90[a]	(194)[a]
Resistance method	95	(203)
b.Class 130 (Class B):		
Thermocouple method	110[a]	(230)[a]
Resistance method	120	(248)
c.Class 155 (Class F):		
Thermocouple method	135[a]	(275)[a]
Resistance method	140	(284)
d.Class 180 (Class H):		
Thermocouple method	150[a]	(302)[a]
Resistance method	160	(320)
e.Class 200 (Class N):		
Thermocouple method	165[a]	(329)[a]
Resistance method	175	(347)
f. Class 220 (Class R):		
Thermocouple method	180[a]	(356)[a]
Resistance method	190	(374)
6. Phenolic composition employed as electrical insulation or as a part the deterioration of which results in a risk of fire or electric shock	150[d]	(302)[d]
7. Wood and other combustible material	90	(194)
8. Rubber- or thermoplastic-insulated wire and cord	60[d, e]	(140)[d, e]
9. Other types of insulated wire	f	f
10. A surface upon which a stationary unit is mounted and surfaces that are adjacent to the unit when so mounted	90	(194)
11. Any point on or within a terminal box or wiring compartment of a fixed unit which field-installed conductors are able to contact	60[c]	(140)[c]

Table 40.2 Continued on Next Page

Table 40.2 Continued

Materials and Components	Degrees °C	Degrees (°F)
12. Thermoplastic sealing compound	g	g
13. Selenium rectifier	75[h, d]	(167)[h, d]
14. Power semiconductor	i	i
15. Printed-wiring board	j	j

[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by a thermocouple is able to be 5°C (9°F) higher than that specified when the temperature of the coil as measured by the resistance method is not more than that specified.

[b] A capacitor that operates at a temperature of more than 65°C (149°F) for electrolytic or more than 90°C (194°F) for other types that are rated for a higher temperature shall not exceed its marked or specified rated temperature limit.

[c] The temperature observed on the terminals and at points within a terminal box or wiring component of a unit is able to exceed the values specified and shall not attain a temperature higher than the temperature marking required 48.9(c).

[d] The temperature limitation on phenolic composition and on rubber and thermoplastic insulation do not apply to a compound that has heat-resistant properties in accordance with:

1. The Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B for the United States and
2. Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada.

[e] For a short length of rubber- or thermoplastic-insulated cord inside the unit, a temperature greater than 60° C (140°F) where each individual conductor has supplementary insulation rated for the measured temperature and has dielectric properties in accordance with:

1. The Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A for the United States and
2. Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada; and
3. The Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B for the United States and
4. Evaluation of Properties of Polymeric Materials, CAN/CSA C22.2 No. 0.17 for Canada.

[f] Other than specified in (e), the maximum temperature shall not to exceed the temperature rating of the wire.

[g] The sealing compound temperature limit is 15°C (27°F) less than the softening point of the compound as determined in accordance with the test method for Vicat Softening Temperature of Plastics, ASTM D1525-91.

[h] A maximum temperature of 85°C (185°F) applies where the stack assembly is insulated with phenolic composition or other insulating material rated for a temperature of 150°C (302°F) or more.

[i] For a power-switching semiconductor and similar devices, the maximum temperature limit on the case shall not exceed the maximum case temperature specified by the semiconductor manufacturer.

[j] For a printed-wiring board, the maximum temperature shall not exceed the temperature rating of the board.

40.3 The temperature of a surface that is subject to contact shall not be more than specified in Table 40.1.

Exception: The temperature maximums specified for casual contact in Table 40.1 do not apply when:

a) The unit is a fixed unit that is typically not subject to contact by persons and

b) The unit is marked as required by 47.8.

40.4 An automatic voltage regulator (AVR) or field current regulator (FCR) shall be loaded under the manufacturers' maximum declared rating.

Exception: The AVR or FCR may alternatively be tested with the field coil of the intended generator as the load in the end product application.

40.5 The temperature maximums in Table 40.1 and Table 40.2 are based on an ambient temperature of 25°C (77°F). Tests are to be performed in the ambient temperature specified in Table 40.3 and corrected in accordance with Table 40.3.

Table 40.3
Temperature measurement correction

Ambient temperature rating of unit	Test ambient temperature	Correction of observed temperature
1. 25°C (77°F)	Range of 10 – 40°C (50 – 104°F)	a
2. Range of 25 – 40°C (77 – 104°F)	Range of 20 – 40°C (68 – 104°F)	b
3. Above 40°C (104°F)	Rated ambient [c]	d

[a] The measured temperature is to be corrected by addition [when the test ambient temperature is lower than 25°C (77°F)] or by subtraction [when the test ambient is higher than 25°C (77°F)] of the difference between 25°C (77°F) and the test ambient temperature.

[b] The measured temperature is to be corrected by addition (when the test ambient temperature is lower than the rated ambient temperature) or by subtraction (when the test ambient temperature is higher than the rated ambient temperature) of the difference between the rated ambient temperature and the test ambient temperature.

[c] Tolerances are:

Minus – not less than 5°C (9°F) below rated ambient.

Plus – not specified.

[d] When the test ambient temperature equals rated ambient, no correction is to be made, and the measured temperature shall not exceed the maximum temperature limit specified in Table 40.2. When the test ambient temperature is other than rated ambient, correction is to be made as described in b.

40.6 Temperatures used to determine compliance are to be stable. A temperature is stable when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, and not less than 15 min. apart, indicate no further increase in temperature.

40.7 During the temperature test, the unit test set up is as specified in 40.1 and all loads per Table 46.2 that can be simultaneously energized while in normal operation, the wiring shall be sized for the rated voltage and ampacity. It is to be mounted as in normal service to provide for the manufacturer's normally specified cooling method.

40.8 A unit intended for mounting or support in more than one position or in a confined location is to be tested in a manner representing the most severe conditions. An adjacent mounting or supporting surface shall consist of 25.4-mm (1-inch) thick soft-pine boards.

40.9 Thermocouples are to consist of wires not larger than 24 AWG and not smaller than 30 AWG. When thermocouples are used in determining temperatures, it is common practice to employ thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer type instrument. Such equipment is to be used whenever referee temperature measurements by thermocouples are required. The thermocouples and related instruments are to be accurate and calibrated in accordance with laboratory practice. The thermocouple wire is to conform with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

41 Dielectric Voltage-Withstand Test

41.1 Immediately following the temperature test or with the unit at normal operating temperature, a unit shall withstand for 1 min without breakdown the application of an 50/60 Hz ac rms test potential of:

a) One thousand volts plus twice the maximum voltage (see 41.2) between:

1) The input circuit and dead metal parts;

2) The output circuit and dead metal parts; and

3) the input and output circuits.

Exception: A test between input and output circuits is not required for an AVR not provided with a transformer or capacitor network isolating the input from the output circuit.

b) Five hundred volts between a secondary circuit operating at 50 volts or less and dead metal parts; 1000 volts plus twice the maximum secondary circuit voltage between a secondary circuit operating at more than 50 volts and dead metal parts.

c) One thousand volts plus twice the voltage between the terminals of a capacitor used across the ac or dc power circuit for electromagnetic interference elimination or power factor correction; and between the terminals of a capacitor connected between an ac or dc power circuit and the enclosure.

Exception No. 1: This test potential does not apply to capacitors that comply with either:

1) The Standard for Capacitors, UL 810 for the United States and

2) Capacitors for power factor correction, CSA C22.2 No. 190 for Canada;

3) The Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14 for the United States and

4) Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains, CAN/CSA-E60384-14 for Canada; or

5) The Standard for Electromagnetic Interference Filters, UL 1283 for the United States and

6) Electromagnetic interference (EMI) filters, CSA C22.2 No. 8 for Canada.

Exception No. 2: As an alternative to the ac rms test potential specified, use of a dc test potential of 1.414 times the ac rms value is permitted.

41.2 The maximum voltage determined in accordance with 41.2 and 41.3 is to be used as a basis for the:

a) Calculation of the dielectric voltage-withstand test potentials specified in 41.1, and

b) Determination of the minimum spacings specified in Spacings, Section 38, or 38.2.

41.3 A connector or comparable part that is expected to be disconnected during intended operation is to be both connected and disconnected during the test to obtain maximum voltage.

41.4 When a complex voltage is present, the peak value of the voltage is to be measured and this value is to be used for calculation of the dielectric voltage-withstand potential and determination of the minimum spacings. For a sinusoidal or a direct current voltage, the rms or average values respectively is to be measured.

41.5 To determine whether a unit complies with the requirements in 41.1, the unit is to be tested using a 500 volt-ampere or larger capacity transformer, the output voltage of which is variable. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level

for 1 min. The increase in applied potential is to be at a substantially uniform rate as rapid as is consistent with correct indication of its value by a voltmeter.

Exception: When a voltmeter is connected across the output circuit to directly indicate the test potential, the transformer is not required to be rated 500 or more volt-amperes.

41.6 A low-voltage control circuit or a sensor circuit is not required to be connected during the test. Any circuit which is connected from input to output circuit shall remain connected during the test and provide proper isolation in accordance with 3.8.8.

42 Breakdown of Components Test

42.1 General

42.1.1 Single fault testing shall be conducted on the programmable control per the test method as follows for Breakdown of Components, a 3 A fast acting fuse attached to the chassis or equipment grounding terminal through a grounding conductor shall be used in the setup. The programmable control, circuit diagrams and component specifications are examined to determine those fault conditions that might reasonably be expected to occur. Components, such as capacitors, diodes, solid-state devices, and similar components, are to be short- or open-circuited, any two terminals, one pair at a time. Short circuiting a resistor is excluded.

Exception: This test is not required:

a) Where circuit analysis indicates that no other component or portion of the circuit is able to be overloaded or

b) For components in low-voltage, limited-energy (LVLE) circuits, or other circuits that are not required to be investigated in accordance with this Standard.

42.1.2 There shall be no emission of flame or molten metal nor ignition of cotton loosely placed over all openings of ventilated equipment or totally around open type devices when capacitors, diodes, or other solid-state components are short- or open-circuited.

Exception: When it is not practical to use cotton around a wire mesh cage for testing of open type equipment the wire cage and cotton may be replaced with cheese cloth draped over the sample and tissue paper under the sample as a flame indicator.

42.1.3 When a programmable controller is used in fire pump and Level 1 emergency power supply applications, the single fault condition shall not effect a critical operation of the controller.

42.1.4 Fault insertion/injection testing, see:

a) Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements, IEC 61508 or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 for the United States and

c) Automatic electrical controls – Part 1: General requirements, CAN/CSA-E60730-1, Annex H, H.27.1.2 for Canada,

requirements for electronic circuit fault conditions may be used to identify applicable conditions of component faults.

42.1.5 When a remote potentiometer is to be field connected to the device, the terminals to the remote potentiometer shall also be open and short circuited.

42.2 Loss of Control Circuit

42.2.1 An engine generator or engine fuel system programmable control shall cease the export of power or secure the flow of fuel from the source to the unit upon the loss of control circuit power when tested in accordance with 42.2.2.

42.2.2 The engine generator or engine fuel system programmable control is to be connected to its rated input supply source and simulated control circuit or end product control application. A single fault is to be placed such that it disables the power to the control circuit.

Exception No. 1: When the control circuit is unable to be disabled under any single fault condition, this test is not required to be performed.

Exception No. 2: The unit may continue to export power if it continues to meet operational limits of the end product standard or manufacturers declared limits with the single fault specified in 42.1 in place.

43 AC Output Short Circuit Test of a Current Limiting Device in a Short Circuit Condition

43.1 General

43.1.1 The test shall be conducted in accordance with the AC Output Short Circuit Test specified in the Standard for Stationary Engine Generator Assemblies, UL 2200 in the end product.

43.2 Large Scale Power Plants – Signal Injection Simulated Fault

43.2.1 The signal injection method is only applicable to controls using pass-through type current transformers to simulate an ac output short circuit condition to demonstrate the programmable controllers' ability to act as a current limiting device in an ac output short circuit fault condition.

44 Integrated Combined Heat and Power controls (iICHP)

44.1 Inductive and resistive load controls shall comply with 22.2 and 22.3 for risk of fire and shock.

MANUFACTURING AND PRODUCTION-LINE TEST

45 Cabinet AVR Excitation Power Circuit Production-Line Dielectric Voltage-Withstand Testing

45.1 Each unit shall withstand without breakdown, as a routine production-line test, the application of a potential:

a) From input and output wiring, including connected components, to accessible dead metal parts that are able to become energized, and

b) From input and output wiring to accessible low-voltage, limited-energy metal parts, including terminals.

45.2 Other than as noted in 45.3, the potential for the production-line test shall be in accordance with Condition A or Condition B of Table 45.1 at a frequency within the range of 40 – 70 Hz.