STANDARDS UPDATE NOTICE (SUN)
ISSUED: August 20, 2018

STANDARD INFORMATION

Standard Number: UL 9540
Standard Name: Energy Storage Systems and Equipment
Standard Edition and Issue Date: 1st Edition Dated November 21, 2016
Date of Revision: November 21, 2016
Date of Previous Revision of Standard: UL Subject 9540 1st Edition Dated June 30, 2014

EFFECTIVE DATE OF NEW/REVISED REQUIREMENTS

Effective Date: **July 31, 2020**

IMPACT, OVERVIEW, AND ACTION REQUIRED

Impact Statement: A review of all Listing Reports is necessary to determine which products comply with new/revised requirements and which products will require re-evaluation. **NOTE:** Effective immediately, this revised standard will be exclusively used for evaluation of new products unless the Applicant requests in writing that current requirements be used along with their understanding that their listings will be withdrawn on Effective Date noted above, unless the product is found to comply with new/revised requirements.

Overview of Changes:

- Requirements for many tests were added including impulse, blocked shaft qualification, mechanical failure qualification, hydrostatic strength, and pneumatic strength tests
- Addition of requirements for mechanical and thermal energy storage systems
- Addition of requirements for Outdoors installations subject to moisture exposure
- Addition of requirements for Installation in seismic environments

Specific details of new/revised requirements are found in table below.

If the applicable requirements noted in the table are not described in your report(s), these requirements will need to be confirmed as met and added to your report(s) such as markings, instructions, test results, etc. (as required).

Client Action Required:

Information – To assist our Engineer with review of your Listing Reports, please submit technical information in response to the new/revised paragraphs noted in the attached or explain why these new/revised requirements do not apply to your product (s).

Current Listings Not Active? – Please immediately identify any current Listing Reports or products that are no longer active and should be removed from our records. We will do this at no charge as long as Intertek is notified in writing prior to the review of your reports.

STANDARD INFORMATION

CLAUSE	VERDICT	COMMENT
		Additions to existing requirements are underlined and deletions are shown lined out below.
7	Info	**Non-Metallic Materials**
7.2		***New clause added;*** In addition to the items in 7.3, polymeric electrical enclosures shall have the following properties: a) Minimum 5 VA flame rating, or the enclosure complies with the 127 mm (5 inch) Flame test of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and may require flame spread testing per the Enclosure Flammability – Large Surface Area Considerations test of UL 746C; b) Insulation material properties per the Material Property Considerations table of UL 746C; c) Compliance with the Strain-Relief Test after Mold Stress-Relief Distortion of UL 746C if serving as a securement means for a strain relief ; d) Compliance with the Ultraviolet Light Exposure test of UL 746C if exposed to UV rays in the end use; e) Compliance with the Water Exposure and Immersion test of UL 746C if exposed to rain in the end use; and f) Compliance with the Conduit Connections in the Enclosure Requirements table of UL 746C if mounting conduit connections.
9	Info	**Enclosures and Guarding of Hazardous Parts**
9.2		Openings in the enclosure of an electric energy storage system shall be designed to prevent inadvertent access to hazardous parts. Compliance shall be determined in accordance with the Tests for Protection Against Access to Hazardous Parts Indicated by the First Characteristic Numeral, Clause 12 of the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529, or the Standard for Degrees of Protection Provided by Enclosures (IP Code), CAN/CSA-C22.2 No. 60529, for a minimum IP rating of IP2X and the Canadian Electrical Code, Part I Safety Standard for Electrical Installations, C22.1, the Enclosure Selection Table for Nonhazardous Locations, Table 65, with consideration of the end use installation.
10	Info	**General Electrical Safety and Walk-in Systems**

CLAUSE	VERDICT	COMMENT
10.1		***New clause added;*** The instructions shall include measures and procedures for worker safety in, on or adjacent to the energy storage system according to the Standard for Electrical Safety in the Workplace, NFPA 70E, and the Standard for Workplace Electrical Safety, CSA Z462, and Section 2 of the Canadian Electrical Code, Part I Safety Standard for Electrical Installations, C22.1, and in accordance with this standard.
10.3		Entrances to the enclosure shall be designed to prevent persons from becoming trapped within the enclosure (i.e. entrances shall be able to be opened from inside the enclosure without use of a tool or key should they become closed). Personnel door(s) intended for entrance to, and egress from an enclosure, shall open in the direction of egress. The egress door shall be marked with the word "Exit" and the line-of-sight to an exit sign shall not be interrupted. Any doorway or passage that might be mistaken for an exit shall be marked "Not an Exit" or with an indication of its actual use. See 39.9.
10.4		Work space dimensions and requirements within an energy storage system, including walk-in enclosures, shall be in accordance with the National Electrical Code, NFPA 70, and the Canadian Electrical Code, Part I Safety Standard for Electrical Installations, C22.1, or the National Electrical Safety Code, IEEE C2 as applicable. The space requirement shall also provide for appropriate arc flash safety under specified personal protective equipment (PPE). See 39.6.
10.7		***New clause added;*** The type of protection equipment to be provided for arc flash hazards shall be determined by an arc flash risk assessment conducted according to the Standard for Electrical Safety in the Workplace, NFPA 70E, and the Standard for Workplace Electrical Safety, CSA Z462. The arc flash assessment results shall be labeled on the energy storage system. The assessment shall determine: a) The arc flash incidental energy level; b) The restricted approach boundary; and c) The required arc flash personal protective equipment.
10.8		An arc that can create a second degree burn to unprotected skin and therefore considered the level for determining an unprotected arc flash boundary, has an arc rating above 5 J/cm2 (1.2 cal/cm2) incident energy level per the Standard for Electrical Safety in the Workplace, NFPA 70E, and the Standard for Workplace Electrical Safety, CSA Z462.
10.9		Energy storage system enclosures that can be fully entered by persons shall have adequate ventilation for persons working within the enclosure. The amount of airflow determined adequate is based upon the floor area of the energy storage system and the maximum number of persons that can enter the walk-in enclosure at one time in accordance with the Standard for Ventilation for Acceptable Indoor Air Quality, ASHRAE 62.1. ASHRAE 62.1 provides a formula for calculating this based upon different types of occupancies. As guidance for determining suitable

CLAUSE	VERDICT	COMMENT
		airflow in a normally unoccupied energy storage system enclosure, the values for a storage space of dry goods may be used as a close approximation for estimating airflow in an area that is not routinely occupied, and using Table 6.2.2.1 of ASHRAE 62.1 for values. If the number of persons to occupy the space is not known, it is recommended to use 2 persons/100 m^2 as a default amount.
10.11		Electrical equipment including electrical equipment that is located in the walk-in enclosure in areas that will be subject to condensation, or the effects of condensation from equipment or systems that are provided with and installed in, on or around the energy storage system enclosure, shall be suitable for outdoor use or suitably protected against contact with water and protected against unsafe conduction of hazardous voltages to personnel via water as a conduction path.
10.12		Lighting shall be provided in enclosed working spaces. Lighting must be adequate and lighting outlets shall not be controlled by automatic means. Additional lighting outlets shall not be required where the work space is illuminated by an adjacent light source. Lighting within an energy storage system including lighting within a walk-in enclosure shall be installed in accordance with Article 410 of the National Electrical Code, NFPA 70, or Section 30 of the Canadian Electrical Code, Part I Safety Standard for Electrical Installations, C22.1 as applicable to the system where the system is installed.
10.13		***New clause added;*** Where there is more than one source of supply energizing the energy storage system, the energy storage system shall be provided with information and markings to indicate which disconnect device or devices are required to be operated to completely isolate the equipment.
10.14		***New clause added;*** Protection against lightning surges shall be provided in accordance with the requirements of the National Electrical Code, NFPA 70, the Canadian Electrical Code, Part I Safety Standard for Electrical Installations, C22.1, or the National Electrical Safety Code, IEEE C2 as applicable.
11	Info	**Wiring and Electrical Supply Connections**
11.3		***New clause added;*** An energy storage system or component of the energy storage system shall have provision for connection of the system to an external wiring system consisting of: a) Wiring terminals or wiring leads; or b) A means for connection of cable or conduit in accordance with the codes in 11.2.

CLAUSE	VERDICT	COMMENT
11.4		***New clause added;*** A wiring terminal or lead that is supplied as a component of the energy storage system shall be rated and sized for connection to a field wiring conductor having an ampacity of no less than 125% of the ac or dc current that the circuit carries during rated conditions and in accordance with the codes in 11.2.
11.5		***New clause added;*** A field-wiring lead shall not be more than two wire sizes smaller than the copper conductor to which it is to be connected, and shall not be smaller than 2.08 mm^2 (14 AWG). A field-wiring lead shall not be less than 152.4-mm (6-in) long.
12	Info	**General Electrical Service Equipment**
12.2		~~A hazardous voltage energy storage system shall have a manual disconnect to prevent inadvertent access to hazardous voltage parts during servicing. The manual disconnect shall be in a location accessible to the technician servicing the system and as close to the system being disconnected as possible.~~ Exposed hazardous voltage in an energy storage system should have a lockable manual disconnect to enable Lock-Out-Tag-Out (per the Standard for Electrical Safety in the Workplace, NFPA 70E, and the Standard for Workplace Electrical Safety, CSA Z462) during servicing or for emergency procedures. The lockable manual disconnect shall have sufficient interrupt ratings, shall be accessible to the technician servicing the system or first responders and as close to the exposed hazardous voltage conductor as possible. If not provided directly on the system, the installation instructions shall indicate the type and ratings of the disconnect to be provided in the installation, how it is to be installed and connected in the circuit and where it is to be located in regard to the energy storage system. Exception: A lockable disconnect is not required where it may be infeasible based upon the design of the system (e.g. interspersed in the middle of a high voltage battery string, within a battery system, to segment the string into segments less than the minimum hazardous voltage).
13	Info	**Electrical Spacings and Separation of Circuits**
13.3		There are no minimum spacings applicable to parts where insulating compound completely fills the casing of a compound or subassembly if the distance through the insulation, at voltages above 60 Vdc or above 30 Vrms is a minimum of 0.4-mm (0.02-in) thick for supplementary or reinforced insulation, and passes the Dielectric Voltage Withstand Test. There is no minimum insulation thickness requirement for insulation of circuits at or below 60 Vdc or for basic or functional insulation. Some examples include potting, encapsulation, and vacuum impregnation. Materials employed as electrical insulation shall meet the requirements of 7.4. In Canada, the limits for dc circuits is 42.4 Vdc as defined in the General Requirements – Canadian Electrical Code, Part II, CAN/CSA-C22.2 No. 0.

CLAUSE	VERDICT	COMMENT
16	Info	**Remote Controls**
16.1		Energy storage systems which have the ability to be controlled remotely shall be provided with an accessible means to disconnect the system from the remote control. The remote control disconnect shall either be provided on the system or instructions in the installation manual shall provide the location and type of disconnect to be provided in the end use installation. The use of a remote control systems shall not lead to an unsafe condition as determined by the system safety analysis and shall not be able to override local safety controls. If the remote control disconnect is to be provided as part of the installation (not built into the energy storage system), the instructions shall include information on the electrical connections including means to prevent the disconnect from being overridden by the remote control system.
17	Info	**Communication Systems**
17.1		Instructions for installation and operation of the energy storage system shall identify the communication protocols used by the energy storage system for communication between external systems intended to be connected to the energy storage system.
19	Info	**Piping Systems, Pressure Vessels, Fuel and Other Fluid Supply Connections and Controls**
19.1		Piping systems utilized to carry fluids in an energy storage system such as water, heated air, fuel gases, etc. shall comply with the ~~appropriate part(s) of the Power Piping, ASME B31.1 or the Process Piping, ASME B31.3~~ ASME Codes for Power Piping, ASME B31 (all applicable parts), or the Boiler, Pressure Vessel, and Pressure Piping Code, CSA B51, or the Mechanical Refrigeration Code, CSA B52, or the Oil and Gas Pipeline Systems, CSA Z662, or the Natural Gas and Propane Installation Code, CSA B149.1 as applicable.
19.3		Flammable fuel supply connections on the energy storage system shall be ~~in accordance with the National Fuel Gas Code, NFPA 54. Hydrogen supply connections to the energy storage system shall be in accordance with the Hydrogen Technologies Code, NFPA 2.~~ suitable for the material contained and in accordance with the applicable part of ASME 31 based upon the fluid, temperatures and pressures they are subjected to.
19.7		Manual shut off valves shall be provided on or near the energy storage system in a location where they can be accessed to allow for disconnection of the fuel or water supply from the energy storage system for maintenance, etc. If not provided on the system itself, installation instructions shall indicate type, ratings and location for installation of appropriate manual shut off valves. Automatic (nonelectric type) and manual valves intended for the use in flammable fluid lines shall comply with the Standard for Valves for Flammable Fluids, UL 842, or the Guide for the Investigation of Valves for Flammable and Combustible Liquids, ULC/C842. Solenoid valves shall comply with the Standard for Electrically Operated Valves, UL 429, or the Standard for Electrically Operated Valves, C22.2 No. 139. Where flammable liquids are in use, an automatic shutoff valve should be provided to limit the release of fuel during an abnormal condition.

CLAUSE	VERDICT	COMMENT
21	Info	**Hazardous Fluid Containment**
21.1		~~Energy storage systems that employ vented battery systems requiring electrolyte maintenance or other systems where there may be the potential for spills of hazardous electrolytes or other liquids, are to be provided with liquid spill containment that can contain the anticipated volume of a spill. Containment systems are to be made of materials resistance to deterioration when exposed to the contained liquids and if necessary, provided with a means to neutralize aqueous hazardous liquid spills.~~ Where the system design is such that there is a potential for spills of hazardous liquids, provisions for containment and/or neutralization of those liquids shall be provided. Methods utilized for containment shall be sufficient to hold the maximum anticipated quantity of liquid that could occur and designed to prevent inadvertent filling with rain if located outdoors. Instructions regarding the provision of suitable spill containment and neutralization shall be provided by the system manufacturer with the installation instructions, if required containment and/or neutralization is not provided as part of the energy storage system. Where flammable liquids are contained, provision for applicable fire detection and protection systems should be provided as determined per Section 23. Automatic leak detection to indicate the release of a hazardous/flammable liquid shall be provided.
21.2		***New clause added;*** Energy storage systems that contain fluids shall be designed to prevent venting of toxic vapors in concentrations considered to be hazardous based on an evaluation conducted in accordance with Sections 33 and 34.
21.3		***New clause added;*** Where multi-battery energy storage systems use conductive fluids that may come in contact hazardous voltages, containment shall be provided separately for each battery.
23	Info	**Fire Detection and Suppression**
23.1		~~The level of fire detection and suppression required for an energy storage system is dependent upon the size, technology and location of installation of the system. The protection may be as basic as instructions regarding the appropriate fire extinguishing materials to maintain within the location, installation instructions and basic housekeeping and safety procedures to follow, etc. to installation of fire suppression systems at the location of installation of the energy storage system.~~ The level and type of fire detection and suppression required for an energy storage system is dependent upon the size, technology and location of installation as well as the local building and fire codes or utility requirements. The fire detection and suppression system shall be built into the energy storage system's enclosure as determined from the fire risk analysis. Also, as a result of these various factors,

CLAUSE	VERDICT	COMMENT
		small energy storage systems such as single package residential systems located in accordance with local residential and fire codes, may only need to be provided with instructions regarding the appropriate fire extinguishing materials to maintain within the location and housekeeping and safety procedures to follow.
24	Info	**Utility Grid Interaction**
24.1	Info	**General**
24.1.3		***New clause added;*** The inverter shall also be designed to properly interconnect with the particular energy storage technology it is connected to as determined by the system safety analysis.
24.1.4		***New clause added;*** Products that rely upon internal or external utility interconnection protection functions or devices shall be specifically identified for the particular product. External utility interconnection protection may be required by means of utility protection relays as defined by specific product ratings and instructions.
24.1.5		***New clause added;*** It is intended that the acceptability of grid support utility interactive inverters shall be determined by the local electric utility.
24.2	Info	**Utility grid interactive inverter**
24.2.2		***New clause added;*** The utility-interactive inverters or converters may also include additional grid support and or special purpose utility-interactive features and/or functions that may be enabled in accordance with local utility interconnection protection requirements. For example, products may be evaluated for compliance with the NERC Reliability Standard for Generator Frequency and Voltage Protective Relay Settings, PRC-024-1.
24.2.3		***New clause added;*** Grid support utility-interactive inverters or converters may also include additional grid support utility-interactive functions addressed through other standards, and other functions that may be enabled in accordance with local utility SRD(s). The Standard for Interconnecting Distributed Resources with Electric Power Systems Amendment 1, IEEE 1547A and the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems Amendment 1, IEEE 1547.1A allow for grid support functionality.
24.3	Info	**Special purpose utility-interactive energy storage system inverters**

CLAUSE	VERDICT	COMMENT
24.3.2		***New clause added;*** Special purpose utility-interactive products are intended for use in specific power production applications that export power to the electric utility. These units are often installed in power farm applications. These units may be evaluated for compliance to a subset of the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547 and the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1 requirements and they may also include additional special purpose utility-interactive features addressed through other standards, and other functions that may be enabled in accordance with local utility interconnection protection requirements. Special purpose utility-interactive energy storage system inverters shall comply with all of the Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources, UL 1741 construction requirements defined for utility-interactive products, or the Standard for General Use Power Supplies, C22.2 No. 107.1.
24.3.4		***New clause added;*** Special purpose utility-interactive energy storage system inverters shall be evaluated for compliance with specific documents or requirements (in addition to the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547 and the Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547.1) only if those specific documents or requirements are referenced in the product ratings.
25	Info	**Energy Storage System Technologies**
25.1	Info	**Electrochemical energy storage systems**
25.1.1		Batteries, electrochemical capacitors, hybrid battery-capacitor systems or flow batteries used in an electrochemical energy storage system shall comply with the requirements of the Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications, UL 1973. Testing and evaluation of the battery system, which would include the battery and its battery management system is conducted as part of evaluation to UL 1973. Inverters and charging equipment that are part of the energy storage system shall be designed for use with the battery system employed in the energy storage system. For general information on battery safety, see also informative Appendix B.
25.2	Info	**Electrochemical energy storage systems**
25.2.1		A chemical energy storage system consists of storage of hydrogen fuel and the means to change the fuel into electrical energy using a fuel cell system or a hydrogen generator. To convert electrical energy into hydrogen fuel, a hydrogen generator using water electrolysis is also part of the overall system. Fuel cell systems that are part of a chemical energy storage system shall comply with the Standard for Fuel Cell Technologies – Part 3-100: Stationary Fuel Cell Power

CLAUSE	VERDICT	COMMENT
		Systems – Safety, CSA FC 1, Fuel Cell Power Systems. ~~shall be installed in energy storage systems in accordance with the Standard for the Installation of Stationary Fuel Cell Power Systems, NFPA 853, or other applicable regional or local installation codes.~~
25.2.3		~~Hydrogen equipment supplying fuel cell power systems shall comply with the applicable requirements outlined in the Hydrogen Technologies Code, NFPA 2 or other applicable regional or local codes.~~ Water electrolysis type hydrogen generators used in an energy storage system to provide hydrogen for storage shall be evaluated and found to be in compliance to an appropriate safety standard for the equipment.
25.2.4		~~Fuel controls and equipment supplying fuel cell power systems with integral reforming shall meet the applicable requirements of the National Fuel Gas Code, NFPA 54, the International Fuel Gas Code, ICC IFGC, the Flammable and Combustible Liquids Code, NFPA 30, or other applicable regional or local codes.~~ Hydrogen fuel containing parts of a chemical energy storage system shall be constructed of materials suitable for gaseous hydrogen service at the pressures and temperatures of use. Pressure vessels used for storage of gaseous hydrogen and piping employed as part of a chemical energy storage system shall comply with Section 19.
25.3		***New section added;*** **Mechanical energy storage systems**
25.3.1		Mechanical energy storage systems such as, but not limited to, flywheel systems or compressed air energy storage (CAES) systems shall be evaluated to determine that hazards associated with moving parts with the capacity to store kinetic energy, and high pressure and high temperature fluids contained in the system are mitigated. Compliance is determined by evaluation to the requirements of this standard.
25.3.2		Flywheel systems and other systems with moving parts with the capacity to store kinetic energy shall comply with the Containment of Moving Parts tests of Section 32 and the Strength Tests of Section 34. Parts containing hazardous fluids shall comply with the Leakage Tests of Section 33 and the Strength Tests of Section 34.
25.4		***New section added;*** **Thermal energy storage systems**
25.4.1		Thermal energy storage systems shall be evaluated to determine hazards associated with containment of high temperature and high pressure and potentially hazardous fluids are mitigated. Compliance is determined by evaluation to the requirements of this standard. Parts containing hazardous fluids and fluids at high temperatures and pressures shall comply with the Leakage Tests of Section 33 and the Strength Tests of Section 34.
	Info	**PERFORMANCE**

CLAUSE	VERDICT	COMMENT
26	Info	**General**
26.2		All tests conducted in accordance with this standard shall be conducted in an environment with an ambient temperature of 25 ±5°C (77 ±9°F), unless otherwise noted in the test method. Any cooling systems or other auxiliary systems that are part of the energy storage system ~~may~~ shall be operating during testing when their operation can affect the outcome of the test or when otherwise noted in the test method. For testing purposes, samples and parameters used for testing shall consider smallest size conductors and maximum allowed overcurrent protection in addition to worse case loading and temperatures conditions.
27	Info	**Normal Operations Test**
27.2		In conducting the electrical tests required in this standard, the energy storage system shall be operated through a ~~maximum~~ minimum of 2 cycles of charge and discharge of the system at the maximum loading rates as specified by the manufacturer. During the test, consideration shall be given to maximum and minimum ambient conditions. During operation, temperatures on critical components that are temperature sensitive shall be monitored and operating parameters of components of the system monitored to determine that they are operating within their ratings.
28	Info	**Dielectric Voltage Withstand Test**
28.2		Circuits at 42.4 Vpeak/ 30 Vrms or 60 Vdc or higher shall be subjected to a dielectric withstand voltage in accordance with the Electric Strength clause in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1/C22.2 60950-1. In Canada, the dc limits are 42.4 Vdc.
29		***New section added;*** **Impulse Test**
29.1		The impulse voltage test is intended to evaluate the energy storage system's ability to withstand lightning or similar surges. Systems provided with protection that has already been evaluated for voltage surges (e.g. inverters meeting the Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE 1547 criteria) need not be tested.
29.2		The impulse voltage test shall be performed with an impulse generator able to provide voltage having a 1.2/50 µs waveform with an output impedance not exceeding 2 W at voltages in accordance with Table 29.1, and is intended to simulate an overvoltage condition due to lightning or switching of equipment.

CLAUSE	VERDICT	COMMENT
		Impulse voltages
Table 29.1		

Voltage of Circuit Under Test V	Impulse test voltage, voltage between circuits and accessible parts.			
	Circuits connected to mains		Circuits not connected to mains	
	Basic or supplementary insulation V	Reinforced insulation V	Basic or Supplementary V	Reinforced Insulation V
≤ 50	500	800	800	1500
100	800	1500	1500	2500
150	1500	2500	2500	4000
300	2500	4000	4000	6000
500	4000	6000	6000	8000
1000	6000	8000	8000	12000
> 1000	a	a	a	a
[a] Interpolation is permitted for circuits above 1000 V.				

29.3		Pulses shall be applied at 1.2/50 µs for each polarity in ³ 1 s time intervals at the peak voltage for the rating of the circuit under test ±5% per Table 29.1. The test voltage is to be applied between the terminal/circuit under test and accessible parts. For circuits at 1000 V or less, three pulses at each polarity shall be applied. For circuits over 1000 V, 5 pulses at each polarity shall be applied.
29.4		As a result of the applied impulse voltage test, there shall be no puncture of insulation (i.e. electrical breakdown through solid insulation), occurrence of flashover (i.e. electrical breakdown over the surfaces of solid insulation), or spark-over (i.e. electrical breakdown through fluids such as air).
32	Info	**Containment of Moving Parts**
32.1	Info	**Over speed qualification test**
32.1.2		The system controls shall be subjected to single fault in the controls that would allow over speed of the moving parts. The DUT shall be operated at over speed conditions until a secondary protection control operates to stop operation of the DUT. ~~a) The part has operated for 30 min under an over speed condition and then as gradually slowed down after discontinuation of operation;~~ ~~b) A secondary protection control operates to stop operation of the DUT; or~~ ~~c) The part has loosened and is completely or partially disconnected from its securement means.~~
32.1.3		As a result of the over speed condition, the moving part(s) shall not become loosened or disconnected in a manner that would result in a hazardous condition. If completely loosened or disconnected as a result of the over speed conditions, the containment means shall safely contain the part(s) in accordance with the Faulted Securement Qualification Test in 32.2.
32.2	Info	**Faulted securement qualification test**

CLAUSE	VERDICT	COMMENT
32.2.2		~~The moving parts of the system shall be subjected to a single fault of their securement, such as a removed screw or other part of the securements means and then operated at maximum normal operation of the part. The parts tested shall be determined through a safety analysis such as being the potential worst case results.~~ The moving parts of the system shall be subjected to a single fault of the primary means of securement, and then operated at maximum normal operation. The primary means of securement to be removed, such as a failed bearing, shaft, or other part of the securement of the moving part with respect to the stationary housing, shall be determined through a safety analysis that identifies failure of the selected means as representing the potential worst case condition.
32.3		***New section added;*** **Blocked shaft qualification test**
32.3.1		An energy storage system with moving parts with the capacity to store kinetic energy shall be subjected to the blocked shaft qualification test if blocking the shaft or moving parts may result in a hazard.
32.3.2		With the moving part blocked to prevent movement, the system shall be operated at maximum operating conditions.
32.3.3		The system shall be operated: a) With the part blocked for 30 min and then stopped; b) Until a protection control operates to stop operation of the DUT with the blocked part; or c) Until any moving parts break off or become completely or partially disconnected from its securement means. Exception: Moving parts already evaluated for blocked shaft conditions as part of a component evaluation, need not be tested.
32.3.4		As a result of operating the system with a blocked shaft/moving part condition, the part shall not become loosened or disconnected to result in a hazardous condition. If the part becomes completely loosed or disconnected, the containment means for the part shall safety contain the part(s). There shall be no overheating of parts that will result in a hazard such as fire or explosion.
32.4		***New section added;*** **Mechanical failure qualification test**
32.4.1		An energy storage system with any moving part having the capacity to store kinetic energy shall have the rotating energy storage elements subjected to a mechanical failure qualification test. The mechanical failure qualification test shall be conducted to assure that at maximum operating speed, the mechanical energy storage element or flywheel will have a margin of safety of a factor of at least 2.0 between the stress that exists in the mechanical energy storage element at

CLAUSE	VERDICT	COMMENT
		maximum normal operating speed and the ultimate tensile strength of the mechanical energy storage element material at room temperature.
32.4.2		The mechanical energy storage element shall be subjected to a mechanical failure qualification test in a test facility capable of safely containing a mechanically failed component. The mechanical energy storage element shall be subjected to a qualification test. The qualification test shall subject the DUT to a stress that is at least 2x greater than the calculated stress at maximum operating speed. For a solid mechanical energy storage element such as a solid metal rotor, the qualification test shall be dynamic. The qualification test rotation rate shall be the rotation rate attained by the mechanical storage element without failure. The mechanical energy storage elements used in service shall be operated at no greater than 70% of the qualification test rotation rate. For hollow cylindrical mechanical energy storage elements, as an alternative to the dynamic test, a static test may be performed whereby the DUT is subjected to an internal pressure that creates maximum stress in the DUT that is greater than 2x the maximum stress under normal operating conditions. The mechanical energy storage element DUT shall: a) Be a production mechanical energy storage element; b) Be new; and c) Meet the manufacturer's quality assurance requirements for production units.
32.4.3		In the event of a deviation of any mechanical characteristic or material property that results in an increase of more than 15% between calculated stress in production mechanical energy storage elements and demonstrated stress in the previously qualified mechanical energy storage elements, the mechanical failure qualification test shall be repeated.
33	Info	**Leakage Tests**
33.1		Energy storage systems that contain hazardous fluids shall be subjected to the Leakage Test <u>in accordance with 33.2 and 33.3.</u> ~~Section 5.4 of the Standard for Fuel Cell Technologies – Part 3-100: Stationary Fuel Cell Power Systems – Safety, CSA FC 1.~~ ~~Exception: Energy storage systems need not be subjected to this test if already evaluated for external leakage as part of the specific technology safety standard.~~
33.2		***New clause added;*** Leakage from energy storage systems containing hazardous fluids shall not result in the risk of fire, electric shock, or injury to persons.
33.3		***New clause added;*** Compliance is determined by subjecting the fluid-containing parts and their connections to a fluid pressure of 1.5 times the maximum pressure (if testing with liquid) or 1.1 times the maximum pressure (if air pneumatic testing) of intended use during operation of the system. There shall be no leaks from fluid-containing parts or their connections as a result.

CLAUSE	VERDICT	COMMENT
34	Info	**Strength Tests**
34.1	Info	**General**
34.1.1		***New clause added;*** Energy storage systems that contain hazardous fluids shall comply with the Strength Tests in accordance with 34.2 and 34.3.
34.2		***New section added;*** **Hydrostatic strength test**
34.2.1		Parts of the energy storage system containing hazardous fluids (gases or liquids) shall be subjected to a hydrostatic strength test of 1.5 times the design pressure of the system for a period of 1 min after reaching the maximum pressure. The pressure shall be gradually increased until the maximum pressure is reached in approximately 1 min using either the liquid used in the system or water. Testing is done at ambient temperature.
34.2.2		As a result of the hydrostatic strength test, there shall be no fracture, distortion, rupture or other damage to the fluid containing parts.
34.3		***New section added;*** **Pneumatic strength test**
34.3.1		The pneumatic strength test is an alternative to the hydrostatic strength test of 34.2 and is conducted in accordance with 34.3.2.
34.3.2		Parts of the energy storage system containing hazardous fluids (gases or liquids) shall be subjected to a pneumatic strength test of 1.3 times the design pressure of the system for a period of 1 min after reaching the maximum pressure. The pressure shall be gradually increased until the maximum pressure is reached in approximately 1 min using either air or inert gas. Testing is conducted at ambient temperature.
34.3.3		As a result of the pneumatic strength test, there shall be no fracture, distortion, rupture or other damage to the fluid containing parts.
35	Info	**Special Environment Installations**
35.1	Info	**General**
35.1.1		Energy storage systems intended for installation in special environments shall be evaluated for their ability to operate safely in those environments. These environmental conditions can include exposure to salt fog for marine environments, testing for seismic ratings, high altitudes, etc. depending upon the particular special exposure. Environmental standards such as the IEC 60068 series of environmental testing standards ~~or other accepted environmental test procedures may be used to determine compliance.~~ shall be used to determine compliance. The installation instructions and nameplate labels on the energy storage system shall identify the special environmental conditions in accordance with 39.3, 39.8, and Section 40.

CLAUSE	VERDICT	COMMENT
		Exception: Testing need not be conducted on systems or parts of the system if already covered as part of the specific technology safety standard.
35.2		***New section added;*** **Outdoors installations subject to moisture exposure**
35.2.1		Energy storage systems intended for installation outdoors where they will be subject to rated levels of moisture exposure shall be tested in accordance with their environmental ratings outlined in their nameplate labels and installation instructions of 39.8 and 40.4.
35.2.2		Based upon the ratings of the system, moisture resistance testing shall be done in accordance with either the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529, Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, or the Standard for Enclosures for Electrical Equipment, Environmental Considerations, C22.2 No. 94.2.
35.2.3		At the conclusion of the test, the sample is to be subjected to the electric insulation tests of Sections 28 and 31 and examined for signs of water in the system that could result in a hazardous condition.
35.2.4		As a result of the water exposure, there shall be no evidence of water on parts that could result in a hazard and no reduction of spacings or breakdown/deterioration in insulation levels.
35.3		***New section added;*** **Outdoor installation near marine environments**
35.3.1		Energy Storage Systems intended for installation outdoors near marine environments in accordance with the installation instructions in 40.6 where they will be subject to salt fog exposure, shall be tested as outlined below.
35.3.2		The systems shall be tested in accordance with the Standard for Environmental Testing Part 2: Tests – Tests Kb, Salt Mist, Cyclic (Sodium Chloride Solution), IEC 60068-2-52 for Severities 1 or 2.
35.3.3		At the conclusion of the testing, the systems shall be subjected to the electrical insulation tests of Sections 28 and 31 to determine that insulation has not been damaged in a manner that would result in an electric shock hazard.
35.3.4		The system shall be examined for signs of damage as a result of salt exposure that would indicate a potential for a safety hazard (e.g. corrosion of parts that could result in weakening of a securement or an enclosure, damage to insulation). If operational, the system is to be operated to determine that it can do so without hazard.
35.3.5		As a result of the test, the energy storage system shall not show evidence of damage from salt fog exposure that could result in a hazard such as electrical, shock, overheating or damage that could result in a physical hazard.

CLAUSE	VERDICT	COMMENT
35.4		***New section added;*** **Installation in seismic environments**
35.4.1		Energy storage systems intended for installation where they will be subject to seismic activity shall be evaluated and if necessary tested in accordance with their seismic ratings and installations instructions per 39.3 and 40.6. The installation instructions shall indicate the limitations of the particular seismic rating of the equipment. Standards that provide guidance on seismic evaluation such as the Recommended Practice for Seismic Design of Substations, IEEE 693, the Recommended Practices for Seismic Qualification of Electrical Equipment of the Safety System for Nuclear Generating Stations, IEC 60980, or similar, shall be used for this evaluation.
35.4.2		The energy storage system shall be examined for signs of explosion, fire, combustible concentrations (if applicable to technology), rupture of the enclosure, electrolyte leakage, electric shock and loss of protection controls that may lead to any of the other non-compliant results in 35.4.3.
35.4.3		As a result of the test, any of the following results in (a) – (g) are considered a non-compliant result: a) Explosion; b) Fire; c) Combustible Concentrations (if applicable to technology); d) Rupture (enclosure); e) Electrolyte Leakage (external to enclosure); f) Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown); g) Loss of protection controls.
36	Info	**Dielectric Voltage Withstand Test**
36.1		A dielectric withstand test as outlined in the Dielectric Voltage Withstand Test in Section 28 shall be conducted on 100% production of energy storage systems with working voltage exceeding 60 Vdc or 30 Vrms/42.4 Vpeak. In Canada, replace “60 Vdc” with “42.4 Vdc”.
37		***New section added;*** **Grounding and Bonding System Check**
37.1		The grounding and bonding system of an energy storage system shall be subjected to a check using an impedance measuring device. The measurements shall occur between any two locations of the grounding and bonding system.
37.2		No resistance measurements of the grounding and bonding system shall exceed 0.1 W.

CLAUSE	VERDICT	COMMENT
38		***New section added;*** **Maximum Abnormal Operating Speed**
38.1		Every production mechanical storage element shall be subjected to a maximum abnormal operating speed test. The test shall be performed at the maximum speed reached during the Over Speed Qualification Test of 32.1. The test shall be performed in an environment which will safely contain any mechanical failure of the mechanical storage element.
	Info	**MARKINGS**
39	Info	**General**
39.3		***New clause added;*** Energy storage systems shall be marked with the manufacturer's name, trade name, trademark or other descriptive marking which identifies the organization responsible for the product, part number or model number, and electrical ratings and other ratings in (a) – (k). All ratings and rating information necessary for the installation and operation of the energy storage system shall be provided in the system instructions. If the installation location of the system has limitations (i.e. can only be located indoors where it is sheltered from rain and UV or outdoors only), these location limitations shall be indicated on the label and installation instructions. If the system is intended for installation in a location where local regulations indicate a need for a seismic rating on equipment, an appropriate seismic rating shall be included on the label. a) Output and input current (maximum) in Amps; b) Output and input voltage (maximum) in Volts; c) Power input and output (maximum) in Volts; d) Energy output in Wh (maximum); e) Auxiliary output and input voltage (V), current (A) and frequency (Hz) if applicable; f) Number of phases (for input and output); g) Frequency in Hz; h) Duty cycle (if applicable); i) Maximum short circuit current in Amps; j) Ambient temperature range in °C or °F; k) Special environmental ratings and limitations as applicable (e.g. seismic, indoor/outdoor only, etc.); l) Weight (maximum) in lbs or kg, ect.; and m) Maximum dimensions for height, width, and length (this dimensions information need not be marked on the system as long as it is provided in the installation instructions).
39.4		Energy storage systems shall also be marked with the date of manufacture, which may be in the form of a code that does not repeat within ~~10~~ 20 years. All external terminals and connections shall be provided with identification.

CLAUSE	VERDICT	COMMENT
39.6		The Energy storage system that contains hazardous voltage circuits shall be marked "WARNING: Hazardous Voltage Circuits" or be marked with the electric shock hazard symbol ISO 3864 No. 5036 (lightning bolt within a triangle). Electrical equipment parts of the energy storage systems such as control panels and the enclosures of disconnecting devices are also to be marked with arc flash markings according to the Standard for Electrical Safety in the Workplace, NFPA 70E and arc flash personal protective equipment (PPE) requirements, to warn service personnel of potential for arc flash hazards arc flash hazards and necessary protection to be worn if applicable.
39.8		~~An energy storage system shall be marked with the environmental rating of its enclosure (i.e. IPX2, Type 4X, etc.).~~ An energy storage system intended for installation where it may be exposed to moisture shall be marked with the environmental rating of its enclosure (i.e. IPX2, Type 4X, etc.) suitable for that type of exposure. See 35.2.
	Info	**INSTRUCTIONS**
40	Info	**General**
40.2		All cautionary markings and ratings provided on the system, as well as system specifications needed for installation and operation of the system, shall be included in the instructions.
40.4		***New clause added;*** With reference to 40.3, the installations instructions shall specify that the system be installed in accordance with local electrical, building, fire and other codes or utility requirements as applicable to the installation and equipment, by qualified service personnel in accordance with the installation instructions and appropriate practices. Systems intended for installation in restricted access locations per 6.17 shall be designated by the manufacture if they are to be considered under this standard. If restricted access locations are identified by the manufacturer, the training required to gain access shall also be identified by the manufacturer including information in the installation, operation and maintenance instructions. The specific application location information such as the system being intended for utility premise installations or residential and commercial installations, etc. shall be identified in the installation instructions, if the system limited to installation only in those locations.
40.5		***New clause added;*** With reference to 40.3, the installation instructions for energy storage systems containing large amounts of free electrolyte (e.g. 55 gal single vessel or 1000 gal aggregate vessels per the Fire Code, NFPA 1) such as flow batteries or lead acid types, etc. shall be provided with instructions for location of eye wash stations. In addition, if necessary in accordance with building codes, installation instructions shall provide information on spill containment to be installed with the system per 21.1.

CLAUSE	VERDICT	COMMENT
40.6		***New clause added;*** Energy storage systems intended for installation only in certain environments such as indoors only or where exposed to moisture, seismic activity or near marine environments, or to be installed in restricted access locations, shall indicate this in the installation instructions. Systems intended for exposure to moisture, marine environments or seismic activity per installation instructions shall be evaluated per Section 34.
40.11		***New clause added;*** The maintenance instructions shall be provided with information on field replacement of replaceable materials, components and parts for ongoing maintenance and repair of the system. These instructions shall include detailed information on where to obtain and how to install the replaceable items. The instructions shall indicate that all servicing and replacement of parts are to be done by qualified persons only and that only approved materials, components and parts are to be used for replacements.
40.12		***New clause added;*** The installation instructions shall contain all energy storage system operation mode/settings, operation function/settings and protection/settings, which the inverters can provide.
		CUSTOMERS PLEASE NOTE: This Table and column “Verdict” can be used in determining how your current or future production is or will be in compliance with new/revised requirements.