21.6 The resistance shall be calculated from the measured voltage drop and current. The determined resistance shall be less than or equal to 0.1 Ω.

21.7 To check the continuity of the bonding connections, the resistance can be measured between two points on the bonding connections using a milli-ohmmeter. The measured resistance between any two bonding connections shall be less than or equal to 0.1 Ω.

22 Failure of Cooling/Thermal Stability System

22.1 The purpose of this test is to determine if the battery system can safely withstand a failure in the cooling/thermal stability system.

Exception: Testing may be conducted at a subassembly level if that is representative of the energy storage system.

22.2 The DUT shall be fully discharged to the manufacturer's end of discharge condition EODV and then conditioned at maximum specified operating ambient for a period of 7 h or until thermally stable per 8.3, whichever is shorter. While still in the conditioning chamber, the DUT, with its cooling/thermal stability system disabled shall then be charged at its maximum specified charge rate until completely charged or until operation of a protective device.

22.3 The DUT shall be fully charged (MOSOC per 8.1) and then conditioned at maximum specified operating ambient for a period of 7 h or until thermally stable per 8.3, whichever is shorter. While still in the conditioning chamber, the DUT, with its cooling/thermal stability system disabled shall then be discharged at the maximum discharge rate until it reaches its specified end of discharge condition or until operation of a protective device.

22.4 During the test, one of the detection methods outlined in Section 9 shall be used to detect the presence of combustible vapor concentrations. If required based upon system design or installation, venting of toxic releases shall be continuously monitored during the testing per Section 13.

22.5 If the DUT is operational after the test it shall be subjected to a discharge and charging cycle in accordance with the manufacturer's specifications. See 12.2 for details regarding user resettable devices. An observation period per 8.5 is then conducted.

22.6 At the conclusion of the observation period, the DUT shall be subjected to an ″as received″ dielectric voltage withstand test per Section 20. The DUT shall be examined for signs of rupture and evidence of leakage.

22.7 The test method of 22.2 – 22.6 shall be repeated with the DUT conditioned at the minimum specified operating ambient.

22.8 As a result of the failure of cooling/thermal stability test, the following in (a) – (h) are considered non-compliant results. For additional information on non-complying results refer to Table 12.1.

a) E – Explosion;

b) F – Fire;

c) C – Combustible vapor concentrations;

d) V – Toxic vapor release;

e) S – Electric shock hazard (dielectric breakdown);

f) L – Leakage (external to enclosure of DUT);

g) R – Rupture (of DUT enclosure exposing hazardous parts as determined by 7.3.3);

h) P – Loss of protection controls.

23 Working Voltage Measurements

23.1 This test is to measure the working voltage of a battery system.

23.2 The working voltage between live parts of opposite polarity, live and dead metal parts, live parts and a metal enclosure, and live and ground connections under both normal charging and discharging conditions as specified by the manufacture is measured.

23.3 The dead metal parts and metal enclosure shall be assumed to be connected to the negative terminal of the system for testing purpose.

23.4 The values obtained during the measurements outlined in 23.2 shall be used to verify electrical spacings criteria per 7.5.

24 Tests on Electrical Components

24.1 Locked-rotor test for low voltage dc fans/motors in secondary circuits

24.1.1 The purpose of this test is to determine if a low voltage dc fan or motor does not present a hazard in a locked rotor condition. Fans complying with UL 507 are considered to comply with this requirement without test.

24.1.2 A sample of the fan or motor is placed on a wooden board, which is covered with a single layer of tissue paper, and the sample in turn is covered with a single layer of bleached cotton cheesecloth of approximately 40 g/m^2.

24.1.3 The sample is then operated at the voltage used in its application and with its rotor locked for 7 h or until steady conditions are established per 8.3, whichever is the longer.

24.1.4 There shall be no ignition of the tissue paper or cheesecloth.

24.2 Input

24.2.1 The input current draw of a control or accessory separate from the pack such as a mains supplied control or an accessory control evaluated independent from a system, shall be subjected to the input test of 24.2.2.

24.2.2 The current or watts input to an ac mains supplied unit, when connected to an ac supply adjusted to the test voltage specified in Table 24.1 shall not be more than 110% of the rated/specified value. The current or watts input draw of a dc supplied unit, when connected to a dc supply, shall not exceed the rated/specified value of the device.

Table 24.1
AC Test voltages

Device rating (Vac)	Test supply voltage (Vac)
110 – 120	120
220 – 240	240
254 – 277	277
380 – 415	415
440 – 480	480
560 – 600	600

24.3 Leakage current

24.3.1 For separate controls or other accessories of the system that are cord connected and supplied by ac mains circuits, the controls shall comply with the Touch current and protective conductor current test of the Touch Current and Protective Conductor Current Section in UL 60950-1/CAN/CSA-C22.2 No. 60950-1.

24.4 Strain relief test

24.4.1 The purpose of this test is to determine if the strain relief means for a non-detachable accessible cord prevents damage or displacement upon being pulled.

24.4.2 The battery system or accessory provided with a strain relief shall withstand without damage to the cord or conductors and without displacement, a direct pull of 156 N (35 lbf) applied to the cord for 1 min. Supply connections within the equipment shall be disconnected from terminals or splices during the test when applicable. If the strain relief is mounted in a polymeric enclosure or part, the test is conducted after the mold stress test after the part has cooled to room temperature.

24.4.3 As a result of the pull force, there was no damage or displacement of internal connectors. Inner conductors may not elongate more than 2 mm (0.08 in) from the pre-test position.

24.5 Push-back relief test

24.5.1 The purpose of this test is to determine if the strain relief of a non-detachable accessible cord provides adequate protection to connections and prevent hazardous displacement of internal wiring and connections as a result of push back.

24.5.2 A product shall be tested in accordance with 24.5.3 and 24.5.4 without occurrence of any of the following conditions:

a) Subjecting the supply cord to mechanical damage;

b) Exposing the supply cord to a temperature higher than that for which it is rated;

c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or

d) Damaging internal connections or components.

24.5.3 The supply cord shall be held 25.4 mm (1 in) from the point where the cord or lead emerges from the product and is then to be pushed back into the product. When a removable bushing, which extends further than 25.4 mm (1 in) is present, the bushing shall be removed prior to the test.

24.5.4 When the bushing is an integral part of the cord, then the test shall be carried out by holding the bushing. The cord shall be pushed back into the product in 25.4-mm (1-in) increments until the cord buckles or the force to push the cord into the product exceeds 26.7 N (6 lbf).

24.5.5 The supply cord shall be manipulated to determine compliance with 24.5.1.

24.5.6 If the strain relief is mounted in a polymeric enclosure or part, the test is conducted after the mold stress test after the part has cooled to room temperature.

MECHANICAL TESTS

25 Vibration Test (LER Motive Applications)

25.1 The purpose of this test is to determine the battery system's resistance to anticipated vibration in LER motive installations and applies only to those systems intended for installation in that application.

25.2 The sample shall be secured to the testing machine by means of a rigid mount, which supports all mounting surfaces of the sample.

Exception: The sample may be mounted within a mounting fixture representative of the intended end use application.

25.3 The fully charged sample (MOSOC per 8.1) shall be subjected to a vibration test in accordance with the Simulated Long Life Testing at Increased Random Vibration Levels Tests of IEC 61373, for the appropriate Category and Class of equipment as determined by the intended rail installation. (Category and Class of equipment is defined in IEC 61373.)

25.4 The DUT shall be subjected to vibration in 3 mutually perpendicular directions. During the test the OCV of the DUT and temperatures on the center cell/module shall be monitored for information purposes.

25.5 During the test, one of the detection methods outlined in Section 9 shall be used to detect the presence of combustible vapor concentrations. If required based upon system design or installation, venting of toxic releases shall be continuously monitored during the testing per Section 13.

25.6 If the DUT is operational after the test it shall be subjected to a discharge and charging cycle in accordance with the manufacturer's specifications. See 12.2 for details regarding user resettable devices. An observation period per 8.5 is then conducted.

25.7 At the conclusion of the observation period, the DUT shall be subjected to an ″as received″ dielectric voltage withstand test in accordance with Section 20. The DUT shall be examined for signs of rupture and evidence of leakage.

25.8 As a result of the vibration test, the following in (a) – (h) are considered non-compliant results. For additional information on non-complying results refer to Table 12.1.

a) E – Explosion;

b) F – Fire;

c) C – Combustible vapor concentrations;

d) V – Toxic vapor release;

e) S – Electric shock hazard (dielectric breakdown);

f) L – Leakage (external to enclosure of DUT);

g) R – Rupture (of DUT enclosure exposing hazardous parts as determined by 7.3.3);

h) P – Loss of protection controls.

26 Shock Test (LER Motive Applications)

26.1 The purpose of this test is to determine the battery system's resistance to anticipated shock in LER motive installations and applies only to those systems intended for installation in that application.

26.2 The sample shall be secured to the testing machine by means of a rigid mount, which supports all mounting surfaces of the sample. During the test, temperatures on the center module are monitored for information purposes.

Exception: This sample may be mounted within a mounting fixture representative of the intended end-use rail application.

26.3 A fully charged sample (MOSOC per 8.1) shall be subjected to a shock test in accordance with IEC 61373 for the appropriate Category and Class of equipment as determined by the intended rail installation. (Category and Class of equipment is defined in IEC 61373.)

Exception: This test may be conducted at the module level if it can be shown that testing shall be representative of the battery system.

26.4 Both positive and negative direction shocks shall be applied in each of 3 mutually perpendicular directions for a total of 18 shocks.

26.5 During the test, one of the detection methods outlined in Section 9 shall be used to detect the presence of combustible vapor concentrations. If required based upon system design or installation, venting of toxic releases shall be continuously monitored during the testing per Section 13.

26.6 If the DUT is operational after the test it shall be subjected to a discharge and charging cycle in accordance with the manufacturer's specifications. An observation period per 8.5 is then conducted.

26.7 At the conclusion of the observation period, the DUT shall be subjected to an ″as received″ dielectric voltage withstand test in accordance with Section 20. The DUT shall be examined for signs of rupture and evidence of leakage.

26.8 As a result of the shock test, the following in (a) – (h) are considered non-compliant results. For additional information on non-complying results refer to Table 12.1.

a) E – Explosion;

b) F – Fire;

c) C – Combustible vapor concentrations;

d) V – Toxic vapor release;

e) S – Electric shock hazard (dielectric breakdown);

f) L – Leakage (external to enclosure of DUT);

g) R – Rupture (of DUT enclosure exposing hazardous parts as determined by 7.3.3);

h) P – Loss of protection controls.

27 Crush Test (LER Motive Applications)

27.1 This test is conducted on a fully charged battery system intended for LER motive applications to determine its ability to withstand a crush that could occur during an accident and applies only to those systems intended for installation in that application.

27.2 A sample shall be crushed between a fixed surface and a ribbed test platen in accordance with the test fixture described in SAE J2464, with the following exceptions as noted below. Packs with 3 axes of symmetry, are subjected to 3 mutually perpendicular directions of press. A different sample of the DUT may be used for each crush.

Exception No. 1: The maximum force applied to the DUT shall be 100 ±6 kN.

Exception No. 2: Battery systems with only 2 axes of symmetry, such as cylindrical designs are subjected to 2 mutually perpendicular directions of press.

Exception No. 3: The DUT may be installed in a protective framework representative of what is provided in the end use application.

Exception No. 4: A subassembly may be tested instead of a complete battery system if it can be demonstrated to be equivalent to testing a complete battery system.

27.3 A detection method as outlined in Section 9 shall be used to detect the presence of combustible vapor concentrations within the sample. Venting of gases may occur, but shall not exceed ERPG-2 levels using the measurement methods outlined in Section 13. The sample shall be subjected to an observation period and the examined.

27.4 As a result of the crush test, the following in (a) – (d) are considered non-compliant results. For additional information on non-complying results refer to Table 12.1.

a) E – Explosion;

b) F – Fire;

c) C – Combustible vapor concentrations;

d) V – Toxic vapor release;

28 Static Force Test

28.1 The purpose of this test is to determine if the enclosure has sufficient strength to safely withstand a static force that may be applied to it.

28.2 The enclosure of a fully charged DUT (MOSOC per 8.1) shall withstand a steady force of 250 N ±10 N for a period of 5 s, applied in turn to the top, bottom and sides of the enclosure fitted to the DUT, by means of a suitable test tool providing contact over a circular plane surface 30 mm (1.2 inch) in diameter. However, this test is not applied to the bottom of an enclosure having a mass of more than 18 kg (39.7 lbs). If the DUT is operational after completion of the application of the static force, it shall be subjected to a discharge and charging cycle in accordance with the manufacturer's specifications. An observation period per 8.5 is then conducted.

28.3 If deemed necessary (i.e. due to design of system and anticipation of venting of cells), one of the detection methods outlined in Section 9 shall be used to detect the presence of combustible vapor concentrations. If required based upon system design or installation, venting of toxic releases shall be continuously monitored during the testing per Section 13.

28.4 After the observation period, the DUT shall be subjected to an ″as received″ dielectric voltage withstand test in accordance with Section 20. The DUT shall be examined for signs of rupture and evidence of leakage.

28.5 As a result of the static force test, the following in (a) – (h) are considered non-compliant results. For additional information on non-complying results refer to Table 12.1.

a) E – Explosion;

b) F – Fire;

c) C – Combustible vapor concentrations;

d) V – Toxic vapor release;

e) S – Electric shock hazard (dielectric breakdown);

f) L – Leakage (external to enclosure of DUT);

g) R – Rupture (of DUT enclosure exposing hazardous parts as determined by 7.3.3);

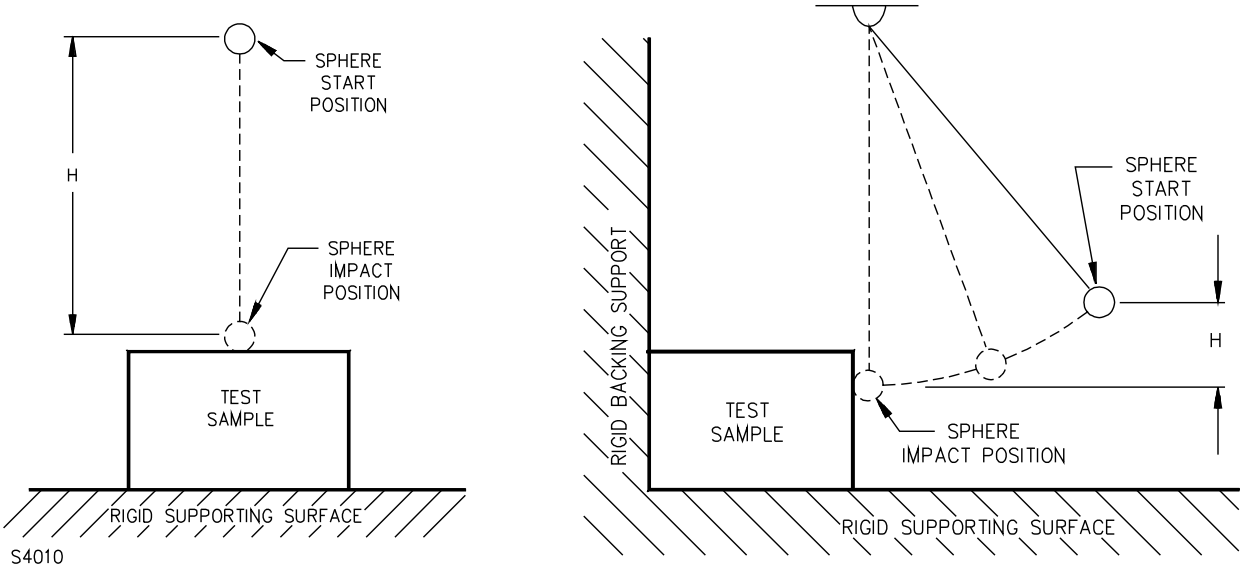
h) P – Loss of protection controls.

29 Impact Test

29.1 The purpose of this test is to evaluate the mechanical integrity of the enclosure and its ability to provide mechanical protection to the battery system contents.

29.2 A fully charged sample (MOSOC per 8.1) shall be subjected to a minimum of three impacts of 6.8 J (5 ft-lb) on any surface that can be exposed to a blow during intended use. The impact shall be produced by dropping a steel sphere, 50.8 mm (2 inches) in diameter, and weighing 535 g (1.18 lb) from a height, H, of 1.29 m (50.8 in). For surfaces other than the top of an enclosure, the steel sphere shall be suspended by a cord and swung as a pendulum, dropping through the vertical height of 1.29 m (50.8 in), with the product being impacted placed against a restraining vertical wall. See Figure 29.1. A different sample may be used for each impact.

Figure 29.1
Impact test



– H in figure indicates the vertical distance the sphere must travel to produce the desired impact, 1.29 m (50.8 in).

– For the ball-pendulum impact test the sphere shall contact the test sample when the string is in the vertical position as shown.

– The DUT shall rest on a concrete floor. An equivalent non-resilient supporting surface may be used.

– The backing surface shall consist of 19-mm (3/4-in) plywood over a rigid surface of concrete.