6.3.4.1.3 Indentation Induced Internal Short Circuit (IIISC) Test

6.3.4.1.3.1 General

The purpose of the IIISC test is to evaluate the lithium ion cell's ability to safely withstand a localized internal short circuit condition. This test creates a localized internal short circuit condition in a lithium cell by pressing on the cell case externally using a metal indenter with a blunted tip until the desired drop in the cell's open circuit voltage (i.e. signaling an internal short circuit) is reached. The test is conducted on ten intact cells representative of production.

The IIISC test requires the use of a stepper-motor-powered press equipment with a control/monitoring system and integral conditioning chamber with the following attributes:

a. Response time of the control trigger: 10^{-2} sec. or less;
b. Maximum load capacity of the press: 1500N or greater as necessary to provide sufficient force on sample during the test;
c. Sampling rate for the load force measurement: 100Hz or greater;
d. Press speed: 0.1± 0.01 mm/sec;
e. Sampling rate for the open circuit voltage (OCV) measurement: 100 Hz or greater; and
f. Noise limit on the OCV reading: +/- 5mV or less.

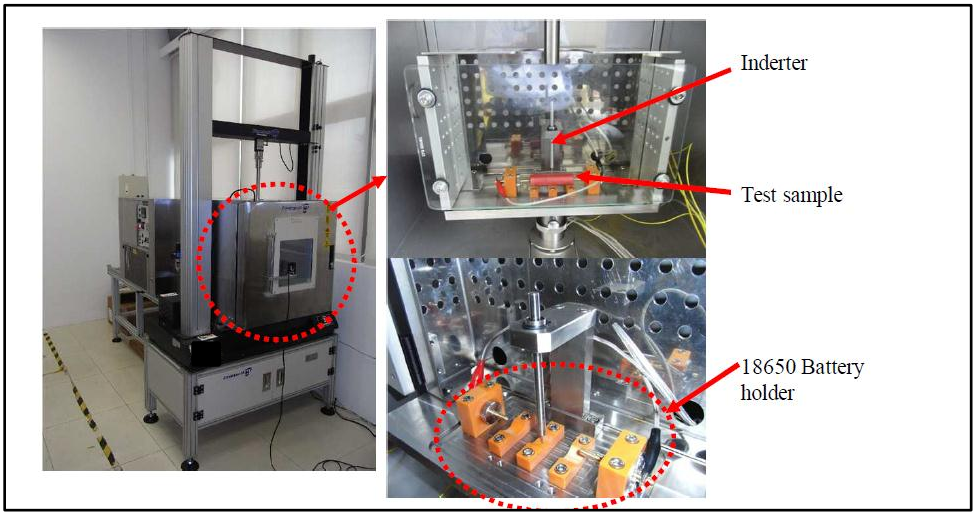
The integral conditioning chamber of the test press equipment should be designed to withstand a fire and explosion in the event the cell should fail in that manner.

6.3.4.1.3.2 Test Method

The sample shall be insulated from the supporting surface of the test equipment chamber to prevent shorting to the support surface and excessive heat transfer during testing. The use of a special insulated support structure may be necessary to maintain the sample in place during testing. See Figure 6.3.4.1.3-1 for an example of the press equipment with conditioning chamber and a sample support structure.

Temperatures are monitored on the sample during testing for information purposes using a thermocouple. The thermocouple should be located on the sample near the location of press, but should not interfere with the press mechanism.

Figure 6.3.4.1.3-1 – Example of press equipment and sample holder



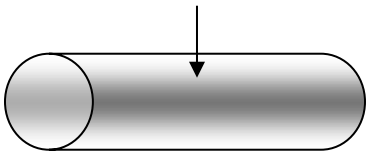
Ten cell samples are subjected to this test. A thermocouple is to be placed on each cell case to monitor temperatures during testing.

The location of the thermocouple on the cell case shall be chosen to prevent contact with the metal test indenter. Prior to testing, the cells are to be cycled three times in accordance with the manufacturer's specifications for charging and discharging at the maximum limits of the cell operating region. This cycling is to be conducted with five samples conditioned at the manufacturer's lowest normal charging temperature limit of the operating region and five samples are to be conditioned at the manufacturer's highest normal charging temperature limit of the operating region. For each cycle, the samples are to be charged to the manufacturer's specified maximum charging voltage limit and discharged down to the manufacturer's specified end point voltage.

At the conclusion of cycling, and prior to conducting the IIISC test, the samples are to be charged to the manufacturer's specified maximum charge voltage limit and conditioned at the manufacturer's maximum charging temperature. The temperatures on the cell casing are to stabilize at the chamber temperature before conducting the IIISC test.

With the fully charged cell maintained in a heated state as noted above, the samples are subjected to a force from the tip of indenter at the center of the cell as shown in Figure 6.3.4.1.3-2. The indenter consists of a tungsten carbide steel indenter with a recommended hardness equal to SKD-11 steel or above and with the tip rounded to prevent penetration of the cell's case. The indenter diameter is 3.2-mm (0.125-in) and the dimension of the tip is varied as necessary for the form factor of the cell being testing as shown in Figure 6.3.4.1.3-3.

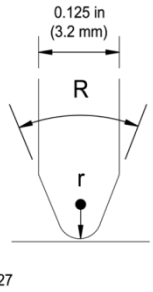
Figure 6.3.4.1.3-2
Location of crush



During the test, the cell case temperature, the force applied to the cell case and displacement of the indenter, and the open circuit voltage (OCV) of the cell is monitored continuously with an OCV, force and displacement sampling rate of 100 measurements/second. The maximum rate of crush when the indenter is in contact with the case is 0.1 mm/s. The monitored values of temperature, OCV drop, force and displacement are to be included in the test results documentation.

The indentation force on the cell case is continued until a localized internal short circuit (limited to one or several layers) is obtained as evidenced by a maximum OCV drop of 100 mVdc. The indentation force is stopped immediately upon reaching the OCV drop and the cell is to remain in the chamber while still monitoring the temperature, force and voltage for 1 hour or until the cell OCV drops to near zero and temperatures stabilize. The cell is then allowed to cool to room temperature and examined for signs of fire and explosion.

Figure 6.3.4.1.3-3
Indenter Tip Dimensions



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a) Cylindrical cell: R = 45°, r = 0.9 mm (0.035 in)

b) Prismatic or pouch cell: R = 45°, r = 0.9 mm (0.035 in) to 1.2 mm (0.047 in)

Note: the smaller value for “r” is preferred to limit the area of the internal short circuit, but may need to be increased to the large diameter to prevent puncture of the prismatic our pouch cell case. Puncture of the pouch cell case is acceptable if it occurs due to swelling after the 100 mVdc internal short circuit is obtained.

6.3.4.1.3.3 Acceptance criteria

Cells shall not exhibit signs of fire or explosion when subjected to an indentation induced internal short circuit (IIISC).