1.0   PURPOSE

1.1. This test procedure is used by the Electrical Safety Division (ESD) for the evaluation of intrinsically safe apparatus to determine the minimum internal resistance and the maximum short circuit current of a battery.

1.2. To provide a person knowledgeable in the appropriate technical field with a written procedure that will assure consistent repeatable test data and results independent of the person conducting the test.

2.0   SCOPE

This Standard Test Procedure (STP) applies to tests on batteries requiring a flash current test as a component of equipment evaluated, approved, or certified under 30 CFR Parts 18, 19, 20, 22, 23, and 27.

3.0   REFERENCES

3.1. ACRI2001 "Criteria for the Evaluation and Test of Intrinsically Safe Apparatus and Associated Apparatus"

3.2. 30 CFR Part 18 "Electric Motor-Driven Mine Equipment and Accessories"

3.3. 30 CFR Part 18.68(b)(1) Short-circuit tests shall be conducted on batteries at normal operating temperature. Tests may be made on batteries at elevated temperature if such tests are deemed necessary.

3.4. 30 CFR Part 19 "Electric Cap Lamps"

3.5. 30 CFR Part 20 "Electric Mine Lamps Other Than Standard Cap Lamps"

3.6. 30 CFR Part 22 "Portable Methane Detectors"

3.7. 30 CFR Part 23 "Telephones and Signaling Devices"

3.8. 30 CFR Part 27 "Methane-Monitoring Systems"

4.0   DEFINITIONS

4.1. Load Resistor (R_{load}) - The resistor that is connected across the terminals of the battery upon closure of the switch/relay. Its purpose is to sense current via a voltage drop across a known resistance value.

4.2. Test Resistance (R_{test}) - The total circuit resistance. This is the sum of R_{load} and the resistance of the test circuit connections between R_{load} and the battery.

4.3. Flash Current (I_{flash}) - The current that flows through the total circuit after the switch/relay is closed. It is found by dividing V_{flash} by R_{load}.

4.4. Flash Voltage (V_{flash}) – The maximum recorded voltage (disregarding transients occurring in the first 20 microseconds of the response trace after initial triggering of the scope) measured with the oscilloscope across R_{load}.
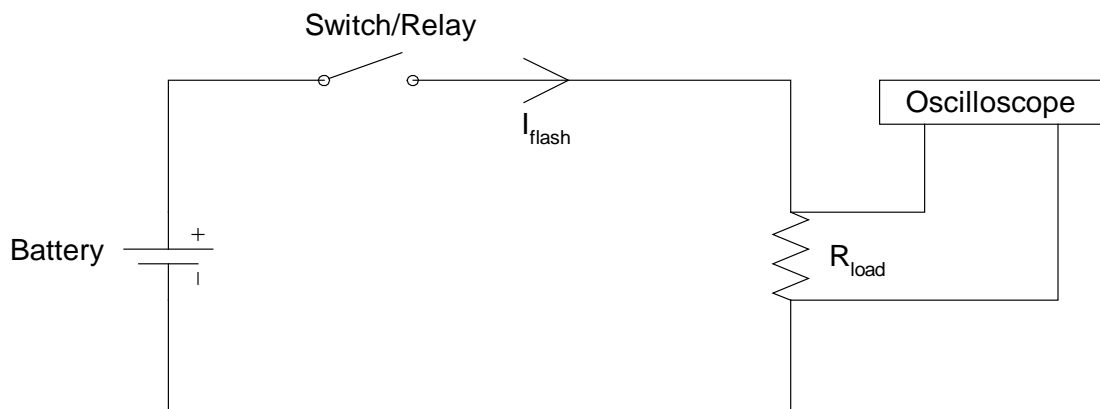
5.0   TEST EQUIPMENT

5.1. A storage oscilloscope having the capability to display a total sweep time of at least 50 microseconds with a minimum of 1000 data points (Agilent Model 54642A or Agilent Technologies InfiniiVision Model DSO6052A Oscilloscopes).

5.2. A high current, low contact resistance switch or relay for opening and closing the test circuit, and a power supply or battery capable of energizing the relay (if necessary).

5.3. A 0.1 ohm (+ or - 2%), non-inductive load resistor (R_{load}) with a minimum 50 amp continuous current rating (Dale RH-250 or a Leeds and Northrup Company, Catalog No. 4360 resistor).

5.4. A voltmeter to measure open-circuit voltage of the battery to 3 decimal places (Agilent Model 3458A Digital Multimeter).

5.5. A four terminal input ohmmeter to measure the value of the test resistance (R_{test}) and the load resistor (R_{load}) to 3 decimal places (Agilent Model 3458A Digital Multimeter).

5.6. A digital thermometer with a range of at least 35°C, resolution of at least 1°C, and an accuracy of at least ±1°C (Omega Model 650 Type K Thermocouple Thermometer).

5.7. Thermocouple consisting of wires not larger than No. 24 AWG or equivalent. (Type K).

Note: Equipment models listed are acceptable equipment currently used by the ESD to perform the test. Equivalent or more accurate equipment may be used.

6.0   TEST SAMPLES

Three fresh primary batteries, or three fully charged secondary batteries.

Note: It is not acceptable to test three battery packs, instead, three individual batteries used to construct the pack must be tested.

7.0   PROCEDURES

7.1. Conduct the test in an ambient temperature of 25±10° Celsius, with battery samples that have stabilized to the ambient temperature. Record the ambient temperature at time of test.

7.2. Measure and record the resistance of the 0.1 Ω load resistor (R_{load}) to be used to 3 decimal places.

7.3. With the test battery NOT connected, close the relay or switch contacts, and measure the total test resistance (R_{test}) at the two points that will be attached to the battery. This resistance must be less than 0.11 ohms. If greater than 0.11 ohms, rewire the test circuit until a value less than 0.11 ohms is achieved.

7.4. Open the relay or switch contacts. Connect the battery to the circuit that contains both the load resistor (R_{load}) and the relay/switch.

7.5. Measure and record the open-circuit voltage of the battery (V_{open}) to 3 decimal places.

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7.6. Connect the oscilloscope leads to the 0.1 Ω load resistor (R_{load}). Adjust the time per division and the voltage per division for the expected response based on previous testing. If the expected response is unknown, the voltage per division and time per division must be set via trial and error, which may require a fourth sample of a primary battery, or a recharge of a secondary battery.

Note: The time per division must be increased if the battery output is increasing during the sweep time.

7.7. Momentarily close the switch/relay. Record the trace obtained across the load resistor from each closure. The flash current (I_{flash}) is determined by dividing the flash voltage (V_{flash}) by the measured value of the 0.1 Ω load resistor (R_{load}).

7.8. Repeat 7.5 through 7.7 at least five times recording the new V_{open} and I_{flash} obtained for each trace.

7.9. Calculate the short circuit current for each trace obtained in 7.7 using the two following equations:

    1. $$R_{internal} = \frac{V_{open}}{I_{flash}} - R_{test}$$

    2. $$I_{short} = \frac{V_{open}}{R_{internal}}$$

7.10. Print or plot the stored flash current trace of 7.7 that produced the highest calculated short circuit current found in 7.9.

7.11. Repeat 7.4 through 7.10 for the remaining two samples.

8.0   TEST DATA

8.1. Identify the manufacturer, part number, chemistry type, nominal voltage, and freshness date printed on battery (if applicable) for each sample tested.

8.2. Record the following measured and calculated values to 3 decimal places for each sample tested: open circuit voltage of the battery, resistance of the test circuit, resistance of the load resistor, the flash voltage, the flash current (as

determined from 7.7), the internal resistance of the battery, and the short circuit current produced by the battery.

8.3. Record the calibrated equipment used for testing. This should include: manufacturer, model number, serial number, and calibration due date for each piece of equipment.

8.4. A plot of the transient flash current that produced the highest short circuit current for each sample tested.

8.5. Add any applicable data to the comments section of the test sheet (e.g. ambient temperature at time of test, etc.).

9.0   PASS/FAIL CRITERIA

There is no pass/fail criteria associated with this test procedure. The purpose of this test is to determine the minimum internal resistance and the maximum short circuit current of a battery. These parameters will be used in determining the intrinsic safety of the battery or of a particular circuit.