

## 1.0 PURPOSE

1.1 This test procedure is used by the Electrical Safety Division to determine if representative samples of a piezoelectric device meet the impact test requirements of ACRI2001, "Criteria for the Evaluation and Test of Intrinsically Safe Apparatus and Associated Apparatus," Section 9.14.

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 piezoelectric devices that are utilized in intrinsically safe apparatus or associated apparatus evaluated, approved, or certified per 30 CFR Parts 18, 19, 20, 22, 23, and 27.

## 3.0 REFERENCES

ACRI2001, "Criteria for the Evaluation and Test of Intrinsically Safe Apparatus and Associated Apparatus", Section 9.14: "Piezo-Electric Component Test".

## 4.0 DEFINITIONS

4.1. Piezoelectric Component - A device containing a ceramic or crystal material, including any associated integral circuitry, capable of generating a voltage output when subjected to mechanical impact or pressure.

4.2. Test Fixture - A mounting bracket, for the apparatus containing the piezoelectric device under test, capable of withstanding 20 joules of kinetic impact energy.

## 5.0 TEST EQUIPMENT

5.1. Digital Thermometer. Minimum resolution of 0.2 degree Celsius and minimum range from 0 to 40 degrees Celsius (Fluke 2170A).

5.2. A test mass made of solid hard metallic material that weighs 5.0 pounds shaped symmetrically about an axis with a 25 mm diameter hemispherical impact head.

- 5.3. Two types of impact testing may be performed, the pendulum method or the vertical free fall method. Either impact test apparatus must be capable of delivering an impact energy of 20 joules to the apparatus containing the piezoelectric device. The pendulum method is preferred due to safety considerations and the consistency of impact point.
- 5.3.1. Pendulum Method: The pendulum impact test apparatus is a test fixture capable of allowing the test mass to swing through a 90° arc (pendulum arm is a steel rod having a 0.375 inch diameter and 37 inches length) from the 3 o'clock position to the 6 o'clock position and apply an impact energy of 20 joules to the object under test (ref. Figure 1).

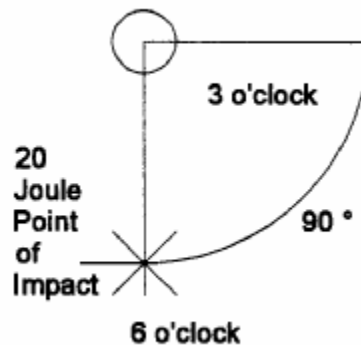


Figure 1: Pendulum Method

- 5.3.2. Vertical Free Fall Method: The vertical free fall impact test apparatus is a test fixture capable of allowing the test mass to drop 36 inches in a vertical direction, perpendicular to the earth's plane, applying an impact energy of 20 joules to the object under test.
- 5.4. The impact test apparatus shall include a mounting bracket to position the apparatus containing the piezoelectric device so that the impact will occur normal to the flat surface being tested, or if the surface is not flat, normal to a tangent to the surface.
- 5.5. A data acquisition system with a minimum sampling time of 10 microseconds per point or a digital oscilloscope device with a frequency response of 100 megahertz or greater (HP 541615B).

- 5.6. A capacitance meter capable of measuring microfarad or picofarad capacitance to three significant figures (Sencore LC 103).

## 6.0 TEST SAMPLES

- 6.1. Three (3) samples of the apparatus containing the piezoelectric device of a quality, design, and construction consistent with that of the final manufactured product.

Note: If justified, mockups of the apparatus assembly may be tested in lieu of the actual assembly.

- 6.1.1. The preferred test samples will consist of the piezoelectric device in its normal mounting with output leads directly attached to the piezoelectric crystal.
- 6.1.2. When the piezoelectric device contains associated integral circuitry, the applicant may be required to submit special samples of the piezoelectric device simulating a worst case, two fault condition in its internal circuitry.

## 7.0 PROCEDURES

- 7.1. EXERCISE EXTREME CARE - TYPICAL PIEZOELECTRIC VOLTAGES IN EXCESS OF 800 VOLTS ARE POSSIBLE.
- 7.2. Conduct the test in an ambient temperature of  $25 \pm 10$  degrees Celsius. Record the ambient temperature on test sheet.
- 7.3. Take a photograph of the device. This will be used as a reference for the test sheet.
- 7.4. Calibrate the oscilloscope test leads (if necessary) with the oscilloscope calibrator or data acquisition device calibrator.
- 7.5. Measure the capacitance value at the output leads of the piezoelectric device under test. If the piezoelectric device is a sealed unit with integral circuitry, obtain the required capacitance value from approval drawings, manufacturer's specifications, or measurements from an unsealed unit.
- 7.6. From the manufacturer's specifications, determine a point of impact on the apparatus enclosure, that is accessible when the apparatus is mounted as it would be in its intended application and that will likely provide the

maximum voltage output from the piezoelectric crystal. If the manufacturer's specifications do not indicate the point of maximum energy output, the point of impact may be determined by applying non-destructive impacts to different points on each surface of the apparatus to determine the impact test point providing maximum energy output from the piezoelectric device. The direction of the impact is to be normal to the flat surface being tested, or if the surface is not flat, normal to a tangent to the surface. The component is to be tested in its normal mounted position.

- 7.7. Mount the apparatus containing the piezoelectric device securely in the test fixture.
- 7.8. Position and align the test fixture with the impact test apparatus test mass to comply with Section 7.6.
- 7.9. Choose either of the following impact test methods:
  - 7.9.1. Pendulum Method - Utilize the test mass located at a distance of 30.5 inches from the arc origin. Position the pendulum to swing through a 90° arc from the 3 o'clock position to the 6 o'clock position. Repeat the test on a total of 3 samples such that each sample is impact tested twice at its maximum energy output location.
  - 7.9.2. Vertical Free Fall Method - Allow the test mass to fall 36 inches vertically such that each of 3 samples is impacted twice at its maximum energy output location.
- 7.10. Measure the output voltage versus time of the piezoelectric device under test using the data acquisition system or digital oscilloscope test leads connected directly to the piezoelectric terminals during each impact.
- 7.11. Record all data on the test sheet.

## 8.0 TEST DATA

- 8.1. Ambient temperature.
- 8.2. Impact test method (Pendulum or Vertical Free Fall).
- 8.3. Manufacturer's name and model or part number of the piezoelectric device.

- 8.4. Manufacturer's name and part number of the apparatus containing the piezoelectric device.
- 8.5. Sample number.
- 8.6. Piezoelectric device capacitance value as measured at the terminals.
- 8.7. Surface impact point.
- 8.8. Maximum peak voltage generated (positive or negative).
- 8.9. Calculated energy generated by the sample from the formula:

$$E = \frac{1}{2} * C * V^2$$

Where

E = Energy in Joules,

C = Capacitance of the piezoelectric device, and

V = Maximum peak voltage generated after impact.

- 8.10. Record any additional information pertinent to each test (e.g. unique mounting conditions, location of protective components, etc.).

## 9.0 PASS/FAIL CRITERIA

The maximum energy stored by the capacitance of the piezoelectric device for each test sample shall not exceed 1500 microjoules.