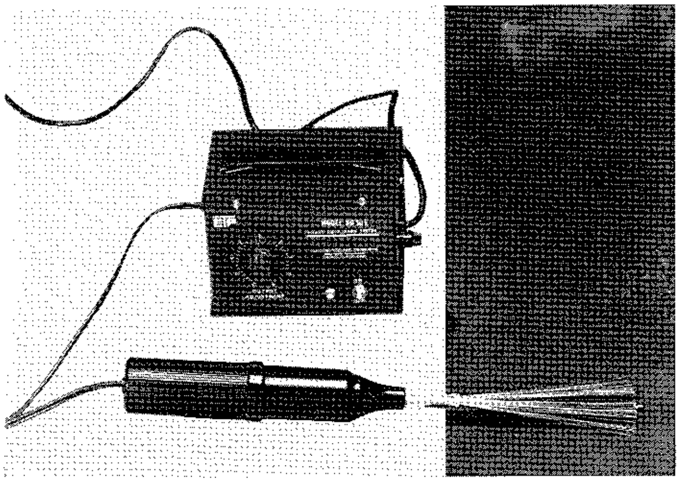
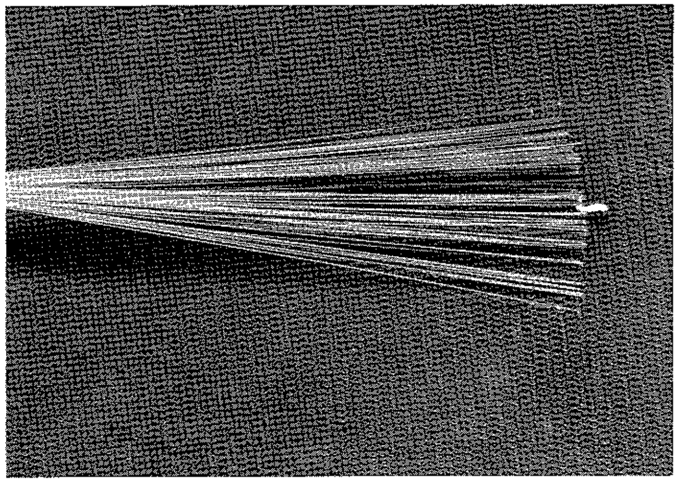


Spark testers, such as this Electro-Technic BD50-E, are used to find leaks in tank linings.



A bright white spark identifies a pinhole in the lining.

High Voltage Used to Leak-Test Tank Linings

HIGH-VOLTAGE spark testers have been used for years to leak-test cargo tank linings, and HM-183 requires the use of spark testers on tank trailers in corrosive service.

Linings for corrosive service cargo tanks are usually ⅛-inch- to ¼-inch-thick rubber. The linings are manufactured by firms specializing in the business, and many companies install the linings to meet customer specifications.

Problems with rubber linings come from three sources: the manufacturer, the installation process, and the age of the vessel.

Before a lining test, the cargo tank must be degassed and dried. Proper drying can take up to two hours. When performing a leak test, safety procedures in the National Tank Truck Carriers maintenance manual must be followed. When a lining inspector is inside a tank, another employee must be present outside at the manhole to assist in an emergency.

Directions for test methods are found in HM-183 Sec 180.407. The rules require annual testing of the lining in tanks with a high-frequency spark tester that can produce voltage sufficient to ensure proper calibration; use of a probe with an L-shaped $\frac{3}{32}$-inch wire with up to a 12-inch bottom leg or equally sensitive probe; and use of a steel calibration block with a known leak, equivalent to a puncture caused by a 22-gauge hypodermic needle, lined with the same materials as those to be tested.

According to the rules, the probe shall be passed over the surface of the calibration block in a constant uninterrupted manner until the leak is found. Leaks are detected by white or light-blue sparks.

A leak-free lining causes dark-blue or purple sparks. Rules require voltage to be adjusted to the lowest setting that will produce a minimum ½-inch spark measured from the top of the lining to the probe. The spark tester is to be calibrated using a test calibration block, the same power source, probe, and cable length to assure the setting on the probe is unchanged.

Problems with rubber linings come from three sources: the manufacturer, the installation process, and the age of the vessel.

The spark tester must be calibrated to detect short perpendicular holes and longer, oblique holes including the air space between the tester-tip and the rubber lining. While the tester-tip touches the surface of the lining, contact is not always maintained. Many leaks also are found in seams, where the rubber lining abuts other pieces.

These areas require a high-voltage setting that will produce a minimum ½-inch spark. At least 34kv is needed to produce a ½-inch spark through short through-thickness holes and longer oblique holes.

Using the maximum voltage will produce a longer spark and is not destructive to the lining. Watch for the bright white spark; mark the hole with chalk for later repair. Thin films and coatings must be tested with caution. Failure of thin coatings can be caused by the thermal and mechanical effects of high voltages.

Rubber linings are not damaged by spark testers. Tests by researchers at Northwestern University found that normal usage of spark testers on ⅛-inch and thicker rubber sheets does not cause dielectric breakdown.

Creating holes in rubber linings while spark testing is unlikely because of the brief time the spark tester tip is over any part of the lining. Spark testing will not cause holes in good linings, but if an air bubble is underneath the lining, the spark tester will puncture it, exposing a cavity. Most lining inspectors want to find this kind of hidden hole because it will leak, but if there is a pinhole in the lining a spark tester may enlarge it.

For more information, contact Electro-Technic Products Inc, 4642 N Ravenswood Ave, Chicago IL 60640-4592. □

Reprinted from Modern Bulk Transporter

Leak Testing of Tank Linings by High Voltage Discharge

by Buckley Crist, Jr.*

Abstract

The use of high voltage testing for dielectric materials such as tank linings is reviewed. The output from the test equipment should be large enough to cause a spark discharge through a distance about 1/2 in. (13 mm) greater than the thickness of the material being examined. It is demonstrated that high voltage testing with a unit like the Electro-Technic Model BD-50E does not create holes or other damage in lining or sheets 1/16 in. (1.6 mm) or thicker.

A. Spark Test Mechanism

A high voltage probe is passed over the surface of an insulating tank lining. So long as there are no holes from the top surface to the conducting tank wall beneath, no current is drawn from the high voltage probe, beyond that associated with corona generation at the electrode tip. When the probe encounters a hole (Figure 1b), spark discharges occur from the probe to the tank wall through the air path defined by the hole in the dielectric tank lining. The spark discharge is usually easy to see running from the probe tip to the location of the hole on the top surface of the lining. Certain test equipment detects the discharge by electronic measurement.[1]

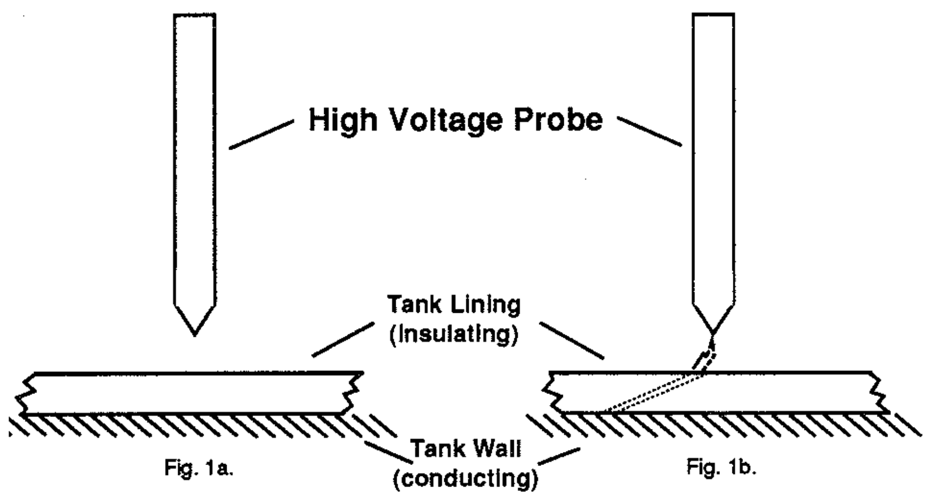


Figure 1. Spark testing a tank lining. No hole is present in (a), and no spark discharge occurs. A hole is present in (b), and a spark discharge can be seen between the probe tip and the point at which the hole intercepts the top surface. The oblique hole sketched in (b) is longer than the lining surface.

B. Proper Voltage Settings

Any "spark tester" should have controls for adjusting the high voltage at the probe tip. The following procedure is consistent with ASTM D 3486. [2]

1. A test hole should be made in a piece of material of the same formulation and thickness as the tank lining to be evaluated. For rubber or elastomers a 22-gauge hypodermic needle makes an appropriate test hole; we have found that 19-gauge and 25-gauge needle holes give similar results.

**Buckley Crist, Jr. is a professor of Materials Science and Engineering at Northwestern University, Evanston, IL.60208. He is active in polymer research and consulting.*

Small drill bits can be used with more rigid materials such as thermoplastics and thermosets. The test piece should be at least 3 in. x 3 in. (75 mm x 75 mm) to insure that flashover does not occur around the test piece to the conductor below.

2. The test piece is placed on a conducting metal surface. Adjust the voltage to the point where a discharge occurs through the test hole when the probe tip is 1/2 in. (13 mm) **above** the test hole (1/2 in. plus the lining thickness above the conductor). This is to insure that the voltage is high enough to find longer and more tortuous holes which are not straight and perpendicular to the surface.

An example is given for hydrocarbon and silicone rubber sheets of thickness 1/4 in. to 5/16 in. (6.4 mm to 8.0 mm). Through these were made 19-gauge needle holes perpendicular to the sheet surface and at angles as small as 18° to the surface. Detection of these longer oblique holes requires a larger voltage as summarized in Table I. The probe tip was about 1 mm above the hole for these tests. Electro-Technic Model BD-40E and BD-50E Spark Testers were used; each has a high voltage frequency of about 0.5 MHz.

Table I

Spark Detection of Perpendicular and Oblique Holes

Angle to Surface	Hole Length	Discharge Voltage
90°	6.4-8.0 mm	11-12 kV
28°	18 mm	22 kV
18°	21 mm	26 kV

If the unit were set at about 12 kV to detect the short through-thickness test hole, it would **not** detect oblique holes having greater lengths. However, 34kV is required to discharge through 1/2 in. (13 mm) of air and the short 5/16 in. (8 mm) test hole; this is adequate for sensing longer oblique holes in the tank lining.

C. Dielectric Breakdown

When a hole is discovered by the spark discharge method, the question sometimes arises as to whether the hole was present originally or if it was created by the test. This is a valid question when testing thin films, say 1/32 in. (0.8 mm) or less. Experiments were done to confirm that a commercial spark tester such as the Electro-Technic Model BD-50E, with maximum output of 50 kV peak, will **not** make holes in sound tank linings of thickness in the normal range about 1/4 in. (6.4 mm).

Dielectric breakdown and dielectric strength of polymers are well studied; the interested reader is referred to references 3-5. At issue here is short term dielectric strength similar to that measured in ASTM D 149. [6] Experiments were done with polyethylene and polypropylene having dielectric strengths of 450-1000 V/mil (18-39 kV/mm) and 600 V/mil (24 kV/mm) respectively, based on 1/8 in. sheets. [7] Sheets of 1/16 in. (1.6 mm) thickness were placed on a grounded conductor with a single probe tip (radius about 3 mm) nearly touching the top sheet surface. These were exposed to the maximum 50 kV output of the Electro-Technic Model BD-50E for 5 min.; the sheets were not moved for the duration of the test. There was **no dielectric breakdown**, only some local heating. The nominal electric field strength in this test was 800V/mil (32 kV mm). Similar endurance tests were done with 1/4 in. thick rubber for periods up to 15 min.; no dielectric breakdown occurred, nor was there any obvious erosion or other modification of the surface of the rubber.

Short time (ca. 5 sec.) dielectric breakdown was observed when 3 mil (75 μm) films of polyethylene were subjected to the maximum 50 kV output of a Model BD-50E with the probe about 0.5 mm above the grounded conductor plate. Failure of the film appeared to be by a combination of thermal and electro-mechanical effects (see references 3-5) at a nominal field strength of 2500 V/mill (100 kV/mm). This figure is consistent with published dielectric strengths [7] and the fact that dielectric strength is larger in thinner films. [3-5]

D. Summary

The spark test or discharge method of checking for holes in tank linings and similar assemblies is found to be reliable and nondestructive. The probe voltage should be large enough to achieve spark discharge through long, oblique holes. There is no danger from creating holes by dielectric breakdown in sound linings for material thicker than 1/16 in., provided the test is done with an Electro-Technic Model BD-50E with its particular voltage and frequency characteristics. This latter statement is based on extensive published literature and some experiments with conventional thermoplastics and rubbers. It is possible that certain materials are extremely sensitive to electric fields or the corona which accompanies a high voltage test of this sort. Any user of high voltage test equipment should perform control tests if a problem is suspected.

References and Notes

1. Model BD-60 Self-Sensing Leak Detector from Electro-Technic Products, Inc., Chicago, IL.

2. ASTM D 3486 "Practices for Installation of Vulcanizable Rubber Tank Linings and Pipe Linings", American Society for Testing Materials, Philadelphia, PA, Vol. 09.02.

3. H. L. Saums and W. W. Pendleton, *Materials for Electrical Insulating and Dielectric Functions*, Hayden Book Co., Rochelle Park, NJ (1973)

4. B. R. Varlow, "Electric Breakdown" in *Methods of Experimental Physics*, Vol. 16C, R.A. Fava, ed., Academic Press, New York, NY (1980), pp. 443 ff.

5. K. N. Mathes, "Electrical Properties" in *Encyclopedia of Polymer Science and Engineering*, Vol. 5, H. Mark, et al., eds Wiley-Interscience, New York, NY (1986), pp. 512 ff.

6. ASTM D 149 "Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies", American Society for Testing Materials, Philadelphia, PA, Vol. 08.01.

7. *Modern Plastics Encyclopedia*, McGraw-Hill, New York, NY (1988) pp. 510 ff.