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]

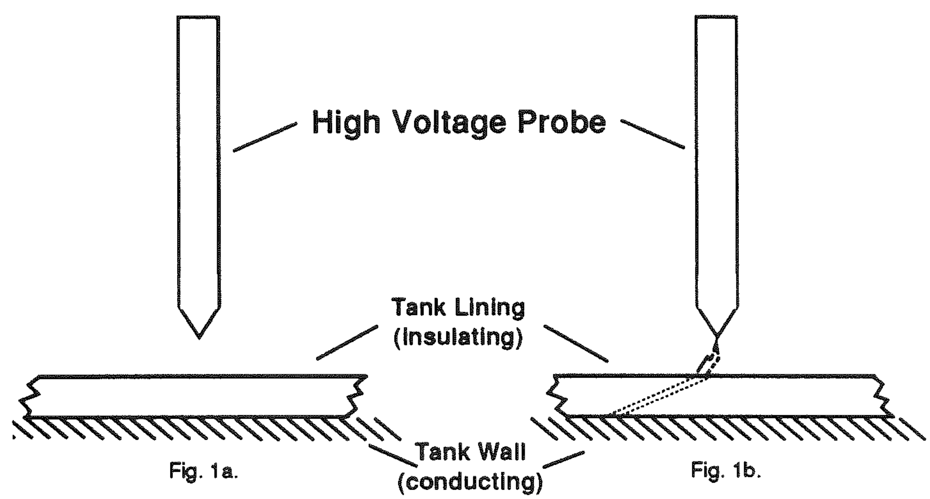

Figure 1. Spark testing a tank lining. No hole is present in (a), and no spark discharge occurs. A hole is present in (b), and a spark discharge can be seen between the probe tip and the point at which the hole intercepts the top surface. The oblique hole sketched in (b) is longer than the lining surface.

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.