

BELL SYSTEM PRACTICES
Outside Plant Construction
and Maintenance

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PRESSURE TESTING

LOCATION OF GAS LEAKS

PRINCIPLES OF LEAK LOCATION

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1. GENERAL

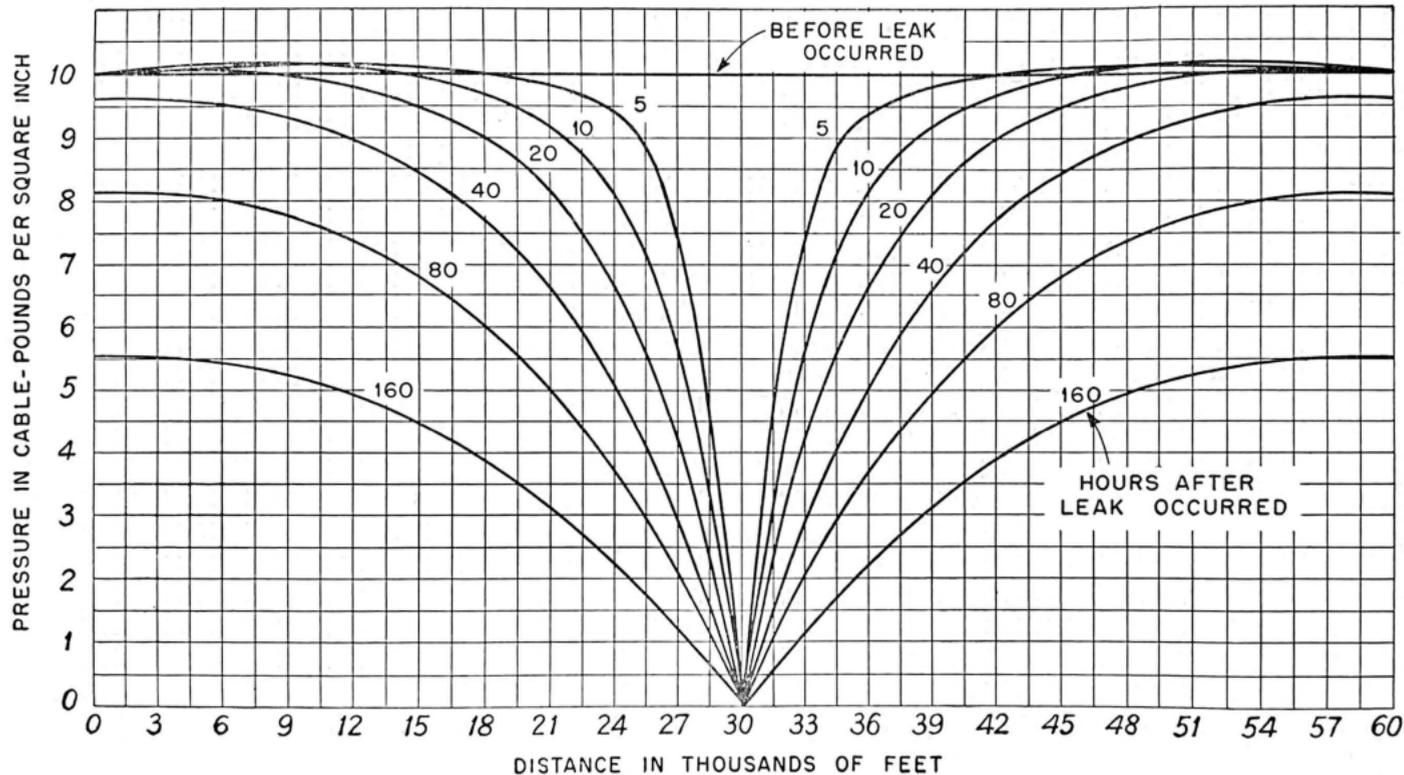
1.01 This section covers the formation of leak gradients and the principles involved in the location of gas leaks in cables maintained under pressure.

1.02 The information on location of gas leaks previously contained in Section G73.245, Issue 1, which is cancelled, has been revised and divided into several sections in this group to simplify the presentation of the information. Leak location methods are covered in a separate group of sections.

2. FORMATION OF LEAK GRADIENTS

2.01 When a length of cable containing no leaks is charged with gas and allowed to stand the pressure will become stabilized and will be uniform throughout its length. If a leak occurs in this cable, the stable condition is disturbed and gas will flow toward the leak through which it escapes into the atmosphere. This disturbance travels in both directions from the leak and results in a gradual loss of pressure throughout the disturbed distance.

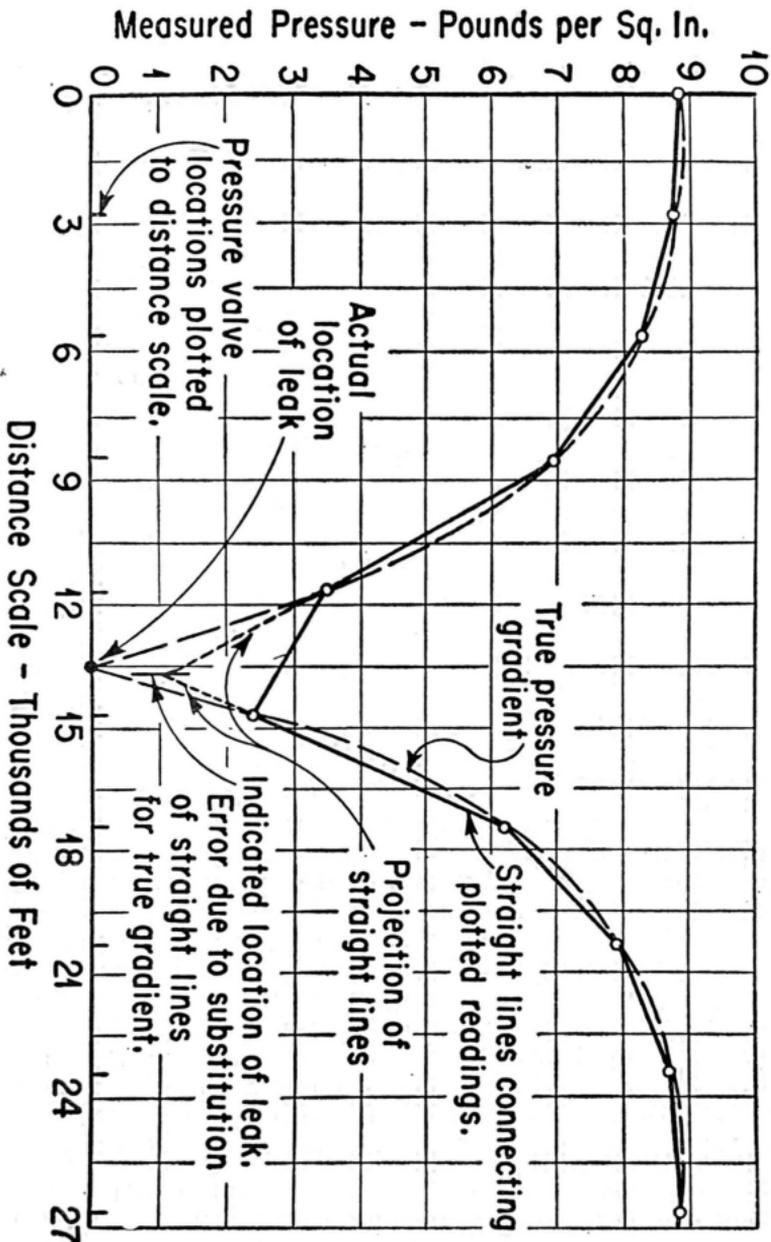
2.02 The change in the appearance of the pressure gradient of a cable at various intervals from 5 to 160 hours after the occurrence of a large leak near the midpoint of a gas section is illustrated in the following graph.



PRESSURE GRADIENT CURVES FOR LARGE LEAK

2.03 When the leak first occurs the disturbance is confined to a short section and a steep gradient is formed. During the first several hours the gradient shape changes rapidly as the disturbance progresses away from the leak in each direction. After several days the disturbance has traveled several miles and the gradient in the vicinity of the leak becomes more stable; pressures at various points adjacent to the leak decrease slowly and the general shape of the gradient does not change.

2.04 Leak gradients are characterized by decreasing cable pressures as the leak is approached, the pressure being lowest at the point of leakage. Leak locating tests by pressure gradient methods are based on finding the point of minimum pressure by making pressure measurements at valves spaced at approximately even intervals along the cable under test and plotting them on a graph as shown in the following illustration. Connecting the plotted points with straight lines gives an approximation of the true pressure conditions at all points in the section of cable under test at the time the pressure readings are made. For comparison the true pressure gradient, which is a smooth curve, is also shown on the illustration.



2.05 The smooth curves shown in the illustration in Paragraphs 2.02 and 2.04 are true leak gradients. That is, the curves represent an instantaneous picture of the pressure relationship along a length of cable if there are no irregularities

in the cable plant nor change in outside conditions influencing the gas flow toward the leak.

2.06 True leak gradients can only be approximated in actual practice because of limitations in methods and instruments used in making pressure measurements, non-uniformity in cable plant, and the effect of changes in conditions surrounding the cable as discussed in the subsequent parts of this section.

3. CONDITIONS AFFECTING LEAK GRADIENTS

3.01 The shape of a leak gradient always reflects any irregularities in the construction of the cable under test and limitations in the method used for making the pressure measurements. A true leak gradient cannot be secured in practice because of the following physical limitations.

- (a) Valve spacing may vary from 500 to 3000 feet.
- (b) Readings cannot be made simultaneously.
- (c) The cable under test may have branch cables or gas filled load or filter cases connected to it. These provide an additional source of gas supply for the flow toward the leak and introduce irregularities in a leak gradient at the points of connection.
- (d) Flow of gas is affected by the pneumatic resistance of a cable. Irregular leak gradients are obtained where measurements are made on each side of a junction of different type cables.
- (e) Stoppages or obstructions which restrict the normal flow of gas through a cable introduce irregularities in a leak gradient.
- (f) The presence of more than one leak complicates securing a true leak gradient for a particular leak.

4. EFFECT OF UNEQUALIZED PRESSURE

4.01 Unequalized pressure in the cable, due to disturbances caused by sheath openings or incomplete charging, will conflict with the gradient formed by a leak. Leak locating tests should not be made until it is reasonably sure that the pressure has stabilized and the leak gradient has assumed its normal shape.

5. EFFECT OF TEMPERATURE

5.01 Temperature changes in a cable during the course of leak locating tests will distort a pressure gradient and cause errors in leak location. Leak locating tests should preferably be made under the most stable temperature conditions, as discussed in the following paragraphs.

Underground and Buried Cable

5.02 Temperature changes in underground and buried cable are generally too slow to introduce appreciable errors in leak locating tests. Part of an underground cable may parallel a steam pipe and have a higher temperature than other portions of the cable. However, as long as the temperature remains constant the pressure will equalize and the leak gradient will not be affected. Similarly, submarine cable may have a lower temperature than adjacent land portions of the same cable but temperature conditions will be stable.

5.03 Pumping water out of flooded manholes and conduit may change the temperature of an underground cable appreciably. To avoid this, the valves required for leak locating tests should be extended to the neck of the manholes. The tests should be deferred until temperature conditions have again become stabilized.

5.04 A section of an underground cable in steel pipe supported on a bridge may be subject to considerable daily temperature change and should be treated as an aerial cable in selecting a time when temperature conditions are most stable.

Aerial Cable

5.05 Aerial cable is subject to wide daily variations in temperature due to the heat of the sun in combination with changing conditions of shade from clouds, trees and buildings. As a result, the pressure in the cable is continuously changing and leak gradients may be distorted sufficiently to cause serious errors in leak location, particularly in the case of small and medium leaks.

5.06 The effects of weather and temperature on a leak gradient in aerial cable are listed below. The most favorable circumstances for leak locating tests are during a steady rain or in the hours of darkness just before sunrise.

<u>Weather Condition</u>	<u>Effect on Gradient</u>
(1) Steady rain	No distortion
(2) Hours of darkness just before sunrise	No distortion
(3) Solid, heavy clouds	Slight distortion where shaded areas are involved.
(4) Even light overcast	Distortion where shaded areas are involved
(5) Sunny day, no clouds	Distortion where shaded areas are involved
(6) Sunny day, drifting clouds	Considerable distortion

Combination Aerial and Underground Cable

5.07 Pressure changes in sections of underground or buried cable in combination with aerial cable usually reflect the variation of cable temperature of the aerial portion with the result that there is a constant flow of gas between the aerial and underground cable. When leak locating tests are to be made in such sections, the aerial portion should be isolated from the underground by closing the by-pass around the pressure plug provided at the junction of the two types of plant. The section of cable in which the leak locating test is to be made may then be treated as an all aerial or all underground section as the case may be.

6. EFFECT OF ALTITUDE

6.01 Where differences in elevation exist between valve points in a section of cable under test, the weight of the gas in the cable increases the pressure at the lower valve points. The resultant distortion of a leak gradient is significant whenever the difference in elevation between valves is 20 feet or more for mercury manometer tests, and one foot or more in making precision tests. Accordingly, the pressures measured at the different valves must be converted to their equivalent values at a common elevation as described in the sections on correction of pressure measurements, before plotting a leak gradient.

7. EFFECT OF ATMOSPHERIC PRESSURE

7.01 Pressure readings made with a mercury manometer indicate the value by which the cable pressure exceeds the prevailing atmospheric pressure at that location. The latter varies with weather conditions.

7.02 Leak locating tests are generally made within a short interval of time during which little or no atmospheric pressure changes occur and hence no correction is necessary. Leak location work with a mercury manometer should not be undertaken during rapidly changing weather conditions.

8. IMPROVING ACCURACY OF RESULTS

8.01 Improving the accuracy of leak locations obtained from pressure measurements will reduce the length of cable that must be inspected to find the leak for repair. In aerial cable, it is necessary to ride the inspected portion and test the sheath with an appropriate solution. In underground cable, the accessible portions in manholes must be inspected. In buried cable and in underground cable when the section containing

the leak is to be repaired, excavation is required to make the cable available for inspection.

8.02 These are time consuming operations and it is, therefore, important to obtain as accurate a location as practicable before proceeding with a detailed examination of the cable. The reduction of effort which can be effected in this way justifies additional care and effort in making the pressure measurements in a manner that will provide an accurate location.

8.03 To obtain accurate results it is necessary to:

- (1) Make the measurements at a time when conditions are such as to minimize the effects of influences on the gradient other than the leak under investigation.
- (2) Make the measurements in the shortest time practicable by methods which will compensate for changes in gradient shape during the interval required to make the measurements.
- (3) Make the measurements at enough points so that the shape of the gradient in the immediate vicinity of the leak will be clearly indicated.

8.04 In some cases, considerable delay may be required before satisfactory measuring conditions can be established. However, it is preferable to wait until one good set of readings can be made under favorable conditions, rather than spend the time in obtaining several sets of measurements hurriedly at the 3000-foot valve points. The latter may leave considerable uncertainty as to the indicated leak location, and may require excessive effort in exposing and inspecting the cable because of the longer length of cable that must be investigated.

8.05 In many instances, particularly in the case of small leaks, it may be desirable to determine the general location of the leak by a preliminary set of measurements. Additional temporary valves can then be installed on each side of the preliminary location and a careful set of measurements taken for final plotting purposes. The final measurements should not be taken until it is reasonably certain that conditions are satisfactory and that the pressure gradient has again become stabilized.