CABLE PRESSURE SYSTEMS
LEAK LOCATION PROCEDURES
GENERAL

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1. GENERAL

1.01 This section covers the principles of leak location and outlines the procedures to be followed in the location of leaks in pressurized cables. A guide to assist craft personnel in the selection of the most advantageous leak location method to fit specific conditions is also covered in this section.

1.02 This section is revised to update the text and include information formerly contained in Section 637-411-011. Since this is a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 Detailed descriptions of the methods available for the approximate location of leaks using pressure gradient methods are given in Section 637-410-504.

2. PRINCIPLES OF LEAK LOCATING

FORMATION OF LEAK GRADIENTS

2.01 When a length of cable containing ***no*** leaks is pressurized and allowed to stand, the pressure will stabilize and be uniform throughout its length. If a leak occurs, the stable condition is disturbed and air will flow toward the leak and escape into the atmosphere. The air within the cable will flow toward the leak from both directions and result in a gradual loss of pressure throughout the cable.

2.02 The change in appearance of the pressure gradient of a cable at intervals from 5 to 160 hours after the occurrence of a large leak near the midpoint of a pressurized cable is illustrated in Fig. 1.

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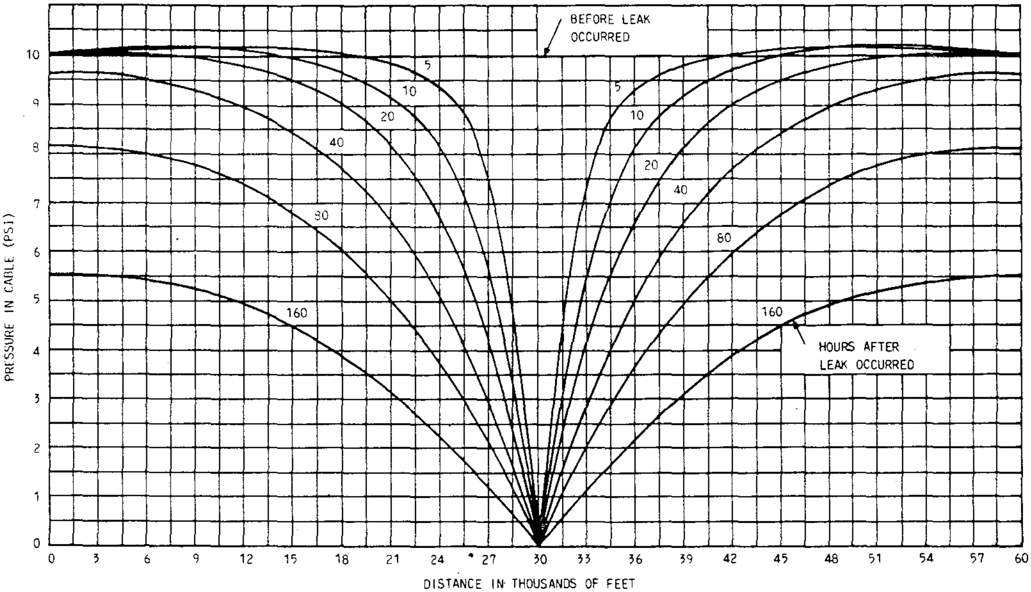

Fig. 1—Pressure Gradient Curves (Large Leak)

2.03 When the leak first occurs, the disturbance is confined to a short section immediately adjacent to the leak 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 a considerable distance 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 leak. Locating leaks by pressure gradient methods is based on finding the point of minimum pressure by taking pressure measurements at approximately even intervals along the cable under test and plotting them on a graph, as shown in Fig. 2. Connecting the plotted points with straight lines gives an approximation of the true pressure conditions of the cable under test at the time the pressure readings are made. For comparison, the true pressure gradient, which is a smooth dotted curve, is also shown.

2.05 The smooth curves shown in Fig. 1 and 2 are true leak gradients, ie, the curves depict the pressure along a length of cable having no irregularities in the cable plant or no change in outside conditions which may influence the airflow toward the leak.

2.06 True leak gradients can only be approximated because of limitations in methods and instruments used for making pressure measurements, nonuniformity in cable plant, and the effect of atmospheric conditions.

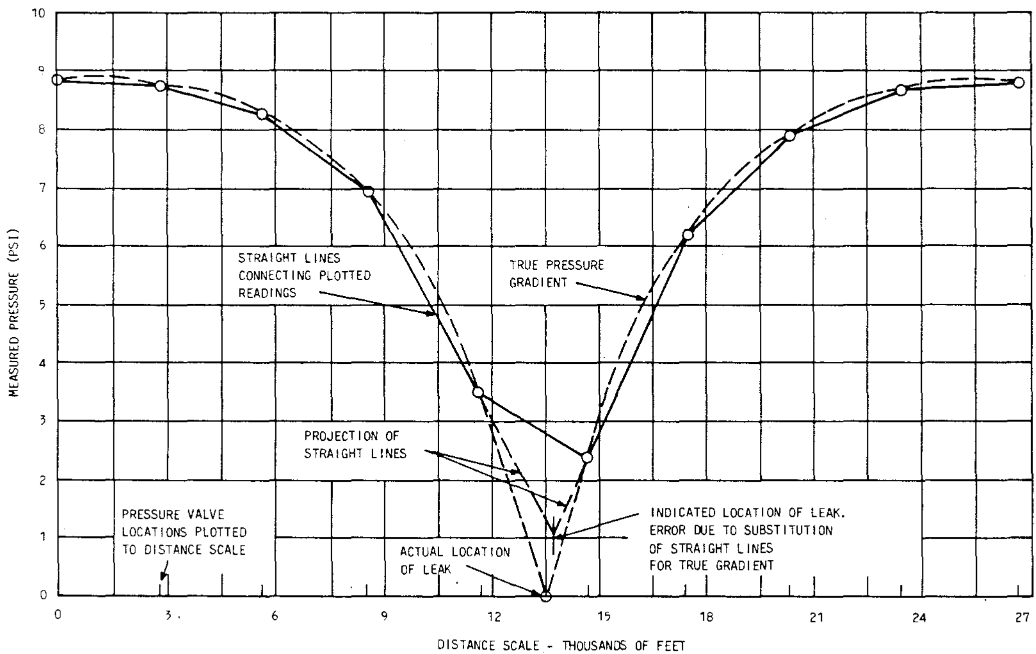

Fig. 2—Plotting Pressure Measurements

CONDITIONS AFFECTING LEAK GRADIENTS

2.07 The shape of a leak gradient always reflects 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 apparatus cases connected to it. These provide additional sources of air supply for the flow toward the leak and introduce irregularities in a leak gradient at the points of connection.

(d) Stoppages or obstructions which restrict the normal flow of air through a cable introduce irregularities in a leak gradient.

(e) The presence of more than one leak complicates securing a true leak gradient for a particular leak.

EFFECT OF UNEQUALIZED PRESSURE

2.08 Unequalized pressure in the cable caused by sheath openings or incomplete pressurization will conflict with the leak gradient. 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.

EFFECT OF TEMPERATURE

2.09 Changes in cable temperature during the leak locating tests will distort a pressure gradient and cause errors in leak location. Leak locating tests preferably should be made when temperature conditions are stable.

2.10 ***Underground and Buried Cable:*** Temperature changes in underground and buried cable generally are gradual and do not cause 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.

2.11 Pumping water from manholes and conduit may change the temperature of an underground cable appreciably. Pressure readings should be deferred until temperature conditions stabilize. Pumping manholes to take pressure readings can be avoided by locating the valves in the neck of the manhole.

2.12 Cable supported from 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.

2.13 ***Aerial Cable:*** 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 changing continuously and leak gradients may be distorted sufficiently to cause serious errors in leak location, particularly in the case of small and medium leaks.

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

WEATHER CONDITION	EFFECT ON GRADIENT
(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

2.15 ***Combination Aerial and Underground Cable:*** 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 air between the aerial and underground cables. When leak locating tests are to be made in such sections, the aerial portion should be isolated from the underground by closing the bypass, if provided, around the pressure plug at the junction of the two types of plant. The section of cable being investigated then may be treated either as all-aerial or all-underground.

EFFECT OF ALTITUDE

2.16 Where differences in elevation exist between valve points in a section of cable under test, the weight of the air in the cable increases the pressure at the lower valve points. The resultant distortion of a leak gradient is significant when the difference in elevation between valves is 20 feet or more for mercury manometer tests, and 1 foot or more in making precision tests. Accordingly, the pressures measured at the different elevations must be converted to their equivalent values at a common elevation, as described in Section 637-400-504, covering correction of pressure measurements, before plotting a leak gradient.

EFFECT OF ATMOSPHERIC PRESSURE

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

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

IMPROVING ACCURACY OF RESULTS

2.19 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. After an approximate leak location is obtained, the suspected area should be tested, using the methods for different types of plant as follows:

TYPE OF PLANT	METHOD USED
Aerial	Spray with pressure testing solution or use ultrasonic method (See Sections 637-414-500 and 081-607-100, respectively).
Underground	Compute the leak location by arithmetical means, as described in Section 637-410-504, before excavating to clear leak.
Buried	Compute as for underground cable and use helium method before excavating to clear leak (see Section 637-416-501).

2.20 The methods discussed in 2.19 are time-consuming operations, and it is therefore important to obtain as accurate a leak location as practicable before proceeding with a detailed examination of the cable. The reduction of effort which may be affected in this way justifies additional care and effort in making the pressure measurements in a manner that will provide an accurate location.

2.21 To obtain accurate results, it is necessary to:

(a) Take measurements when conditions have minimal influence on the gradient.

(b) Make the measurements in the shortest time practical, using methods which will compensate for changes in gradient shape during the interval required to make the measurements.

(c) Take measurements at enough points so the shape of the gradient in the immediate vicinity of the leak will be indicated clearly.

2.22 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 obtaining several sets of measurements hurriedly. The latter may leave considerable uncertainty as to the leak location, and may require excessive effort in exposing and inspecting the cable.

2.23 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 then can 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 the pressure has stabilized.

3. LEAK LOCATING PROCEDURES

3.01 The procedure to be followed in a particular case will depend on the type of cable plant, accessibility, size of the leak, and other factors or irregularities that may affect the pressure gradient. In all cases, good judgment must be exercised to determine the most economical and practical procedure to be employed.

3.02 The procedures for the location of leaks in pressurized cables may be divided into three steps as follows:

- ***Step 1—Leak Detection:*** The purpose of this step is to detect the existence of a leak in a cable section. Generally, this provides a location within three valve sections—approximately 9000 feet.

- ***Step 2—Preliminary Leak Location:*** The purpose of this step is to determine an approximate location of the leak within a regular valve section of 3000 feet. In underground cable, this step generally places the leak within one or two manhole sections.

- ***Step 3—Final Leak Location:*** The purpose of this step is to determine the actual location of the leak by the most accurate and practical methods available.

LEAK DETECTION

3.03 ***Continuous pressure systems equipped with the Cable Pressure Monitoring System (CPMS):*** The CPMS automatically provides a ***nightly status report*** and ***alarm bulletins*** which disclose any suspected trouble location. This report and bulletin(s) are sufficient to state the nature and general location of a problem.

3.04 ***Continuous Pressure Systems Without CPMS:*** With these systems, air leaks are detected by the operation of pressure monitoring devices (contactors and/or transducers). The leak is located within the section monitored by the operated device.

PRELIMINARY LEAK LOCATION

3.05 A preliminary leak location is obtained by taking pressure readings at three or more uniformly spaced valves on each side of the suspected leak location and plotting a pressure gradient from these readings. The ***two-direction method*** of leak locating, described in Section 637-410-504, may be followed for all types of plant to verify the pressure readings and allow for changes in cable pressure during the time required to take the measurements.

FINAL LEAK LOCATION

A. Underground Cable

3.06 Inspect and solution test the cable, sleeves, closures, and apparatus cases in each manhole adjacent to the preliminary leak location.

3.07 If the leak is not found by inspection and solution test, use the airflow indicator (Section 081-603-101) on each side of the preliminary location to determine the conduit section containing the leak. This will indicate the section of cable to be replaced in case repairs are not practicable.

3.08 If the defective section is to be repaired, install temporary valves in three manholes on each side of the defective section and obtain an accurate location, using the gradient methods described in Section 637-410-504.

3.09 After an accurate location has been obtained, excavate the conduit structure, break open the duct containing the cable under test, and expose a 6- to 10-foot section of cable. Visually inspect and solution test the exposed cable. If the leak is not found, install two temporary valves on the exposed cable sheath and use the airflow indicator to determine in which direction the excavation work should progress to find the leak.

B. Buried Cable

3.10 Expose, inspect, and solution test the splices adjacent to the preliminary leak location.

3.11 If the leak is not found, use the airflow indicator at the exposed splice points to determine the section of cable containing the leak. Then install temporary valves at these splices and at sufficient additional points along the cable to provide three valve points spaced 500 to 1000 feet apart on each side of the preliminary location. The temporary valves then should be used to obtain an accurate location, using the gradient methods described in Section 637-410-504.

3.12 After an accurate gradient has been obtained, follow the procedures outlined in Section 637-416-501 covering the helium method of buried cable leak locating before excavating to expose the cable. When the leak is found using the helium method, visually inspect and solution test the exposed cable. If the leak is not found, install two temporary valves on the cable sheath and use the airflow indicator to determine in which direction the excavation work should progress to find the leak.

C. Aerial Cable

3.13 Where a leak in aerial cable is involved, the preliminary measurements usually are sufficiently accurate to permit finding the leak by employing ultrasonic leak locating equipment. There are various types of ultrasonic equipment which locate leaks by detecting the high-frequency sound generated by air escaping from pressurized cable or equipment. The description and use of different types of ultrasonic equipment are covered in Section 081-607-100.