CABLE PRESSURE SYSTEMS

CONTINUOUS FEED — MAINTENANCE

FAULT LOCATING

CONTENTS PAGE

1. GENERAL

1.01 This section describes the procedures used to locate faults (leaks, restrictions, etc) in cables in a continuous feed pressure system.

1.02 This section is reissued to:

- Include information on locating ***smaller than zero*** leaks.
- Provide information on a method for estimating the approximate gas loss caused by a specific leak.
- Make minor revisions in the text for clarification.

1.03 The procedures will depend upon whether pressures are being established initially or being subsequently maintained. The procedures for establishing initially and for maintaining pressure are outlined in Parts 3 and 4, respectively.

1.04 The special procedures recommended for the maintenance of cables pressurized from pipe systems are included in Section 637-050-300.

1.05 Although this section is complete in itself regarding fault locating, a basic understanding of flow analysis, gradient work, etc, as covered in other sections of this series will be necessary. Reference is made to pertinent sections in various parts of this section.

2. ESTABLISHING PRESSURES — GENERAL

2.01 The cable system under consideration shall have initial procedures completed prior to any work in establishing pressures. These procedures are covered fully in Section 637-500-012 and include:

(1) Installing and connecting the pressure source.

(2) Plugging cables at the pressure source.

(3) Plugging and bypassing cross-connecting terminals where necessary.

(4) Plugging building entrance cables.

(5) Placing valves for initial flow analysis.

(6) Plugging nongastight terminals on:

(a) 200-pair and larger cables.

(b) 150-pair cables within 4000 feet of a junction with 200-pair or larger cables.

(c) 100-pair cables within 2500 feet of a junction with 200-pair or larger cables.

(d) Cables smaller than 100-pair within 2000 feet of a junction with 200-pair or larger cables.

2.02 Follow flow analysis procedures as described fully in Section 637-500-013. These procedures include:

(1) Reading and recording pressures obtained at all initial analysis valves on a cable or group of cables that form a single network.

**Reprinted to comply with modified final judgment.

(a) Allow pressures to stabilize at least 1 week before analysis valve readings are taken.

(2) Take analysis valve readings on the cable network and compute the flow rate of lateral cables where valves are placed.

(a) Apply the formula $F = P/R_T$ as covered in Section 637-500-013 or use the Cable Pressurization Computer covered in Section 637-500-014.

(b) When the two analysis valves placed on a lateral have identical readings, zero flow is indicated.

(c) When zero pressure is indicated at the first two laterials out from the pressure source, use zero projection procedures as covered in 2.03, starting from the point of pressure attachment in the vault.

(3) Apply to the main (feeder) cable the flow rate in each lateral to determine the pressure drop that the lateral flow is causing in the main cable.

(a) Apply the formula $P = FR_T$ as covered in Section 637-500-013 or use the Cable Pressurization Computer.

(4) Establish a priority list showing the order of working on individual lateral cables.

(a) The lateral cable causing the largest pressure drop in the main cable should receive attention first. The one causing the second largest pressure drop should be next to receive attention, etc.

(5) Determine the condition of the underground cable.

(a) From the analysis valve data, calculate the pressure in the cable at the manhole.

(b) Plot calculated underground pressures on a gradient graph as covered in Section 637-500-500.

(c) Analyze the gradient, giving due consideration to interlacing and lateral cable leaks.

(d) If there appears to be a leak or restriction in the underground cable, verify the condition by comparing the flow rate on each side of the indicated fault location.

(e) Leaks or restrictions indicated in this manner should be entered at an appropriate position on the priority list.

2.03 Following the establishment of a priority list use zero projection methods to indicate a limited length of cable in which to look for the leak. These methods covered in detail in Section 637-500-013 are basically as follows:

(1) Assume a zero leak. Apply the formula $R_T = P/F$ or use the Cable Pressurization Computer.

(a) P = pressure reading at second analysis valve.

(b) F = flow rate in cable involved.

(2) Convert pneumatic resistance obtained (R_T) to distance in feet.

(a) Apply formula:

Distance (feet) =

R_T (calculated) × 1000
R per 1000 ft (from Pnuematic Resistance Table in 637-020-020 or 637-500-500)

(b) The Cable Pressurization Computer can also be used for this purpose.

(3) A zero projection can also be obtained through the use of a gradient graph. When this method is used, plot pressures against pneumatic resistance rather than distance if a change in cable size or gauge occurs in the gradient area. Total pneumatic resistance can then be converted to distance (feet) in order to find the indicated fault location.

(4) Take a C Cable Drill reading approximately 100 feet on the pressure source side of the indicated zero leak location.

(a) If this reading is approximately zero, the leak is located in that general area.

(b) If there is significant pressure at this location, note and record the pressure. This situation indicates a smaller than zero leak back toward the pressure source. In such a case the distance from the second analysis valve to the smaller than zero leak can be approximated as described in Section 637-500-014, or by using the following formula:

Distance from 2nd Analysis Valve to ***less than zero*** leak =

$$\frac{\text{Distance between Analysis Valves}}{\text{Pressure Drop between Analysis Valves}} \times$$

Pressure drop between 2nd Analysis Valve and the indicated ***zero*** leak location

(5) In aerial cable if the indicated zero leak location is beyond the junction of a feeder cable with its branch cables, take a C Cable Drill reading at this junction.

(a) If this pressure is significantly ***above*** the pressure calculated or projected, a ***smaller than zero*** leak can be assumed to be located between the second analysis valve and the junction. Proceed as in 2.03 (4b).

(b) If the pressure reading at the junction is close to that expected, assume a zero leak beyond the junction. Place a valve within 100 to 300 feet of the junction on each of the branch cables. Calculate the flow rate ($F = P/R_T$) or use the Cable Pressurization Computer in each of the branch cables and compare them to determine which direction the major leaks exist. Apply zero projection principles as appropriate.

(6) The zero projection principles can also be used when localizing indicated underground leaks.

2.04 Where a toll cable is involved, the plotting of a pressure gradient is recommended for determining the general areas and specific locations where leak detecting effort should be concentrated.

(1) Place sufficient valves for an accurate gradient of the leak location.

(2) Allow 16 hours for pressures to settle after the valves are placed except that readings can be taken immediately if C Cable Drills are used.

(3) When zero pressures are encountered, an auxiliary pressure source may be used beyond the leak to improve the accuracy of the gradient. In some instances these leaks can be located without further gradient effort by using ultrasonic or spraying equipment described in Sections 081-607-100 and 081-605-101, respectively.

(4) Take a complete set of pressure readings at the valves involved in the gradient plot.

(a) Readings should be taken by one man in the shortest practical time interval, using one instrument.

(b) Test all valves for leakage before, during, and after taking readings.

(5) Plot the gradient.

(a) If all cable involved in the gradient is of the same size and gauge, use distance in feet as the horizontal component of the graph.

(b) When changes of size and gauge are involved, use pneumatic resistance as the horizontal component. This will eliminate the change in gradient slope where the cable size or gauge changed. Placing three valves in each size and gauge may help localize the fault.

(6) Analyze the gradient as described in Section 637-500-500.

(a) In underground and buried cable sections it may be desirable to eliminate errors resulting from inaccuracies in plotting the gradient by computing the location of the leak as described in Section 637-411-503. Fig. 1 shows a sample work sheet that can be used to accomplish this by filling in the blank spaces and completing the indicated computations.

2.05 The location of a leak plotted on a gradient graph is not necessarily the actual location. The following conditions affect the accuracy of a gradient:

(a) The accuracy of the pressure readings.

(b) The accuracy of plotting.

(c) Pressure differences between valves used for the gradient. The greater the slope in pressure the more accurate the graph will be.

(d) Valve spacing. The closer the valve spacing the more accurate the gradient graph.

(e) The degree of pressure stabilization will also affect the graph. A completely stabilized section will provide the best gradient.

(f) The accuracy of distance between valves.

(g) Variations in temperature.

2.06 After flow or gradient analysis look for the leak in the indicated location as follows:

→ (1) Using ultrasonic or spraying equipment look for the leak in the exact location indicated by the analysis and, if not found, look 6 feet on either side.

(2) If the leak is not found within this 12-foot section, extend the search to two spans (approximately 300 feet) on each side of the indicated location.

2.07 Try to verify that the found leak was primarily responsible for the low pressure condition; otherwise a second visit may be necessary to rebuild the pressure adequately. The flow rate, as can be determined from a flow analysis, shows the magnitude of the leak, as for example 0.05 scfh, 0.15 scfh, etc. When a leak is found, the approximate rate of gas loss• from the leak can be estimated by timing the forming of a 1-inch diameter bubble from pressure testing solution applied to the leak area. The relation of timing of bubble forming and gas loss are shown in Table A.

TABLE A — TIME IN SECONDS FOR PRESSURE TESTING SOLUTION TO FORM 1-INCH DIAMETER BUBBLE

SECONDS	APPROXIMATE GAS LOSS	
	SCFH	SCFD
1	0.54	13.0
2	0.27	6.5
3	0.18	4.3
4	0.13	3.2
5	0.11	2.6
6	0.09	2.1
7	0.08	1.8
8	0.07	1.6
9	0.06	1.5
10	0.05	1.3
11	0.04	1.2
12	0.04	1.1
13	0.04	1.0
14	0.04	0.9
15	0.03	0.9
25	0.02	0.5
40	0.01	0.3

2.08 If the leak is not found, take a new set of pressure readings and reanalyze the flow or gradient:

(1) When encountering low pressures, use an auxiliary pressure source to raise the pressure in the area of the gradient.

(2) If the indicated fault location is still the same, take a C Cable Drill reading at that location and look for the leak again, as described in 2.06.

(3) When the indicated fault location is different from that previously determined, take a C Cable Drill reading at the new location and look for the leak as described in 2.06.

(4) The valve at the indicated fault location will help in analyzing for the possibility of two leaks in the section. When two leaks are indicated, place sufficient valves and plot gradients to locate each of them.

2.09 Locate and repair leaks until the objective pressures are obtained in the toll and trunk cable or at the end of 200-pair or larger subscriber cables.

2.10 When objective pressures are to be obtained at the end of 100-pair or smaller cables, complete the following procedures before attempting to establish pressure in these cables.

(1) Plug nongastight terminals located between the last plug placed previously and the distribution end of 100- and 150-pair cables.

(2) Plug nongastight terminals on cables smaller than 100 pairs within 2000 feet of their junction with 100-pair or larger cables.

(3) Place additional analysis valves to reveal the presence and location of pressure faults in these cables. Follow the flow analysis procedures.

2.11 Analyze the readings obtained at the analysis valves and locate major leaks indicated by the flow analysis.

3. ESTABLISHING PRESSURES — SUBSCRIBER LATERALS FROM CABLES CARRYING TOLL, TRUNK, AND SPECIAL SERVICE CIRCUITS

3.01 Some cables carrying toll, trunk, and special service circuits were pressurized before the present pressurization program was initiated. At that time associated lateral and branch cables that did not carry toll, trunk, or special service circuits were generally plugged at their junction with the feeder cable.

3.02 The following are methods and procedures for pressurizing lateral and branch cables previously plugged and for continuing the same high grade pressure protection on the feeder cables.

3.03 Feed gas to *all* cables that enter each centralized air dryer location. This shall include cables previously pressurized on a periodic charge basis.

3.04 Temporarily leave and maintain nitrogen cylinders placed in the field on feeder cables carrying toll, trunk, and special service circuits.

3.05 Work on one lateral or branch cable at a time. Pick the most important one first, considering length and services involved.

(1) Plug nongastight terminals in each lateral.

(2) Feed gas to these laterals, one at a time, from an auxiliary pressure source at an appropriate location on each lateral.

(3) Locate enough leaks in each lateral to ensure that when the auxiliary sources are removed and the laterals are connected directly to the feeder cable, adequate pressures will remain in the feeder cable.

(4) Bypass the plugs at the main cable junctions and remove the auxiliary source.

(5) Make sure adequate pressures are maintained in the main cable as laterals are connected to it. Do additional work on completed laterals as necessary.

3.06 When the laterals are completed and pressure losses are adequately reduced, remove any auxiliary gas sources that were previously maintained on the main cable.

3.07 Existing pressure contactors on toll and trunk cables that were maintained previously on a periodic charge basis were set to operate at 3 psi in aerial cable and 6 psi in underground cable. These pressure requirements may limit the number of laterals that can be reconnected to the main cable. If the contactor operation point is approached before the laterals are reconnected to the main cable, refer the case to Engineering (or Plant Engineering) Department. These people will determine if resetting the contactors in the main cable or obtaining a gas feed for some of the other laterals from another source, or both, would be advisable.

4. MAINTAINING PRESSURES

4.01 After satisfactory pressures are established in a cable, additional leak location work will be necessary as new sheath faults develop. These faults will be determined either by monitoring devices or by a field check of flows and pressures using flow analysis and gradient techniques. Service-affecting sheath break troubles may alter the frequency of these checks in specific cables or networks.

4.02 When an indication of low cable pressure is received from a monitoring device, check the following:

(1) Make sure that all shutoff valves in the system are open.

(2) Verify that the gas entering the cable is at proper pressure.

(3) Verify as to any cable opening that may have been made or exists in the cable involved.

4.03 All verified indications should be handled as leaks. The procedure to follow will vary with the type of monitoring device from which the indication was received. However, low cable pressure will point to the general section of cable in which the fault is located.

4.04 The following general rules are recommended so that the locating of the more serious leaks can be further localized:

(1) Make a flow analysis on the cable in the area where the fault is indicated by the monitoring device. Use the same principles on this cable as used on an entire network in building pressures initially. It may be unnecessary to determine pressure drop in the feeder cable extending back toward the pressure source. This is true when the flows involved are coming from a common junction on the feeder cable. The highest rate will reflect the most serious leak. These principles are covered in 2.02.

(2) When the flow rate of gas in aerial lateral cables is small, calculate manhole cable pressures and flow analyze or plot a gradient of the underground cable. Verify any leak indications by comparing flow rate ahead of and beyond the indicated fault location. These principles are covered in 2.02.

WORK SHEET
COMPUTATION OF LEAK LOCATION
(REFERENCE 637-411-503)

1. DISTANCES:

   A = V1 TO V2 = ________ FT.

   B = V2 TO V3 = ________ FT.

   C = V3 TO V4 = ________ FT.

2. PRESSURE READINGS:

   V1 = ________ PSI

   V2 = ________ PSI

   V3 = ________ PSI

   V4 = ________ PSI

3. PRESSURE DIFFERENCES:

   X = V1 - V2 = ________ PSI

   Y = V3 - V2 = ________ PSI

   Z = V4 - V3 = ________ PSI

4. FORMULA:

   $$D = \frac{A(BZ \pm CY)}{CX + AZ}$$

   WHERE D IS THE DISTANCE FROM V2 TO THE LEAK[1]

5. COMPUTATION:

BZ	= (B) ________	×	(Z) ________	=	________	(1)
CY	= (C) ________	×	(Y) ________	=	________	(2)
BZ + CY[2]	= (1) ________	−	(2) ________	=	________	(3)
A(BZ + CY)[2]	= (A) ________	×	(3) ________	=	________	(4)
CX	= (C) ________	×	(X) ________	=	________	(5)
AZ	= (A) ________	×	(Z) ________	=	________	(6)
CX + AZ	= (5) ________	+	(6) ________	=	________	(7)
D	= (4) ________	÷	(7) ________	=	________	

LEAK IS AT DISTANCE "D" BEYOND V2

Notes:

1. WHEN V2 IS GREATER THAN V3, CY IS POSITIVE.
   WHEN V2 IS LESS THAN V3, CY IS NEGATIVE.
2. SUBTRACT INSTEAD OF ADDING CY WHEN V2 IS LESS THAN V3.

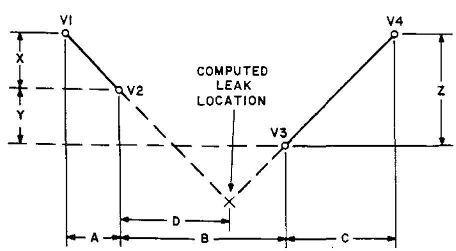

Fig. 1 — Computed Leak Location