Designation: A 674 – 00

Standard Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids[1]

This standard is issued under the fixed designation A 674; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers materials and installation procedures for polyethylene encasement to be applied to underground installations of ductile iron pipe. It may also be used for polyethylene encasement of fittings, valves, and other appurtenances to ductile iron pipe systems.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 149 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies[2]

D 882 Standard Test Method for Tensile Properties of Thin Plastic Sheeting

D 1709 Standard Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method

D 1922 Standard Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method

D 4976 Standard Specification for Polyethylene Plastics Molding and Extrusion Materials

2.2 *ANSI/AWWA Standards:*

C 600, Installation of Ductile Iron Water Mains and Their Appurtenances[3]

C 105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *polyethylene encasement*—polyethylene material, in tube or sheet form, that is used to encase ductile iron pipe.

3.1.2 *securing overlap*—any one of various methods of holding polyethylene encasement in place at the point of overlap until backfilling operations are completed. This may be accomplished with adhesive tape or plastic tie straps.

3.1.3 *linear low-density polyethylene film*—Film extruded from virgin linear low-density polyethylene raw material.

3.1.4 *high-density, cross-laminated polyethylene film*—Film extruded from virgin high-density polyethylene raw material, which is then molecularly oriented by stretching. Two single-ply layers of the film are then laminated together with their orientations at 90° to one another to form the final product.

4. Requirements

4.1 *Materials*:

4.1.1 *Linear low-density polyethylene film*—Linear low-density polyethylene film shall be manufactured of virgin polyethylene material conforming to the requirements of Specification D 4976 shown in Table 1.

4.1.1.1 *Thickness*—Linear low-density polyethylene film shall have a minimum thickness of 0.008 in. (0.20 mm).

4.1.2 *High-density cross-laminated polyethylene film*—High-density cross-laminated polyethylene film shall be manufactured of virgin polyethylene material conforming to the requirements of Specification D 4976 shown in Table 2.

4.1.2.1 *Thickness*—High-density cross-laminated polyethylene film shall have a minimum thickness of 0.004 in. (0.10 mm).

4.2 *Tube Size*—The tube size for each pipe diameter shall be as listed in Table 3.

4.3 *Color*—Polyethylene film may be supplied with its natural color, colors including white and black, or black (weather-resistant) containing not less than 2 percent carbon black with an average particle diameter of 50 mm or less. A minimum of 2 percent of a hindered-amine ultraviolet inhibitor is required in any natural or colored film except black film containing 2 percent or more carbon black.

4.4 *Marking requirements*—The polyethylene film supplied shall be clearly marked, at a minimum of every 2-ft along its length, containing the following information:

(a) Manufacturer's name or registered trademark

(b) Year of manufacture

(c) ASTM A 674

(d) Minimum film thickness and material type (LLDPE or HDCLPE)

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[1] This practice is under the jurisdiction of ASTM Committee A04 on Iron Castings and is the direct responsibility of Subcommittee A04.12 on Pipes and Tubes.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] Available from American Water Works Association, 6666 W. Quincy Ave., Denver, CO 80235.

TABLE 1 Linear Low-Density Polyethylene Characteristics

Raw Material Used to Manufacture Polyethylene Encasement Material	
Group, density, and dielectric strength	in accordance with the latest revision of Specification D 4976
Group	2 (Linear)
Density	0.910 to 0.935 g/cm^3
Dielectric strength, volume resistivity	10^{15} ohm-cm, min
Polyethylene Encasement Material	
Tensile strength	3600 psi (24.83 MPa), min (ASTM D 882)
Elongation	800 %, min (ASTM D 882)
Dielectric strength	800 V/mil (31.5 V/μm) thickness, min (ASTM D 149)
Impact resistance	600 g, min (ASTM D 1709 Method B)
Propagation tear resistance	2550 gf, min (ASTM D 1922)

TABLE 2 High-Density Cross-Laminated Polyethylene Characteristics

Raw Material Used to Manufacture Polyethylene Encasement Material	
Group, density, and dielectric strength	in accordance with the latest revision of Specification D 4976
Group	2 (Linear)
Density	0.940 to 0.960 g/cm^3
Dielectric strength, volume resistivity	10^{15} ohm-cm, min
High-Density Cross-Laminated Polyethylene Encasement Material	
Tensile strength	6300 psi (43.47 MPa), min
Elongation	100 %, min
Dielectric strength	800 V/mil (31.5 V/μm) thickness, min
Impact resistance	800 g, min. (ASTM D 1709 Method B)
Propagation tear resistance	250 gf, min. (ASTM D 1922)

(e) Applicable range of nominal pipe diameter size(s)

(f) Warning—Corrosion Protection—Repair Any Damage

4.4.1 *Marking height*—Letters and numerals used for marking items a through e in Section 4.4 shall not be less than 1 in. (25.4 mm) in height. Item f in Section 4.4 shall be not less than 1½in. (38.10 mm) in height.

5. Installation

5.1 *General*:

5.1.1 The polyethylene encasement shall prevent contact between the pipe and the surrounding backfill and bedding material but is not intended to be a completely airtight or watertight enclosure. All lumps of clay, mud, cinders, etc. which may be on the pipe surface shall be removed prior to installation of the polyethylene encasement. During installation, care shall be exercised to prevent soil or embedment material from becoming entrapped between the pipe and the polyethylene.

TABLE 3 Polyethylene Tube Sizes for Push-On Joint Pipe[A]

Nominal Pipe Diameter, in.	Recommended Polyethylene Flat Tube Width, in. (cm)[B]
3	14 (36)
4	14 (36)
6	16 (41)
8	20 (51)
10	24 (61)
12	27 (69)
14	30 (76)
16	34 (86)
18	37 (94)
20	41 (104)
24	54 (137)
30	67 (170)
36	81 (206)
42	81 (206)
48	95 (241)
54	108 (274)
60	108 (274)
64	121 (307)

[A]These wrap sizes should work with most push-on joint pipe and fitting bell sizes. Where bell circumferences are larger than the sheet sizes shown, the bell areas should be carefully wrapped with cut film sections, effectively lapping and securing cut edges as necessary; or, alternatively, sufficiently large tube or sheet film to effectively cover these joints should be ordered.

[B]For flat sheet polyethylene, see 5.2.3.

5.1.2 The polyethylene film shall be fitted to the contour of the pipe to effect a snug, but not tight, encasement with minimum space between the polyethylene and the pipe. Sufficient slack shall be provided in contouring to prevent stretching the polyethylene bridging irregular surfaces, such as bell-spigot interfaces, bolted joints, or fittings, and to prevent damage to the polyethylene due to backfilling operations. Overlaps and ends shall be secured by the use of adhesive tape or plastic tie straps.

5.1.3 For installations below the water table or in areas subject to tidal actions, or both, it is recommended that tube-form polyethylene be used with both ends sealed as thoroughly as possible with adhesive tape or plastic tie straps at the joint overlap. It is also recommended that circumferential wraps of tape or plastic tie straps be placed at 2 ft (0.6 m) intervals along the barrel of the pipe to help minimize the space between the polyethylene and the pipe.

5.2 *Pipe*—This practice includes three different methods for the installation of polyethylene encasement. Method A and B are for use with polyethylene tubes and Method C is for use with polyethylene sheets.

5.2.1 *Method A (see* Fig. 1*)*:

5.2.1.1 Cut the polyethylene tube to a length approximately

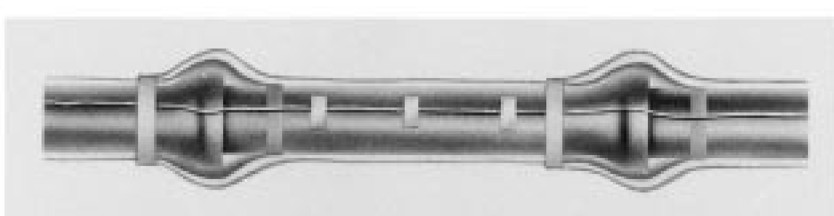

FIG. 1 Method A

2 ft (0.6 m) longer than the length of the pipe section. Slip the tube around the pipe, centering it to provide a 1-ft (0.3-m) overlap on each adjacent pipe section, and bunching it accordion fashion lengthwise until it clears the pipe ends.

5.2.1.2 Lower the pipe into the trench and make up the pipe joint with the preceding section of pipe. A shallow bell hole must be made at joints to facilitate installation of the polyethylene tube.

5.2.1.3 After assembling the pipe joint, make the overlap of the polyethylene tube. Pull the bunched polyethylene from the preceding length of pipe, slip it over the end of the new length of pipe, and secure in place. Then slip the end of the polyethylene from the new pipe section over the end of the first wrap until it overlaps the joint at the end of the preceding length of pipe. Secure the overlap in place. Take up the slack width at the top of the pipe as shown in Fig. 2, to make a snug, but not tight, fit along the barrel of the pipe, securing the fold at quarter points.

5.2.1.4 Repair any rips, punctures, or other damage to the polyethylene with adhesive tape or with a short length of polyethylene tube cut open, wrapped around the pipe, and secured in place. Proceed with installation of the next section of pipe in the same manner.

5.2.2 *Method B (see* Fig. 3*)*:

5.2.2.1 Cut the polyethylene tube to a length approximately 1 ft (0.3 m) shorter than the length of the pipe section. Slip the tube around the pipe, centering it to provide 6 in. (150 mm) of bare pipe at each end. Make the polyethylene snug, but not tight, as shown in Fig. 2; secure ends as described in 5.2.1.

5.2.2.2 Before making up a joint, slip a 3-ft (0.9-m) length of polyethylene tube over the end of the preceding pipe section, bunching it accordion fashion lengthwise. Alternatively, place a 3-ft (0.9 m) length of polyethylene sheet in the trench under the joint to be made. After completing the joint, pull the 3-ft length of polyethylene over or around the joint, overlapping the previously installed on each adjacent section of pipe by at least 1 ft (0.3 m); make snug and secure each end as described in 5.2.1. A shallow bell hole must be made at joints to facilitate installation of the polyethylene tube or sheet.

5.2.2.3 Repair any rips, punctures, or other damage to the polyethylene as described in 5.2.1. Proceed with installation of the next section of pipe in the same manner.

5.2.3 *Method C (see* Fig. 4*)*:

5.2.3.1 Flat sheet polyethylene shall have a minimum width twice the flat tube width shown in Table 3.

5.2.3.2 Cut the polyethylene sheet to a length approximately 2 ft (0.6 m) longer than the length of pipe section. Center the cut length to provide a 1-ft (0.3-m) overlap on each adjacent pipe section, bunching it until it clears the pipe ends. Wrap the polyethylene around the pipe so that it overlaps circumferentially over the top quadrant of the pipe. Secure the cut edge of polyethylene sheet at approximately 3-ft (0.9-m) intervals along the pipe length.

5.2.3.3 Lower the wrapped pipe into the trench and make up the pipe joint with the preceding section of pipe. A shallow bell hole must be made at joints to facilitate installation of the polyethylene. After completing the joint, make the overlap as described in 5.2.1.

5.2.3.4 Repair any rips, punctures, or other damage to the polyethylene as described in 5.2.1. Proceed with installation of the next section of pipe in the same manner.

5.3 *Pipe-Shaped Appurtenances*—Bends, reducers, offsets, and other pipe-shaped appurtenances shall be covered with polyethylene in the same manner as the pipe.

5.4 *Odd-Shaped Appurtenances*—Wrap valves, tees, crosses, and other odd-shaped pieces which cannot practically be wrapped in a tube, with a flat sheet or split length of polyethylene tube. Pass the sheet under the appurtenance and bring up around the body. Make seams by bringing the edges together, folding over twice, and taping down. Handle slack width and overlaps at joints as described in 5.2.1. Tape polyethylene securely in place at valve stem and other penetrations.

5.5 *Repairs*—Repair any cuts, tears, punctures, or damage to polyethylene with adhesive tape or with a short length of polyethylene tube cut open, wrapped around the pipe covering the damaged area, and secured in place.

5.6 *Openings in Encasement*—Make openings for branches, service taps, blow-offs, air valves, and similar appurtenances, by making an X-shaped cut in the polyethylene and temporarily folding the film back. After the appurtenance is installed, tape the slack securely to the appurtenance and repair the cut, as well as any other damaged areas in the polyethylene, with tape. Direct service taps may also be made through the polyethylene, with any resulting damage areas being repaired as described previously. The preferred method of making direct service taps consists of applying two or three wraps of adhesive tape completely around the polyethylene encased pipe to cover the area where the tapping machine and chain will be mounted. This method minimizes possible damage to the polyethylene

FIG. 2 Slack Reduction Procedure—Methods A and B

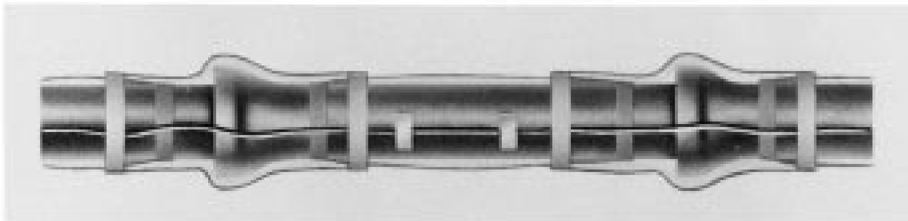

FIG. 3 Method B

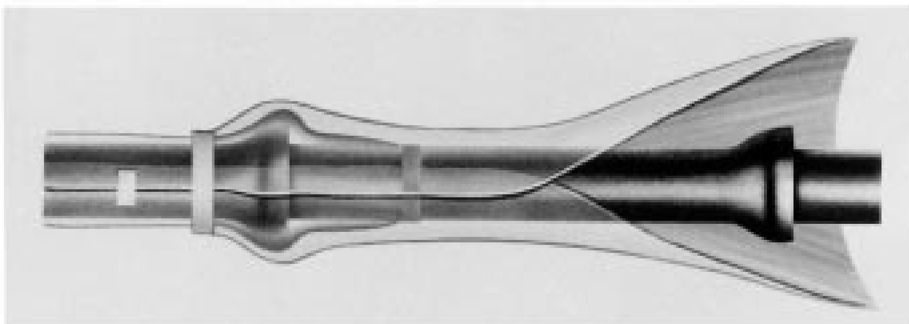

FIG. 4 Method C

during the direct tapping procedure. After the tapping machine is mounted, the corporation stop is installed directly through the tape and polyethylene as shown in Fig. 5. Experience has shown that this method is very effective in eliminating damage to the polyethylene encasement by the tapping machine and chain during the tapping operation. After the direct tap is completed, the entire circumferential area should be closely inspected for damage and repaired if needed.

5.7 *Junctions Between Wrapped and Unwrapped Pipe*—Where polyethylene wrapped pipe joins a pipe that is not wrapped, extend the polyethylene tube to cover the unwrapped pipe a distance of at least 3 ft (0.9 m). Secure the end with circumferential turns of adhesive tape. Service lines of dissimilar metals shall be wrapped with polyethylene or a suitable dielectric tape for a minimum clear distance of 3 ft (0.9 m) away from the ductile-iron pipe.

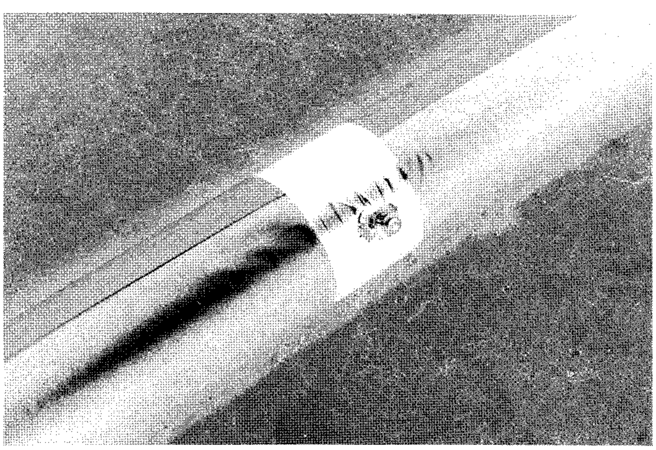

FIG. 5 Preferred Method for Making Direct Service Taps on PE Encased Iron Pipe

5.8 *Backfill for Polyethylene Wrapped Pipe*—Backfill material shall be the same as specified for pipe without polyethylene wrapping. Take special care to prevent damage to the polyethylene wrapping when placing backfill. Backfill material shall be free of cinders, refuse, boulders, rocks, stones, or other material that could damage polyethylene. In general, backfilling practice should be in accordance with the latest revision of ANSI/AWWA C 600.

6. Inspection and Certification by Manufacturer

6.1 *Quality control and inspection*—The manufacturer shall establish the necessary quality control and inspection practice to ensure compliance with this standard.

6.2 *Manufacturer's statement*—The manufacturer shall, if required by the purchaser's specifications, provide a sworn statement that the inspection and all applicable material requirements of Section 4.1 have been met and that all results comply with the requirements of this standard.

6.3 *Freedom from defects*—All polyethylene film shall be clean, sound, and without defects that could impair service.

7. Keywords

7.1 corrosion protection; ductile iron pipe; polyethylene encasement; soil-test evaluation; stray direct current

APPENDIX

(Nonmandatory Information)

X1. PROCEDURES FOR SOIL SURVEY TESTS AND OBSERVATIONS AND THEIR INTERPRETATION TO DETERMINE WHETHER DUCTILE IRON PIPE FOR WATER OR OTHER LIQUIDS REQUIRES POLYETHYLENE ENCASEMENT

X1.1 Scope

X1.1.1 In the appraisal of soil and other conditions that affect the corrosion rate of ductile iron pipe (see Note X1.1), a minimum number of factors must be considered. They are outlined in the following sections. A method of evaluating and interpreting each factor and a method of weighting each factor to determine whether polyethylene encasement should be used are subsequently described.

NOTE X1.1—The information contained in Appendix X1 is also applicable to grey iron pipe. Although grey iron pressure pipe is no longer produced in the United States, many miles of this product remain in service.

These methods should be employed only by qualified personnel who are experienced in soil analysis and evaluation of conditions potentially corrosive to ductile-iron pipe. Factors such as moisture content, soil temperature, location of soil sample with respect to pipe, time between removal of soil sample and testing, and other factors can significantly affect the soil-test evaluation. For example, certain soil environments are generally accepted to be potentially corrosive to ductile-iron pipe based on experience, and thus do not require evaluation to determine the need for corrosion protection. Such environments include, but are not limited to, coal, cinders, muck, peat, mine wastes, and landfill areas high in foreign materials. Experience with existing installations and potential for stray direct current corrosion should also be taken into consideration as a part of the evaluation.

X1.2 Applicable Document

X1.2.1 *ANSI/AWWA Standard*:

C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems[3]

X1.3 Earth Resistivity

X1.3.1 There are three methods for determining earth resistivity: four-pin, single-probe, and soil-box. In the field, a four-pin determination should be made with pins spaced at approximate pipe depth. This method yields an average of resistivity from the surface to a depth equal to pin spacing. However, results are sometimes difficult to interpret where dry top soil is underlain with wetter soils and where soil types vary with depth. The Wenner configuration is used in conjunction with a resistance meter.[4] For all-around use, a unit with a capacity of up to 10 Ω is suggested because of its versatility in permitting both field and laboratory testing in most soils.

X1.3.2 Because of the aforementioned difficulty in interpretation, the same unit may be used with a single probe that yields resistivity at the point of the probe. A boring is made into the subsoil so that the probe may be pushed into the soil at the desired depth.

X1.3.3 Inasmuch as the soil may not be typically wet, a sample should be removed for resistivity determination, which may be accomplished with any one of several laboratory units that permits the introduction of water to saturation, thus simulating saturated field conditions. Each of these units is used in conjunction with a soil resistance meter.

X1.3.4 Interpretation of resistivity results is extremely important. To base an opinion on a four-pin reading with dry top soil averaged with wetter subsoil would probably result in an inaccurate premise. Only by determining the resistivity in soil at pipe depth can an accurate interpretation be made. Also, every effort should be made to determine the local situation concerning ground-water table, presence of shallow ground water, and approximate percentage of time the soil is likely to be water saturated.

X1.3.5 With ductile iron pipe, resistance to corrosion through products of corrosion is enhanced if there are dry periods during each year. Such periods seem to permit hardening or toughening of the corrosion scale or products, which then become impervious and serve as better insulators.

X1.3.6 In making field determinations of resistivity, temperature is important. The result obtained increases as temperature decreases. As the water in the soil approaches freezing, resistivity increases greatly, and, therefore, is not reliable. Field determinations under frozen soil conditions should be avoided. Reliable results under such conditions can be obtained only by collection of suitable subsoil samples for analysis under laboratory conditions at suitable temperature.

X1.3.7 *Interpretation of Resistivity*—Because of the wide variance in results obtained under the methods described, it is difficult specifically to interpret any single reading without knowing which method was used. It is proposed that interpretation be based on the lowest reading obtained with consideration being given to other conditions, such as normal moisture content of the soil in question. Because of the lack of exact correlation between experiences and resistivity, it is necessary to assign ranges of resistivity rather than specific numbers. In Table X1.1, points are assigned to various ranges of resistivity. These points, when considered along with points assigned to other soil characteristics, are meaningful.

X1.4 pH

X1.4.1 In the pH range from 0.0 to 4.0, the soil serves well as an electrolyte. In the pH range from 6.5 to 7.5, soil conditions are optimum for sulfate reduction. In the pH range from 8.5 to 14.0, soils are generally quite high in dissolved salts, yielding a low soil resistivity.

X1.4.2 In testing pH, a combination pH electrode is pushed into the soil sample and a direct reading is made, following

[4] The Vibroground manufactured by Associated Research, Inc. has been found satisfactory for earth resistivity testing.

TABLE X1.1 Soil-Test Evaluation[A]

Soil Characteristics	Points
Resistivity, ohm-cm (based on water-saturated soil-box):	
<1500	10
≥1500 to 1800	8
>1800 to 2100	5
>2100 to 2500	2
>2500 to 3000	1
>3000	0
pH:	
0–2	5
2–4	3
4–6.5	0
6.5–7.5	0[B]
7.5–8.5	0
>8.5	3
Redox potential:	
> +100 mV	0
+50 to +100 mV	3.5
0 to +50 mV	4
Negative	5
Sulfides:	
Positive	3.5
Trace	2
Negative	0
Moisture:	
Poor drainage, continuously wet	2
Fair drainage, generally moist	1
Good drainage, generally dry	0

[A]Ten points = corrosive to or ductile iron pipe; protection is indicated.
[B]If sulfides are present and low or negative redox potential results are obtained, three points shall be given for this range.

suitable temperature setting on the instrument. Normal procedures are followed for standardization.

X1.5 Oxidation-Reduction (Redox) Potential

X1.5.1 The oxidation-reduction (redox) potential of a soil is significant because the most common sulfate-reducing bacteria can live only under anaerobic conditions. A redox potential greater than +100 mV shows the soil to be sufficiently aerated so that it will not support sulfate reducers. Potentials of 0 to +100 mV may or may not indicate anaerobic conditions; however, a negative redox potential definitely indicates the anaerobic conditions in which sulfate reducers thrive. The redox test is performed using a pH/mV meter with a combination ORP electrode inserted into the soil sample. It should be noted that soil samples removed from a boring or excavation can undergo a change in redox potential on exposure to air. Such samples should be tested immediately on removal from the excavation. Experience has shown that heavy clays, muck, and organic soils are often anaerobic, and these soils should be regarded as potentially corrosive.

X1.6 Sulfides

X1.6.1 The sulfide determination is recommended because of its field expediency. A positive sulfide reaction reveals a potential problem due to sulfate-reducing bacteria. The sodium azide-iodine qualitative test is used. In this determination, a solution of 3 % sodium azide in a 0.1 *N* iodine solution is introduced into a test tube containing a sample of the soil in question. Sulfides catalyze the reaction between sodium azide and iodine, with the resulting evolution of nitrogen. If strong bubbling or foaming results, sulfides are present, and the presence of sulfate-reducing bacteria is indicated. If very slight bubbling is noted, sulfides are probably present in small concentration and the result is noted as a trace.

X1.7 Moisture Content

X1.7.1 Since prevailing moisture content is extremely important to all soil corrosion, every effort must be made to determine this condition. It is not proposed, however, to determine specific moisture content of a soil sample, because of the probability that content varies throughout the year, but to question local authorities who are able to observe the conditions many times during the year. (Although mentioned in X 1.3, this variability factor is being reiterated to emphasize the importance of notation.)

X1.8 Soil Description

X1.8.1 In each investigation, soil types should be completely described. The description should include color and physical characteristics, such as particle size, plasticity, friability, and uniformity. Observation and testing will reveal whether the soil is high in organic content; this should be noted. Experience has shown that in a given area, corrosivity may often be reflected in certain types and colors of soil. This information is valuable for future investigations or for determining the most likely soils to suspect. Soil uniformity is important because of the possible development of local corrosion cells due to the difference in potential between unlike soil types, both of which are in contact with the pipe. The same is true for uniformity of aeration. If one segment of soil contains more oxygen than a neighboring segment, a corrosion cell can develop from the difference in potential. This cell is known as a differential aeration cell.

X1.8.2 There are several basic types of soil that should be noted: sand, loam, silt, clay, muck. Unusual soils, such as peat or soils high in foreign material, should also be noted and described.

X1.9 Potential Stray Direct Current

X1.9.1 Any soil survey should include consideration of possible stray direct current with which the gray or ductile cast iron pipe installation might interfere. The widespread use of rectifiers and ground beds for cathodic protection of underground structures has increased the potential of stray direct current. Proximity of such cathodic protection systems should be noted. Among other potential sources of stray direct current are electric railways, industrial equipment, including welding, and mine transportation equipment. Normally, the amount of stray current influence from cathodic protection systems on an electrically discontinuous ductile iron pipeline will be negligible. It is not detrimental to the expected life of the system, unless the pipeline comes close to an impressed current cathodic protection anode bed where the current density is high. When ductile iron pipelines are exposed to high density stray current environments, the pipeline should be rerouted or the anode bed relocated. If neither of these options is feasible, the ductile iron pipe in this area should be electrically bonded together, electrically isolated from adjacent pipe, polyethylene encased, and appropriate test leads and “current drain” installed.

X1.10 Experience with Existing Installations

X1.10.1 The best information on corrosivity of soil with respect to ductile iron pipe is the result of experience with this material in the area in question. Every effort should be made to acquire such data by questioning local officials and, if possible, by actual observation of existing installations.

X1.11 Soil-Test Evaluation

X1.11.1 Using the soil-test procedures described herein, the following tests are considered in evaluating corrosivity of the soil: resistivity, pH, redox potential, sulfides, and moisture. For each of these tests, results are categorized according to their contribution to corrosivity. Points are assigned based on experience with ductile iron pipe. When results of these five test observations are available, the assigned points are totaled. If the sum is equal to ten or more, the soil is corrosive to ductile iron pipe and protection against exterior corrosion should be provided. This system is limited to soil corrosion and does not include consideration of stray direct current. Table X1.1 lists points assigned to the various test results.

X1.12 General

X1.12.1 These notes deal only with ductile iron pipe, the soil environment in which they will serve, and methods of determining the need for polyethylene encasement.

X1.13 Uniquely Severe Environments

X1.13.1 Research and experience has shown that polyethylene encasement alone is a viable corrosion protection system for ductile and gray iron pipe in most environments. However, other options should be considered for environments where all the following characteristics co-exist: (1) soil resistivity $\leq$500 ohm-cm; (2) anaerobic conditions in which sulfate reducing bacteria thrive {neutral pH (6.5 to 7.5), low or negative redox-potential (negative to +100 mV), and the presence of sulfides (positive or trace)}; and (3) water table intermittently or continually above the invert of the pipe.