Designation: G218 – 19

Standard Guide for External Corrosion Protection of Ductile Iron Pipe Utilizing Polyethylene Encasement Supplemented by Cathodic Protection[1]

This standard is issued under the fixed designation G218; 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 guide will discuss standard practices which have been successfully utilized in the field for over 35 years to provide external corrosion protection of polyethylene encased ductile iron pipe supplemented with cathodic protection (CP). This guide may also be used for ductile iron fittings, valves, and other appurtenances specific to ductile iron pipe systems. Case histories and publications reporting on the use of cathodic protection to supplement polyethylene encasement are included as an Appendix in this guide.

1.2 Other external corrosion control methods which have been used for ductile iron pipe include, but are not limited to: cathodic protection, metallic zinc coatings, bonded dielectric coatings, dielectric coatings with cathodic protection, and trench improvement. Detailed information on these methods of protection are available from other sources and are beyond the scope of this guide.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 The most recent version of the following documents should be consulted as references by those using this guide:

2.2 *ASTM Standards:*[2]

A674 Practice for Polyethylene Encasement for Ductile Iron Pipe for Water or Other Liquids

A746 Specification for Ductile Iron Gravity Sewer Pipe

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

D1709 Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method

D1922 Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method

D4976 Specification for Polyethylene Plastics Molding and Extrusion Materials

G51 Test Method for Measuring pH of Soil for Use in Corrosion Testing

G57 Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

G97 Test Method for Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications

G187 Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method

G193 Terminology and Acronyms Relating to Corrosion

G200 Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil

G215 Guide for Electrode Potential Measurement

2.3 *ANSI/AWWA Standards:*[3]

ANSI/AWWA C105/A21.5 Polyethylene Encasement for Ductile-Iron Pipe Systems

[1] This guide is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.10 on Corrosion in Soils.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

ANSI/AWWA C110/A21.10 Ductile-Iron and Gray-Iron Fittings
ANSI/AWWA C111/A21.11 Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings
ANSI/AWWA C151/A21.51 Ductile-Iron Pipe, Centrifugally Cast, for Water
ANSI/AWWA C600 Installation of Ductile-Iron Mains and Their Appurtenances

2.4 *NACE International Standards:*[4]
SP0169 Control of External Corrosion on Underground or Submerged Metallic Piping Systems
SP0104 The Use of Coupons for Cathodic Protection Monitoring Applications
TM0497 Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
Publication 05107 Report on Corrosion Probes in Soil or Concrete
Publication 10A292 Corrosion and Corrosion Control for Buried Cast- and Ductile-Iron Pipe

2.5 *ISO Standards:*[5]
ISO 8180 Ductile iron pipelines – Polyethylene sleeving for site application
ISO 8179 Part 1 Ductile iron pipes, fittings, accessories, and their joints – External zinc-based coating – Part 1: Metallic zinc with finishing layer

2.6 Various additional publication references related to specific topics discussed in this guide are included as Appendix X1.

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *100 mV criterion*—a specific degree of cathodic polarization between the pipe surface and a stable reference electrode, both in contact with the electrolyte; the degree of polarization can be measured during formation or decay.

3.1.2 *–850 mV criterion*—the degree of polarized potential measured relative to a saturated copper/copper sulfate reference electrode, which is used to verify cathodic protection has been achieved.

3.1.3 *annealing oxide*—a layer of tenacious and complex oxides of iron and silicon formed on ductile iron pipe during the annealing process.

3.1.3.1 *Discussion*—See 5.3 of this guide.

3.1.4 *cathodic protection coupon*—a metal sample representing the pipeline at the site, used for cathodic protection testing, and having a chemical composition approximately the same as the pipe.

3.1.5 *ductile iron pipe*—see Section 5 of this guide.

3.1.6 *enhanced linear low density (ELLD) polyethylene encasement film*—film extruded from virgin linear low density polyethylene raw material with additives designed to control generalized corrosion and microbiologically induced corrosion (MIC).

3.1.7 *ER probe*—an ER (electrical resistance) corrosion measurement probe that has been adapted for use in soil-side applications (also known as SCP – soil corrosion probe).

3.1.8 *free-corrosion coupon (also known as native coupon)*—a coupon that is immersed in the soil or aqueous environment adjacent to the structure but is not connected to the structure.

3.1.9 *high-density, cross-laminated (HDCL) polyethylene film*—film extruded from virgin high-density polyethylene raw material, which is then molecularly oriented by stretching; the final product is then formed by two single-ply layers of the film that are then laminated together with their orientations at 90° to one another using molten, high-density, virgin resin.

3.1.10 *linear low-density (LLD) polyethylene film*—film extruded from virgin linear low-density polyethylene raw material.

3.1.11 *LPR probe*—a linear polarization resistance (LPR) probe which determines the corrosion rate on its metal electrode or electrodes by measuring the polarization resistance under the application of a small applied potential, typically 10 to 20 mV, above the free corroding potential of the electrode or electrodes; the probe elements are generally made of the same or similar material as the structure to be monitored.

3.1.12 *polyethylene encasement*—polyethylene material, in tube or sheet form, that is used to encase ductile iron pipe and fittings for the purposes of corrosion protection or stray current mitigation, or both.

3.1.12.1 *Discussion*—See Section 6 of this guide.

3.1.13 *shopcoat*—the standard external coating for ductile iron pipe as described in ANSI/AWWA C151/A21.5; it consists of a painted coating approximately 1 mil (0.025 mm) thick which is normally applied to the outside of ductile iron pipe and fittings.

3.1.13.1 *Discussion*—See 5.4 of this guide.

3.2 General terminology and acronyms relating to corrosion are defined in Terminology G193.

4. Significance and Use

4.1 This guide provides basic information on the application of cathodic protection to polyethylene encased ductile iron pipe for engineers, owners, water companies, corrosion consultants, ductile iron (DI) pipe manufacturers and others who have an interest in providing underground corrosion protection to ductile iron pipe.

4.2 There are many publications, standards, recommended practices, and specifications for the application of coatings and cathodic protection to steel pipe. However, the metallurgy, chemistry, physical properties, surface composition and texture, coating requirements and electrical continuity of standard production ductile iron pipe are significantly different than those of steel pipe, and coating and cathodic protection specifications written specifically for steel pipe may not be directly applicable to ductile iron pipe. The latest revision of a

[4] Available from NACE International (NACE), 15835 Park Ten Pl., Houston, TX 77084, http://www.nace.org.

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

commonly accepted cathodic protection specification (NACE SP0169) states the following in the forward: "This standard does not include corrosion control methods based on injection of chemicals into the environment, on the use of electrically conductive coatings, or on the use of non-adhered polyethylene encasement (refer to NACE Publication 10A292)." It is the purpose of this guide to summarize publications, case histories, and studies which are available regarding cathodic protection installations of polyethylene encased ductile iron pipe to give the reader guidance on this unique method of protection.

4.3 This guide may be utilized with galvanic or impressed current cathodic protection.

4.4 This guide is written specifically for ductile iron pipe and does not apply to any other type of piping material. It may also be used for ductile iron fittings, valves, and appurtenances specific to ductile iron piping systems.

4.5 This guide references requirements for vendor provided information which should be requested and reviewed by the user.

5. Ductile Iron Pipe (DIP)

5.1 *Metallurgy*—Ductile iron is a novel ferrous product containing approximately 93 % iron (Fe), with sufficient carbon (C) and silicon (Si) to qualify as a eutectiferous material. It has been treated in the liquid state so as to cause the majority of the carbon to occur as substantially equiaxed particles appearing as spheroids or nodules in the as-cast structure of the pipe. Ductile irons can be viewed as a family of alloys which combine the principal advantages of gray cast iron with the engineering advantages of steel; that is, good fluidity, castability, machinability, great strength, toughness, and ductility. Ductile iron pipe is typically specified to meet the minimum requirements of ANSI/AWWA C151/A21.51 and Specification A746.

5.2 *Joints*—Joints are the device by which an essentially leak-free connection is produced between two lengths of ductile iron pipe. The joint may be mechanical, push-on, or restrained, and is typically specified to meet minimum requirements of ANSI/AWWA C111/A21.11. Bolts used for securing mechanical joints are also typically specified to conform to the requirements of the same standard, and pipe with other types of joints specified to comply with the joint dimensions and weights agreed upon at the time of purchase.

5.3 *Annealing Oxide*—Modern production practices for ductile iron pipe include an annealing heat treatment to allow the material to achieve the optimum balance of material properties. When iron or steel are heat treated in air an oxide film is formed. Unlike mill scale on carbon steel which flakes away, the annealing oxide on ductile iron pipe exhibits a tenacious layer that adheres to the base metal due to the presence of silicon in the oxide structure. Under burial conditions, pores in the annealing oxide film become plugged by relatively insoluble corrosion products. This oxide film protects the underlying metal as long as the oxide layer is protected from the introduction of other species, like chlorides, which can result in partial dissolution of the oxide. Intact polyethylene encasement of the pipe resists introduction of chlorides and other compounds from contacting this protective oxide layer on the pipe surface.

5.4 *Shopcoat*—An exterior coating approximately 1 mil (0.025 mm) thick is normally applied on the outside of ductile iron pipe and fittings. AWWA and ASTM specifications call for the finished coating to be continuous, smooth, and strongly adherent to the pipe. While primarily applied for esthetic purposes, studies have shown asphaltic and other shopcoats do offer limited corrosion protection in conjunction with the annealing oxide and have been shown to reduce current requirements on CP systems (X1.2, X1.18). Shopcoats have also been shown to be compatible with metallic zinc coatings on ductile iron pipe, and have been reported to improve the life and performance of these coatings (X1.3).

5.5 *Metallic Zinc Coating*—Prior to the application of the shopcoat, a metallic zinc coating is sometimes applied to the exterior of ductile iron pipe for external corrosion protection. It is normally applied in accordance with ISO 8179 Part 1 utilizing arc spray or flame spray methods. The metallic zinc coating is typically applied on top of the inherent annealing oxide layer on ductile iron pipe. In severely corrosive soils, metallic zinc coating is normally utilized in conjunction with polyethylene encasement, or an enhanced polyethylene encasement, and may be used with or without additional external cathodic protection (X1.5).

6. Polyethylene Encasement

6.1 *Description and Properties:*

6.1.1 *General Description*—Polyethylene encasement has been the primary asset preservation method utilized for gray and ductile iron pipe since 1958. In the 60+ years of use, over 300 million feet of iron pipe have been installed with polyethylene encasement and over 300 miles of encased pipe installed with supplemental cathodic protection (X1.1, X1.5).

6.1.2 *Mechanisms of Protection:*

6.1.2.1 Polyethylene encasement is an engineered corrosion control system for ductile iron pipelines. The film is manufactured using specially designed virgin material with specific minimum thickness and mechanical requirements, for example, tensile strength, elongation, propagation tear resistance, impact resistance, and dielectric strength, which are specified in national and international standards. In those standards, recycled polyethylene is specifically proscribed from use in the manufacture of the film. Protection is achieved by encasing the pipe with a tube or sheet of loose polyethylene at the trench during the pipe installation process. Once installed, polyethylene encasement acts as an unbonded film, which prevents direct contact of the pipe with the corrosive soil. It also limits the electrolyte available to support corrosion activity to the moisture that might be present in the thin annular space between the pipe and wrap. Although polyethylene encasement is not a watertight system, in typical installations, the weight of the earth backfill and surrounding soil after installation normally prevents any significant exchange of groundwater between the wrap and the pipe (X1.1). Although some groundwater will typically seep beneath the wrap, the water's corrosive characteristics are depleted by initial corrosion