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Contents

Foreword

This guideline is established according to the requirements of *Notice on Issuance of Plan for Development of Electric Power Industry Standards in 2005* issued by the General Office of National Development and Reform Commission (Fagaibangongye [2005] No.739).

There are many underground steel structures buried in the plant areas of electric power projects. Due to the complex soil conditions, these underground steel structures are subject to corrosion of varying degrees, and, are severely corroded in some projects. Despite this, no technical code for anti-corrosion design, construction and operation management of underground steel structures of power projects is available in China to date. It is essential, therefore, to establish the technical guideline for anti-corrosion of underground steel structure.

Appendix A to this guideline is normative.

Appendices B, C and D to this guideline are informative.

This guideline is proposed by China Electricity Council.

This guideline is interpreted and managed by Technical Committee on Electric Power Planning and Engineering of Standardization Administration of Power Industry.

This guideline is drafted by Central Southern China Electric Power Design Institute of China Power Engineering Consulting Group and China Power Engineering Consulting Group Corporation.

The participants in development of this guideline also include Luoyang Ship Material Research Institute of China Shipbuilding Industry Corporation and Marine Chemical Research Institute.

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This guideline is translated by SUNTHER Translation & Solutions under the authority of China Electric Power Planning & Engineering Association.

The opinions and suggestions proposed during the implementation of this guideline are to be referred to the Standardization Center of China Electricity Council at the following address: No. 1 Ertiao Lane, Baiguanglu Rd., Beijing 100761 China.

1 Scope

This guideline specifies the technical requirements for the anti-corrosion of underground steel structures in power projects.

This guideline is applicable to design, construction, acceptance and management of anti-corrosion works of buried steel pipes and earthing grid in power plants and AC substations. It can also be used as a reference standard for anti-corrosion of other underground steel structures.

2 Normative References

The following documents contain provisions which through reference in this text, constitute provisions of this guideline and the version thereof in force at the time of publication of this guideline shall be deemed effective. All the standards indicated below are subject to revision and parties using these guidelines are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

GBZ1 *Hygienic Standards for the Design of Industrial Enterprises*

GBJ87 *Specifications for Design of Noise Control System in Industrial Enterprises*

GB/T 4950 *Sacrificial Anode of Zn-Al-Cd Alloy*

GB 6514 *Safety Code for Painting—Safety, Ventilation and Air Clean-up for Painting Process*

GB/T 7388 *Technical Requirements for Marine Auxiliary Anode*

GB/T 8923 *Rust Grades and Preparation Grades of Steel Surfaces before Application of Paints and Related Products*

GB/T 17731 *Magnesium Alloy Sacrificial Anode*

SY/T 0017 *Standard of DC Drainage Protection for Buried Steel Pipelines*

SY/T 0019 *Design Specification of Sacrificial Anode for Buried Steel Pipeline*

SY/T 0023 *Test Method for Cathodic Protection Parameters of Buried Steel Pipelines*

SY/T 0032 *Standard for AC Influence Drainage Protection of Buried Steel Pipeline*

SY/T 0036 *Design Specification of Impressed Current Cathodic Protection for Buried Steel Pipeline*

SY/T 0063 *Standard Test Methods for Holiday Detection in Pipeline Coatings*

SY/T 0086 *Electricity Insulation Standard for Cathode Protection Pipeline*

SY/T 0096 *Technical Specification of Impressed Current Deep Groundbeds*

SY/T 0315 *Technological Standard of External Fusion Bonded Epoxy Coating for Steel Pipeline*

SY/T 0413 *Technical Standard of Polyethylene Coating for Buried Steel Pipeline*

SY/T 0414 *Technical Standard of Polyethylene Tape Coating for Steel Pipeline*

SY/T 0447 *Standard of Coal Tar Epoxy Coating for Buried Steel Pipeline*

SY/T 0516 *Technical Code for Insulating Flange Design*

SY/T 6151 *Assessment of Corroded Steel Pipelines*

3 Terms and Definitions

The following terms and definitions apply to this standard.

3.0.1

Corrosion

A physical-chemical interaction between metals and ambient medium, resulting in the change of the property of metals, and damages to metals, environment or the function of technical systems consisting of metals and ambient medium.

3.0.2

Corrosion rate

Mass loss of metals caused by corrosion within a unit period of time, usually expressed in mm/a or g/(m^2 • h).

3.0.3

Corrosion potential

Potential of a metal being an electrode in a special field corrosion system.

3.0.4

Self-corrosion potential

Potential of a metal being an electrode without net current flows into and out of its surface.

3.0.5

Coating

Layers of insulation material applied on the surfaces of steel structures and the accessories thereof to separate them from the corrosive environment physically.

3.0.6

Holiday

Physical discontinuity point of the coating.

3.0.7

Cathodic protection

An electrochemical protection method whereby the corrosion potential is reduced in order to decrease the corrosion rate of the protected object obviously.

3.0.8

Sacrificial anode

A metal component which constitutes an anode with lower potential when it is coupled with a protected object being the cathode to form an electrochemical cell and this anode will dissolve to discharge negative current to protect the cathode.

3.0.9

Cathodic protection with sacrifice

An electromechanical protection method whereby a metal component being the sacrificial anode is coupled with a protected object being the cathode and protect the cathode by supplying negative current to it.

3.0.10

Impressed current cathodic protection

An electromechanical protection method whereby an external power supply is employed to supply negative current to a protected object being the cathode thereby protects it.

3.0.11

Impressed current anode

An electrode used in an impressed current cathodic protection system that is connected to the positive pole of an external power supply and is conductive in the cathodic protection circuit so as to form a complete current loop.

3.0.12

Reference electrode

An electrode that has a stable and repeatable potential and serves as an electromechanical half-cell of the measuring cell when measuring the potential of a protected object or other electrodes and is considered as the reference for measurement of electrode potential.

3.0.13

Polarization

A phenomenon where the potential of an electrode drifts as a result of net current flowing between metals and electrolyte.

3.0.14

Cathodic polarized potential

Potential at the interface between the metal and electrolyte under the condition of cathodic polarization, being equal to self corrosion potential plus actual polarization potential.

3.0.15

Degree of cathodic protection

A percentage for expressing the reduction in corrosion damage of the metals by using cathodic protection measures. It is one of the basic parameters for measuring the effectiveness of cathodic protection.

3.0.16

Stray current

Current that flows out of the normal circuit and into unspecified circuit.

3.0.17

Stray-current corrosion

An electrolytic corrosion of metals caused by stray current.

3.0.18

Interference

Harmful impact on a protected system due to the action of stray current or induced current.

3.0.19

Electrical drainage protection

A protection method whereby the stray current is drained out of a protected object or prevented from entering into pipes electrically or physically in order to avoid corrosion caused by stray current.

3.0.20

Cathodic protective potential

A potential at which a protected cathode is polarized through negatively shifting its potential from the self-corrosion potential under the action of the cathodic protective current, with a goal of achieving the cathodic protection.

3.0.21

IR drop

A voltage drop across the resistance in the cathodic protective potential circuit that is calculated in accordance with Ohm's law.

4 General Requirements

4.0.1 The underground steel structures of electric power projects shall be provided with anti-corrosion measures, which shall have a service life comparable to the design life of the power projects.

4.0.2 The anti-corrosion measures for the underground steel structures in electric power projects shall be determined by taking into account the factors described below, in addition to the importance of the pipes and earthing grid in the power projects:

1 Environmental corrosion factors.

1) The corrosivity of the medium existing in the environment;

2) The corrosion rate of materials for the underground steel structures in the soil;

3) The conditions of the neighboring underground steel structures and the interaction between them;

4) The source of stray current that has interference on the underground steel structures and the degree of the effects.

2 Technical and economic factors.

1) The expected service life and maintenance costs of the underground steel structures;

2) The direct and indirect costs caused by leaks of underground steel structures due to corrosion;

3) The costs of the works carried out to protect the underground steel structures from corrosion.

3 Environmental protection factors.

1) The effects on the human health and environment caused by the anti-corrosion system of the underground steel

structures;

2) The geographical features, traffic condition and population density at the place where the underground steel structures are buried;

3) The effects on the soil and water environment caused by the anti-corrosion system.

4 Materials factors.

1) The material, diameter, wall thickness and weight of unit length of the steel pipes;

2) The material, size and weight of unit length of the grounding material;

3) The diameter, wall thickness, material or weight of unit length of the sleeves employed; the material of insulation blocks laid between the pipes and sleeves and the sealing material used at the end of the sleeves.

4.0.3 The underground steel structures of power projects are distributed extensively and are joined with other metal structures, which presents a complex situation. As a result, the materials and quantity of the steel structures shall be censused comprehensively and the connection between them and other steel structures shall be fully considered in order to take anti-corrosion measures correspondingly.

4.0.4 The anti-corrosion measures for underground steel structures of power projects shall be determined with reference to the implementation, operation and test results of the anti-corrosion works for pipes and earthing grid in similar environment.

5 Corrosion Assessment

5.1 Assessment of Environmental Corrosion

5.1.1 Assessment of Soil Corrosivity

1 The soil corrosivity shall be assessed by testing the corrosion current density and the average corrosion rate of the metal materials in the soil. The relation between the average corrosion rate of the carbon steel and soil corrosivity is shown in Table 5.1.1-1.

Table 5.1.1-1 Average Corrosion Rate of the Carbon Steel and Soil Corrosivity

Soil corrosivity	Extremely weak	Relatively weak	Weak	Moderate	Strong
Corrosion current density $\mu A/cm^2$	<0.1	0.1–3	3–6	6–9	>9
Average corrosion rate $g/(dm^2 \cdot a)$	<1	1–3	3–5	5–7	>7

2 The corrosivity of the soil in ordinary areas shall be assessed in terms of the soil resistivity. The relation between the soil resistivity and corrosivity is shown in Table 5.1.1-2.

Table 5.1.1-2 Soil Resistivity and Corrosivity

Soil corrosivity	Weak	Moderate	Strong
Soil resistivity $\Omega \cdot m$	>50	20–50	<20

3 Where there is microbiological corrosion in the soil, the soil corrosivity shall be assessed in terms of the soil redox potential. The relation between the redox potential and soil corrosivity is shown in Table 5.1.1-3.

Table 5.1.1-3 Redox Potential and Soil Corrosivity

Soil corrosivity	Weak	Moderate	Relatively strong	Strong
Redox potential mV	＞400	200–400	100–200	＜100

4 The soil corrosivity shall also be assessed in terms of the soil pH value. The relation between the soil pH value and corrosivity is shown in Table 5.1.1-4.

Table 5.1.1-4 Soil pH Value and Corrosivity

Soil corrosivity	Weak	Moderate	Strong
Soil pH value	6.5–8.5	4.5–6.5	＜4.5

5.1.2 Corrosivity of the Transferred Water

1 Seawater is a highly corrosive medium in which the dielectric medium dominated by sodium chloride (NaCl) accounts for 3.5%. At the sea outfall, seawater is characterized by a salt content of 1%–3%, pH value of 8.1–8.3 and the surface oxygen content as high as 8g/l, presenting the nature of typical oxygen depolarization electrochemical corrosion.

2 Fresh water used for cooling is mainly sourced from rivers, lakes and ground water. It has a salt content varying from 0.01% to 0.5%, a conductivity in the range of 100μs/cm–1000μs/cm and a pH value of 6.5–7.5. After being spraying cooled and recycled, the

cooling water is saturated with oxygen with an oxygen content of more than 8g/l.

5.1.3 DC Interference

1 The extent to which the pipes are interfered by DC current shall be assessed by the forward shift of pipe-to-soil potential or the soil potential gradient.

2 Where the forward shift of pipe-to-soil potential with respect to the natural potential at any point of the pipes exceeds 20mV or the soil potential gradient in neighboring area is beyond 0.5mV/m, it can be confirmed that the pipes are interfered by DC current. Generally, the interference degree can be assessed in terms of soil surface potential gradient. Refer to Table 5.1.3-1 for details.

Table 5.1.3-1 Indices for Assessment of DC Interference Degree

Degree of stray current interference	Small	Moderate	Large
Soil surface potential gradient mV/m	＜0.5	0.5–5.0	＞5.0

3 Where the forward shift of pipe-to-soil potential with respect to the natural potential at any point of the pipes exceeds 100mV or the soil potential gradient in neighboring area is beyond 2.5mV/m, the DC drainage protection or other protective measures shall be taken.

5.1.4 AC Interference

The extent to which the buried pipes are interfered by AC current may be assessed in terms of the AC interference potential in accordance with the indices shown in Table 5.1.4-1.

Table 5.1.4-1 Indices for Assessment of AC Interference to Buried Steel Pipes

Category of Soil	Degree of Severity (Level)		
	Weak	Moderate	Strong
	Assessment indices V		
Alkali soil	＜10	10–20	＞20
Neutral soil	＜8	8–15	＞15
Acid soil	＜6	6–10	＞10

5.2 Assessment of Corrosion Damage of Pipes

5.2.1 The corrosion damage of the pipes shall be assessed qualitatively in terms of the maximum corrosion pit depth in accordance with the standard SY/T 6151. The indices for assessment of corrosion damage degree of the pipes shall be as shown in Table 5.2.1-1.

Table 5.2.1-1 Assessment of Corrosion Damage Degree of Pipes

Index	Grade				
	Mild	Moderate	Serious	Very serious	Perforating
Maximum corrosion pit depth	＜1mm	1mm–2mm	2mm–50% of the wall thickness	(50%–80%) wall thickness	＞80% of the wall thickness

5.2.2 The corrosion rate of steel pipes shall be assessed in terms of two indices, namely, the maximum pitting corrosion rate or the corrosion perforation period, whichever is the severer. The indices for assessment of levels of corrosion rate of steel pipes shall be as shown in Table 5.2.2-1.

Table 5.2.2-1 Assessment of Levels of Corrosion Rate of Pipes

Item	Mild	Moderate	Serious	Very Serious
Maximum pitting corrosion rate mm/a	＜0.305	0.305–0.611	0.611–2.438	＞2.438
Corrosion perforation period a	＞10	5–10	3–5	1–3

5.3 Assessment of Corrosion of Earthing Grid

5.3.1 The corrosivity of the earthing grid is assessed with the mass loss method through measuring the change in the mass of a steel sample before and after being corroded by corrosive medium.

The mass loss is calculated by using the formula below:

$$K = (g_0 - g_1) / S_0 t \qquad (5.3.1\text{-}1)$$

Where:

K—the corrosion rate measured by mass loss method, g/(m^2 • h);

g_0—the weight of the steel sample before the earthing grid is put into service, g;

g_1—the weight of the steel sample after the earthing grid is put into service, g;

S_0—the area of the steel sample before the earthing grid is put into service, m^2;

t—duration of earthing grid corrosion, h.

5.3.2 The thickness method is employed to assess the corrosivity of the earthing grid. Based on the results derived from the mass loss method, the thickness method is employed to assess the corrosivity of grounding network earthing grid, with the assessment indices as shown in Table 5.3.2-1.

The formula below is employed in the thickness method:

$$K_h = K \times 24 \times 365 / 1000d = 8.76K / d \qquad (5.3.2\text{-}1)$$

Where:

K_h —the corrosion rate measured by the thickness method, mm/a;

K—the corrosion rate measured by mass loss method, g/(m^2 • h);

d —the density of the metal, kg/m^3.

Table 5.3.2-1 Assessment of Corrosivity with the Thickness Method

Corrosion Rate mm/a	Assessment of Corrosion Resistance
⩽ 0.05	Excellent
0.05–0.5	Good
0.5–1.5	acceptable
⩾ 1.5	Anti-corrosion measures required

6 Anti-corrosion of Buried Steel Pipes in Electric Power Projects

6.1 General Requirements

6.1.1 Where seawater is used as cooling water, the buried steel pipes delivering circulating water shall be protected against corrosion by using a combination of application of anti-corrosion coating and cathodic protection. Also, measures for preventing seawater from pollution shall be taken.

6.1.2 If the soil resistivity of areas where pipes are newly laid is less than 20Ω • m, then the buried steel pipes shall be protected against corrosion by using a combination of application of anti-corrosion coating and cathodic protection.

6.1.3 For steel pipes buried in areas where they suffer from interference corrosion, the measures for current drainage shall be taken to prevent them from the interference.

6.1.4 Considering that the buried steel pipes will get rusty during long-term operation and there are manufacturing errors, the wall thickness value of Q235 and Q345 steel pipes to be used shall be respectively 2mm and 1mm larger than that derived from structural calculation.

6.2 Surface Treatment of Buried Steel Pipes

6.2.1 Prior to being subjected to anti-corrosion treatment, the steel pipes shall have the metal surface treated in order to remove the moisture, oil, dirt, pollutant, rust and oxide scales thereon, thereby improving the quality and application of painting.

6.2.2 Surface Treatment Methods of Steel Pipes

1 The commonly-used methods for surface treatment of steel pipes include mechanical derusting (including manual, power tool, high pressure water and sand blasting derusting) and chemical derusting.

2 Manual derusting: the rust on the steel pipe surface is removed manually by using scraper, abrasive cloth, wire brush and file. This method is applicable to the locations with less stringent requirement for anti-corrosion and the locations requiring field joint coating.

3 Power tool derusting: the rust on the steel pipe surface is removed by using tools such as power wire brush, power sandpaper disk or grinding wheel. This method is applicable to remove burrs, welding beadings and rough welding seams.

4 High pressure water derusting: the rust is removed by using water spraying with high pressure water jet. Being a new environment-friendly and cost-effective surface treatment method, it is particularly applicable to maintenance of painting system. This method, however, shall not result in certain roughness, otherwise flash rusting will take place.

5 Sand blasting derusting: sand or steel shots are ejected towards surfaces of steel pipes through a nozzle by compressed air at a pressure of 0.4MPa–0.6MPa. With the impact and friction of sand or steel shots ejected at a high speed, the rust, oil, dirt, oxide scales and other foreign matters on the steel pipe surface are completely removed to yield a rough surface exposing the natural metal color. Due to its high efficiency, derusting speed and good quality, this method is most commonly used for surfaces derusting.

6 Chemical Derusting.

1) Acid pickling derusting: inorganic acid or organic acid is used to react with oxide scales and rust on the steel pipe surface to generate soluble ferric salt, which is then removed from the steel pipe surface.

2) Phosphate treatment: a solution dominated by phosphate is used to treat the steel pipe surface to form a crystallized phosphate film that is insoluble in water, which mainly functions to protect the steel pipe surface and prevent the steel pipes from corrosion, or to serve as the primer before application of painting in order to increase the adhesion and anti-corrosion of paint film.

6.2.3 Surface Treatment Grade of Steel Pipes

1 Refer to GB/T 8923 for quality control of derusting of the surface of steel pipes.

2 The original rusting degree of unpainted steel pipe surfaces falls into four classes, respectively Class A, B, C and D:

Class A—The steel surface is thoroughly covered by a layer of oxide scales without rust almost;

Class B—The steel surface has got rusted, and part of oxide scales have peeled off;

Class C—The oxide scales on steel surfaces have peeled off due to rusting, or can be scraped off, with some corrosion attacks left;

Class D—The oxide scales on steel surfaces have peeled off entirely due to rusting, and corrosion attacks appear over a large area.

3 The quality grades of steel pipe surface treatment shall comply with the following requirements:

1) Derusting manually or by using power tool: the quality grades of metal surface treatment can be divided into two grades designated as St2 and St3. Refer to Appendix

A.1 for quality grades of derusting.

2) Blasting derusting: the quality grades of metal surface treatment can be divided into four grades designated as Sa1, Sa2, Sa2.5 and Sa3. Refer to Appendix A.2 for quality grades of derusting. The minimum requirement of steel pipe surface treatment is to reach industrial grade (Sa2), with a value of surface roughness ranging from 40μm to 50μm.

3) Chemical derusting: the quality grade of metal surface treatment is determined to be one grade and designated as Pi.

6.2.4 Time Limit of Painting after Surface Treatment

Once the steel pipe surface is treated, they shall be inspected as soon as possible in accordance with the criteria described in Article 6.2.3. After the surface treatment is acceptable, the surface painting must be carried out within four hours of the surface treatment.

6.3 Coating Anti-corrosion

6.3.1 General Requirements

1 Property of Painting Material and Coating

The paint selected shall have excellent performance and shall be suitable for the service environment of steel pipes and economical efficiency.

The property of paint involves the viscosity, density, covering, solid content, leveling property and aridity of paint. Before use, the paint shall be sampled and tested for the above indicators, and the test report issued by legal inspection authorities shall be provided. The supplier of paint shall provide the technical information such as product specifications and factory certificates.

Refer to the related standards in Appendix B.1 for tests of the property of paint.

Property of coating includes the thickness, adhesion, flexibility, shock resistance, abrasive resistance, heat and humidity resistance, salt spray resistance and weather resistance.

Refer to the related standards as listed in Appendix B.2 for tests of the property of coating.

2 All the anti-corrosion materials must comply with the following environmental protection requirements.

The liquid paint shall be free of benzene and shall contain volatile organic compounds (VOC) less than 400g/l;

The raw materials of all paint shall contain no lead, mercury, arsenic and cadmium;

When used with cathodic protection, the corrosion resistance potential of the anti-corrosion primer shall be higher than 1V.

3 For large-bore buried steel pipes, epoxy bituminous paints, modified epoxy, epoxy powder and polyethylene may be used for the anti-corrosion coating.

4 The anti-corrosion coating of steel pipes shall meet the current national standards and the general requirements, including excellent adhesion, corrosion resistance, shock resistance and temperature variation resistance.

6.3.2 Structure Design of Anti-corrosion Coating

1 The following factors shall be considered for structure design of anti-corrosion coating:

1) Soil environment and the delivered medium conditions;
2) Characteristics of steel pipes (including the diameter, material and importance of pipes);
3) Expected service life of steel pipe structure;
4) Construction environment and conditions of steel pipes

(construction season, factory painting, field painting and repair and maintenance);

5) Field coating repaired conditions;

6) Economic efficiency of anti-corrosion coating and the coordination between anti-corrosion coating and cathodic protection.

2 Structure Design of Anti-corrosion Coating

The anti-corrosion coating of steel pipes may be classified into three grades: ordinary, intensified and specially intensified. The grade of anti-corrosion coating shall be determined in accordance with section 5.1 and 6.1 of this guideline based on the service environment and importance of steel pipes.

1) Anti-corrosion coating on inner wall of steel pipes

Refer to Table 6.3.2-1 for anti-corrosion coating on inner wall of seawater delivering pipes.

Refer to Table 6.3.2-2 for anti-corrosion coating on inner wall of freshwater delivering pipes.

Table 6.3.2-1 Selection of Anti-corrosion Coating on Inner Wall of Seawater Delivering Pipes

Paint	Structure grade of Coating	Anti-corrosion Coating Composition	Thickness of Dry Film/Courses of Paints
Epoxy bituminous paints	Specially intensified	Workshop primer paint (may be omitted)	20μm/1 course
		Anti-corrosion primer paint	160μm/2 courses
		MIO epoxy intermediate layer	80μm/1 course
		Antifouling surface paint	240μm/3 courses
Note: Use epoxy bituminous paints surface paint in cases where pollution is prevented through electrolyzing seawater or supplying chlorine.			

Table 6.3.2-2 Selection of Anti-corrosion Coating on Inner Wall of Freshwater Delivering Pipes

Paints	Anti-corrosion Grade of Coating	Coating Composition	Total Thickness of Dry Film
Epoxy bituminous paints	Ordinary	One course of primer and three courses of surface paint	⩾300μm
	Intensified	Two courses of primer paint surface paint	⩾400μm
	Specially intensified	Two courses of primer and four courses of surface paint	⩾450μm
Modified epoxy paints	Intensified	One course of primer and one course of surface paint	⩾400μm
	Specially intensified	One course of primer and two courses of surface paint	⩾600μm
Note 1: As an alternative for epoxy bituminous paints, high-solid modified epoxy paints are more environment-friendly. The dry film of a single course of this paint after being applied has a thickness as large as 150μm–300μm. Note 2: If the freshwater delivered through steel pipes is potable water, then the paint shall be certified by the Ministry of Health of the People's Republic of China, accompanied by a certificate of "Sanitary License of Products relating to Sanitary Safety of Potable Water".			

2) Anti-corrosion coating on outer wall of steel pipes

When epoxy bituminous paints or modified epoxy paints are used for anti-corrosion layer on outer wall of steel pipes, refer to Table 6.3.2-3 for the coating composition.

Table 6.3.2-3 Selection of Coating on Outer Wall of Steel Pipes

Paints	Anti-corrosion Grade of Coating	Coating Composition	Thickness of Dry Film, μm
Epoxy bituminous paints	Ordinary	One course of primer and three coats of surface paint	⩾300
	Intensified	One course of primer and two coats of surface paint, and one layer of cloth and two courses of surface paint	⩾400

Table 6.3.2–3 (continued)

Paints	Anti-corrosion Grade of Coating	Coating Composition	Thickness of Dry Film, μm
Epoxy bituminous paints	Specially intensified	One course of primer and two coats of surface paint, and one layer of cloth and two courses of surface paint, and one layer of cloth and two courses of surface paint	⩾600
Modified epoxy paints	Specially intensified	One course of primer and two courses of surface paint	⩾500

Alternatively, epoxy powder coating may be used for anti-corrosion of outer wall of steel pipes. In the case of outer epoxy powder coating, the paint film shall be formed at one attempt, with the technical indicators in compliance with the regulations of the standard SY/T 0315, and the thickness and grade of it shall comply with Table 6.3.2-4.

Table 6.3.2–4 **Selection of Coating on Outer Wall of Steel Pipes**

Paints	Anti-corrosion Grade	Total Thickness, μm	Anti-corrosion Coating Composition
Epoxy powder paints	Ordinary	300–400	Film forms at one attempt
	Intensified	400–500	Film forms at one attempt

3 The grade and performance requirements of anti-corrosion coating on steel sleeves and pipe fittings shall not be inferior to that on the pipe body.

4 Where glass fiber cloth is used for the reinforced base cloth of anti-corrosion coating, the glass fiber cloth reel characterized by a thread count of (10 × 10) threads/cm^2, a thickness of 0.10mm–0.12mm, medium alkali (the contents of alkali being no more than 12%), twist-free, plain textures, sealing along both sides thereof and a

mandrel should be used.

6.3.3 Application of Epoxy Bituminous Anti-corrosion Coating

1 Primer shall be applied as soon as possible after satisfactory treatment of steel pipe surface. If the air humidity is excessively high, primer must be applied without delay.

2 At either end of the steel pipe, a section with a length of 100mm–150mm shall be reserved without primer coating, or applied with weldable coating such as zinc silicate paint prior to application of primer. The thickness of which shall not be less than 25μm.

3 The primer coating is required to be evenly applied and free of holiday, air bubbles and clot, the thickness of which shall be no less than 25μm.

4 Where glass fiber cloth is applied as the reinforced base cloth for anti-corrosion coating on outer wall of steel pipes, after the surface of the primer coating is dried, putty shall be smeared on both sides of the welds which are 2mm higher above the surface of steel pipes to form a smooth transition surface.

5 Putty is prepared by mixing evenly the finish coat containing the prepared solidifying agent with talcum powder. No diluent agent shall be added during such mixture. The prepared putty should be used up within four hours.

6 The first course of surface paint shall be applied after the surface of primer coating or putty is dried and before it is cured. The first course of surface paint is required to be applied evenly without any holiday.

7 For anti-corrosion coating of ordinary grade, each coat of surface paint shall not be applied until the preceding coat is dried and cured. Repeat the process until a specified number of coats are applied.

8 For anti-corrosion coating of intensified grade, the second coat of surface paint shall not be applied until the first coat is dried and cured, followed by immediate wrapping of glass fiber cloth thereon. Glass fiber cloth shall be tensioned to present a flat surface free from any wrinkle and bulge. The glass fiber cloth shall be overlapped by a width of 20mm–25mm and shall be overlapped by a length of 100mm–150mm at the end of the cloth. After wrapping the glass fiber cloth, the third coat of surface paint shall be fully applied instantly in sufficient quantity so that all meshes left at the glass fiber cloth shall be filled with paint. The same process is applicable to the forth coat of surface paint.

9 In the case of anti-corrosion coating of specially intensified grade, the operation shall be carried out in accordance with Clause 8 of this section. On the basis of the process in respect of intensified anti-corrosion coating, the application of one layer of cloth and two coats of surface paint is necessary.

6.3.4 Requirements on Application of Anti-corrosion Coating

1 Application of Anti-corrosion Coating at Workshop

1) Steel pipes shall be applied with paint at workshops as practically as possible;

2) The application of anti-corrosion coating shall be carried out strictly in accordance with the relevant work process under controlled environmental conditions;

3) The exposed surface of the reserved steel pipe ends shall be applied with weldable primer paint;

4) If the last course of paint requires field touching up, the paint used shall be reapplied;

5) The quality of anti-corrosion coating being applied shall be tested in accordance with the regulations of the

standards SY/T 0447, SY/T 0413, SY/T 0315 and SY/T 0414, in order to ensure the integrity, continuity of the paint and its adhesion with the base materials.

2 Application of Anti-corrosion Coatings on Site

1) The environment suitable for application of paint shall be determined in accordance with the requirements on paint curing;

2) Appropriate surface treatment process shall be chosen to ensure the compliance of surface treatment with the relevant standard;

3) Standards for control of site application and for control of coating quality shall be specified.

6.3.5 Inspection, Storage, Transportation and Installation of Anti-corrosive Steel Pipes

1 Site quality inspection of anti-corrosive steel pipes shall be in accordance with the following requirements.

1) Appearance: the paint shall be free from such defects as air bubbles, breaking, cracks and scaling etc;

2) Thickness: the thickness of dry film is measured by using a thickness gauge at four points along the circumference of a section respectively at the top, bottom, left and right, and the minimum value shall be taken;

3) Cohesive force: it is measured at a point on the circumference of the measured section by using the peeling method;

4) Continuity: the holiday is detected by using an spark detection instrument, and the holiday detection voltage is calculated according to the following formula:

Where the thickness of the anti-corrosion coating exceeds 0.5mm:

$$U=7900\ T^{1/2} \tag{6.3.5-1}$$

Where the thickness is equal to or less than 0.5mm:

$$U=3300\ T^{1/2} \text{ or } 5\text{V}/\mu\text{m} \tag{6.3.5-2}$$

Where:

T —average coating thickness, mm;

U —holiday detection voltage, V.

2 The anti-corrosive steel pipes as inspected should not be stored in open air for a long time. If unavoidable, they shall be reinspected and repaired promptly.

3 For anti-corrosive steel pipes, measures shall be taken to prevent protective coatings from damage during handling, stacking, moving, transporting and laying down in ditches. Special gaskets and rigging bend shall be used. The use of bare steel wire rope is prohibited.

4 Prior to back filling of the ditches, the anti-corrosion coatings shall be checked for integrity and shall have any damages repaired. The repair and field jointing of coating shall be made by using the material compatible with the original coating, the performance of which shall not be inferior to that of the original coating.

5 The bedding at the bottom of pipes and the earth, stone and other hard materials used for back filling around the pipes shall not cause damage to the anti-corrosion coating further.

6.3.6 The application of anti-corrosion coating shall also satisfy the requirements on safety, health and environmental protection.

1 The safety standard control during rust removal and coating application for pipes shall comply with the standard GB 6514.

2 Noises generated by the equipment used for rust removal and coating application for pipes shall comply with the standard GBJ 87.

3 The content of air-borne dust in the process of rust removal and coating application for pipes shall not exceed the value specified

in the standard GBZ1.

4 The electrical equipment disposed in the work areas of rust removal and coating application for pipes shall satisfy the regulations on electrical equipment arranged in explosion endangered areas made by the relevant national codes. Electrical facilities shall be protected against explosion as a whole and the operating parts thereof shall be equipped with electroshock protectors.

5 During the rust removal and coating application for steel pipes, all mechanical facilities shall be equipped with protection devices, such as protective cover, at the rotating and moving parts.

6.3.7 As-built Information to be provided after completion of application of anti-corrosion coating of steel pipes.

1 Summary, application methods and process data of the anti-corrosion works;

2 Ex-factory certificate and quality inspection report of anti-corrosion coatings and adhesive tapes;

3 Quality inspection records of anti-corrosion coating;

4 Re-work records, including re-work locations, reasons, methods, quantities and inspection results;

5 Other relevant data.

6.4 Cathodic Protection

6.4.1 General Requirements

1 Pipes shall be equipped with insulation devices to form cathodic protection uniform systems that are mutually independent.

2 Cathodic protection of pipes may employ such methods as impressed current cathodic protection or cathodic protection with sacrifice.

3 Cathodic protection of pipes shall not cause interference to

the neighboring buried pipes or structures.

4 In the plant areas of electric power projects where buried steel pipes and structures are crowdedly arranged, the method of cathodic protection with sacrifice is generally employed. Where conditions for regional cathodic protection are available, the impressed current cathodic protection using deep-well anode groundbed should be employed.

5 For newly-built pipes, the cathodic protection of them shall be designed, constructed and put into service simultaneously with the pipes.

6 If cathodic protection is applied to pipes in operation, the insulation resistance of the anti-corrosion coatings shall be tested quantitatively.

7 Where the operating pipes with cathodical protection are cut and connected with other pipes, the newly connected pipes shall be cathodically protected as well.

6.4.2 Cathodic Protection Criteria

1 The protection potential of the pipes that are cathodically protected shall be such that:

1) After application of the cathodic protection, the protection potential measured with the reference electrode made of copper or saturated copper sulfate (hereinafter referred to as CSE reference electrode) shall at least reach −850mV or even lower, and effects caused by IR drop must be considered during potential measurement; or

2) The polarization potential of pipes measured with respect to the CSE reference electrode by using current interruption method shall at least reach −850mV or even lower; or

3) When polarization of cathodic protection forms or attenuates,