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Replacing GB/T 2694-2003

Specification of Manufacturing for Transmission Line Tower

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Foreword

This Standard was drafted according to the rules specified in GB/T 1.1-2009.

This Standard replaces GB/T 2694-2003 "Transmission Line Tower - Technical Requirements for Manufacturing".

Compared with GB/T 2694-2003, besides the editorial amendments, the main technical changes of this Standard are as follows:

- The characteristics of the ultra-high voltage (UHV) steel-tower products were fully considered;
- The chapter "Terms, Definitions and Symbols" was added;
- Requirements for materials were added;
- Parts of the items and tolerances were adjusted, added-deleted;
- Index requirements of test assembling were added;
- Inspection requirements were modified.

This Standard was proposed by and shall be under the jurisdiction of China Electricity Council.

Drafting organizations of this Standard: Power Industry Electric Power Installation and Line Material Quality Inspection Test Center, Weifang Chang'an Steel-tower Stock Co., Ltd., Anhui Hong Yuan Iron Tower Co., Ltd., Changshu Fengfan Power Equipment Co., Ltd., Fujian Electric Power Survey & Design Institute, Zhejiang Shengda Steel-tower Co., Ltd., Nanjing Daji Steel-tower Manufacturing Co., Ltd., Yunnan Electric Power Line Equipment Factory, Guangdong Electric Line Appliance Factory AND Chongqing Jiangjin Electric Power Line Component Factory.

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The previous editions replaced by this Standard are as follows:

- GB 2694-1981, GB/T 2694-2003.

Specification of Manufacturing for Transmission Line Tower

1 Scope

This Standard specifies the requirements such as materials, technical requirements, inspection, packing, marking, transportation and storage during the manufacture process of transmission line towers (hereinafter referred to as "steel-tower").

This Standard is applicable to the manufacturing of transmission line towers, electric power microwave towers, electric power communication towers and similar steel structures, of which the elements are manufactured mainly with angle-steel, connected by fasteners, and resistant to corrosion by hot-dip galvanizing.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendment) applies.

GB/T 41 Hexagon Nuts - Product Grade C (GB/T 41-2000, eqv ISO 4034: 1999)

GB/T 95 Plain Washers - Product Grade C (GB/T 95-2002, eqv ISO 7091: 2000)

GB/T 470 Zinc Ingots (GB/T 470-2008, ISO 752: 2004, MOD)

GB/T 699 Quality Carbon Structural Steels

GB/T 700 Carbon Structural Steels (GB/T 700-2006, ISO 630: 1995, NEQ)

GB/T 702 Hot-rolled Steel Bars - Dimensions, Shape, Weight and Tolerances (GB/T 702-2008, ISO 1035-1~4: 1980, MOD)

GB/T 706 Hot Rolled Section Steel

GB/T 709 Dimension, Shape, Weight and Tolerances for Hot-rolled Steel Plates and Sheets (GB/T 709-2006, ISO 7452: 2002, ISO 16160: 2000, NEQ)

GB/T 805 Tight Nuts

GB/T 985.1 Recommended Joint Preparation for Gas Welding, Manual Metal

Arc Welding, Gas-shield Arc Welding and Beam Welding (GB/T 985.1-2008, ISO 9692-1: 2003, MOD)

GB/T 985.2 Recommended Joint Preparation for Submerged Arc Welding (GB/T 985.2-2008, ISO 9692-2: 1998, MOD)

GB/T 1591 High Strength Low Alloy Structural Steels

GB/T 2828.1 Sampling Procedures for Inspection by Attributes - Part 1: Sampling Schemes Indexed by Acceptance Quality Limit (AQL) for Lot-by-lot Inspection (GB/T 2828.1-2003, ISO 2859-1: 1999, IDT)

GB/T 2829 Sampling Procedures and Tables for Periodic Inspection by Attributes (Apply to Inspection of Process Stability)

GB/T 3098.1 Mechanical Properties of Fasteners-Bolts, Screws and Studs (GB/T 3098.1-2000, idt ISO 898-1: 1999)

GB/T 3098.2 Mechanical Properties of Fasteners-Nuts-Coarse Thread (GB/T 3098.2-2000, idt ISO 898-2: 1992)

GB/T 3323 Radiographic Examination of Fusion Welded Joints in Metallic Materials

GB/T 5117 Carbon Steel Covered Electrodes

GB/T 5118 Low Alloy Steel Covered Electrodes

GB/T 5293 Carbon Steel Electrodes and Fluxs for Submerged Arc Welding

GB/T 5780 Hexagon Head Bolts - Product Grade C (GB/T 5780-2000, eqv ISO 4016: 1999)

GB/T 8110 Welding Electrodes and Rods for Gas Shielding Arc Welding of Carbon and Low Alloy Steel

GB 11345 Method for Manual Ultrasonic Testing and Classification of Testing Results for Ferritic Steel Welds

GB/T 12470 Low-alloy Steel Electrodes and Fluxs for Submerged Arc Welding

GB/T 13912 Metallic Coatings - Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles - Specifications and Test Methods (GB/T 13912-2002, ISO 1461: 1999, MOD)

DL/T 764.4 Cold Forging Hot Dip Galvanizing Bolt and Nut for Tower and Hardware of Transmission Lines

JGJ 81 Technical Specification for Welding of Steel Structure of Building

3 Terms, Definitions and Symbols

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

Part

The minimum unit that composes the component or element of steel-tower, e.g. angle-steel and steel plate, etc..

3.1.2

Component

The unit that is composed of several parts, e.g. weldment.

3.1.3

Element

The steel-tower's basic unit that is composed of parts and components by fastening and connecting.

3.1.4

Assembling

The process, of which connecting the parts into component according to the specified accuracy and technical requirements.

3.1.5

Test assembling

The assembling that is carried out with a view to inspecting whether the element or steel-tower meets the design and installation quality requirements.

3.1.6

Hot-dip galvanizing

The technical process and method that dip the pretreated steel and iron articles into the molten liquid zinc to form a zinc and/or zinc-iron alloy layer on surface.

h - Height

h_f - Weld leg size

L - Overall dimension and length

P - Inclination degree and perpendicularity

S - Pitch of holes and end to end distance

t - Thickness of plate (wall)

Z_0 - Gravity center

α - Angle

δ - Increment

4 General Provisions

4.1 The manufacturing and inspection of steel-tower shall meet the requirements of this Standard and the design document; where there is no relevant requirement in this Standard, the requirements of the relevant national and industry standards shall be met.

4.2 Where the design needs to be modified, the consent of the design organization shall be obtained, and the design alteration document shall be signed.

4.3 Where new technique, process or material is adopted, it shall be assessed through test and verification on whether meeting the design and safety requirements.

4.4 Production process of steel-tower shall be carried out in accordance with the laws and regulations of the state relevant to safety, environment and occupational health as well as the requirements of standards.

5 Materials

5.1 Steel

5.1.1 Steels used for manufacturing steel-tower shall be selected according to the specification and grade required in the design document, the quality indexes of steels shall meet the requirements of such standards as GB/T 699, GB/T 700, GB/T 702, GB/T 706, GB/T 709 and GB/T 1591 and the steels shall be provided with the factory quality certificate; the steels shall be used after passing sampling inspection, and the sampling lot and quantity of steels shall meet the requirements of relevant standards. The quality of imported steels shall meet the requirements of the design

and the standards specified in the contract.

5.1.2 The steels shall be with traceable marks. During the manufacturing process, if the original traceable mark is cut apart, the mark shall be relocated before the material is cut apart.

5.1.3 Where there is no special requirements in the design, the dimension, shape, weight and tolerances for hot-rolled steel plates and sheets shall meet the requirements for category N tolerances stated in the current GB/T 709.

5.1.4 Surface quality of steels: the surface shall be free from crack, folding, rolling skin, inclusion and double skin; where there is rust, pockmark or scratch on the surface, its depth shall not be larger than 1/2 of the negative thickness tolerance of this steel; the accumulative error shall be within the range of negative tolerance.

5.1.5 The formed steel shall be free from such burr larger than 5 mm. The surface defects of formed steel may be removed, but transverse removal is disallowed; the removing place shall be smooth without edge or corner. The removing depth shall not be less than 5 times of the removing depth; the dimension of formed steel, after removing surface defects, shall not exceed the negative dimensional tolerance of steels.

5.2 Welding Materials

5.2.1 The quality requirements for the welding materials (welding electrode, welding wire and flux) used for welding element shall meet product standards such as GB/T 5117, GB/T 5118, GB/T 5293, GB/T 8110 and GB/T 12470 as well as the design requirements.

5.2.2 Surface coating of welding electrode shall be without shedding or wetting phenomenon; the surface of welding wire shall be smooth and flat and shall be free from burr, scratch, rust and oxide scale as well as other residues that may impact to the welding property or the operating performance of welding equipment.

5.2.3 Each kind of welding materials shall be carried out with deposition test before the first time use.

5.3 Fasteners

5.3.1 Specification, grade and anti-corrosion type of the fasteners used for steel-tower shall be selected according to the requirements of design document; the product quality shall be in accordance with those specified in GB/T 3098.1, GB/T 3098.2, GB/T 41, GB/T 5780, GB/T 95, GB/T 805 and DL/T 764.4.

5.3.2 The Grade 8.8 or above high strength bolts shall be provided with the conformity certificates of strength and plasticity tests.

- At the time of manual arc welding, the air velocity is greater than 8 m/s;
- At the time of gas shielded welding, the air velocity is greater than 2 m/s;
- The relative humidity is higher than 90%;
- The weldment surface is wet or be covered by ice or snow.

6.6.3.3.3 Where the welding procedure qualification or design document requires requirements on preheating and post-weld heat treatment, the weldment shall be carried out with preheating and post-weld heat treatment according to the requirements; however, under the following conditions, the weldment shall be preheated in all directions at the welding starting position within the range larger than or equal to 2 times of the steel plate thickness but not less than 100 mm:

- When welding the steels below Q345, the environment temperature is less than -10°C;
- When welding the Q345 steels, the environment temperature is less than 0°C;
- When welding the steels above Q345, the environment temperature is less than 5°C.

6.6.3.4 Weld gap shall not be embedded with metal materials.

6.6.3.5 After the welding of Grade I and II welds is completed, the steel seal indicating the welder No. shall be stamped at an obvious position 50 mm away from the weld toe; if the element is welded by one welder independently, the steel seal indicating the welder No. shall only be stamped at an obvious position of this element; it shall also be distinct and visible after galvanizing.

6.6.4 Welding groove

6.6.4.1 Type and dimension of welding groove shall be in accordance with the relevant requirements of GB/T 985.1 and GB/T 985.2. Where the drawing gives special requirements on the groove type and dimension, the groove type and dimension shall be determined according to the drawing and in combination with welding procedure qualification.

6.6.4.2 Welding groove shall be processed by preferring mechanical method and may also be adopted with flame cutting; however, it shall be guaranteed that the weld groove is flat and smooth, and be free from defects such as burr, crack, melted bead by gas cutting, and intercalated layer.

6.6.5 Welding rework

6.6.5.1 Prior to welding rework, the rework procedure and rework technology shall be formulated in accordance with relevant standards and specifications; it shall also

be strictly complied with.

6.6.5.2 The quality control of welding rework shall be the same as that of formal welding operation.

6.6.5.3 The rework times of one same position of weld should not exceed 2. If it exceeds 2 times, the rework times, position and rework conditions shall be embodied in the product acceptance information.

6.6.6 Weld quality

6.6.6.1 Weld appearance quality

6.6.6.1.1 The weld appearance shall meet: uniform shape, good shaping, and smooth transition between weld passes and between weld and base metal.

6.6.6.1.2 Where the weld appearance appears any one of the following conditions, surface nondestructive inspection shall be adopted to inspect defects:

a) Where crack is discovered in appearance inspection, the same class of welds in this batch shall be carried out 100% surface inspection;

b) Where there is doubt of crack in the appearance inspection, the doubtful position shall be carried out with surface inspection;

c) Where the design drawing specifies conducting surface inspection.

6.6.6.1.3 Appearance quality criterion for Grade I, II and III welds shall be in accordance with those specified in Table 5.

Table 5 Quality Grade and Appearance Defect Rating of Welds In: mm

<table>
<tr><td colspan="2">Item</td><td colspan="3">Tolerance</td></tr>
<tr><td colspan="2">Weld quality grade</td><td>Grade I</td><td>Grade II</td><td>Grade III</td></tr>
<tr><td rowspan="6">Appearance defect</td><td rowspan="2">Incompletely filled weld (not meet the design requirements)</td><td rowspan="2">Disallowed</td><td>≤0.2+0.02t and ≤1.0</td><td>≤0.2+0.04t and ≤2.0</td></tr>
<tr><td colspan="2">The total length of defects in every 100.0 mm weld shall be less than or equal to 25.0 mm</td></tr>
<tr><td rowspan="2">Root shrinkage</td><td rowspan="2">Disallowed</td><td>≤0.2+0.02t and ≤1.0</td><td>≤0.2+0.04t and ≤2.0</td></tr>
<tr><td colspan="2">Length is not limited</td></tr>
<tr><td>Undercut</td><td>Disallowed</td><td>≤0.05t and ≤0.5; continuous length ≤100.0 and total length of undercuts on both sides of weld ≤10% of the full length of weld</td><td>≤0.1t and ≤1.0 and the length is not limited</td></tr>
<tr><td>Crack</td><td colspan="3">Disallowed</td></tr>
</table>

6.6.6.3.2 The internal quality of welds that are required in the design to reach Grade I and II shall be inspected by adopting ultrasonic inspection method; the inspection result shall comply with those specified in GB 11345. Where the ultrasonic inspection fails to judge the defects, the radiographic inspection method shall be adopted to inspect the weld internal quality; the inspection result shall comply with those specified in GB/T 3323.

6.6.6.3.3 Where any unallowable defect is discovered in weld flaw inspection, double quantity of supplemental inspections shall be carried out in its extension direction or at the questionable position. If the supplemental inspection is still unqualified, the whole weld shall be inspected.

6.6.6.3.4 If the weld is discovered with over-proof defect in the radiographic or ultrasonic inspection, the defect shall be removed and repair welding shall be conducted; the weld at this part shall be re-inspected by adopting the original inspection method.

6.6.6.3.5 The weld quality grade of Grade I and II and the internal defect rating shall be in accordance with those specified in Table 10. Where the design does not give the weld quality grade, the welds shall be inspected according to the Grade III weld quality.

Table 10 Weld Quality Grade and Internal Defect Rating

Weld quality grade		Grade I	Grade II
Ultrasonic inspection	Rating	I	II
	Inspection grade	Grade B	Grade B
	Flaw inspection proportion	100%	20%
Radiographic inspection	Rating	II	III
	Inspection grade	Grade B	Grade B
	Flaw inspection proportion	100%	20%
Note: The calculation method for flaw inspection proportion shall calculate the percentage according to each weld, and the flaw inspection length shall not be less than 200 mm; where the weld length is less than 200 mm, the whole weld shall be inspected.			

6.6.7 Post-welding stress relieving treatment

Where the weldment needs to be carried out with post-welding stress relieving treatment, the post-welding stress relieving measures shall be determined according to factors such as the chemical composition, welding type and thickness of base metal, the restraint intensity of welded joint and the service conditions of structure.

6.7 Assembling of Weldment

6.7.1 Before assembling, the parts and components shall pass the inspection; the weld groove and the range of 30 mm~50 mm at each weld edge shall be cleared off surface defects that may affect the welding quality, such as iron rust, burr and oil

Table 13 Thickness and Adhesion Amount of Galvanized Coating

Thickness of galvanized part/mm	Minimum thickness value /μm	Minimum average value	
		Adhesion amount/ (g/m^2)	Thickness/ μm
$T \geq 5$	70	610	86
$T < 5$	55	460	65
Note: Where the thickness of galvanized coating is greater than the specified value, the surface of the galvanized article may have non-uniform dark or grayish color.			

6.9.5 Adhesiveness of galvanized coating: The galvanized coating shall be firmly combined with the metal base and shall be guaranteed of no spalling or peeling phenomenon under the condition without external-force action. Through the drop hammer test, the galvanized coating shall not be convex or peeled off.

6.9.6 Repair: the total repaired skip plating area shall not exceed 0.5% of the total surface area of each galvanized part; the repaired skip plating area on each face shall not exceed 10 cm^2. If the skip plating area is large, re-plating shall be carried out. The repair method may adopt thermal zinc spraying or zinc-rich coating; the thickness of the repaired layer shall be at least 30 μm larger than the minimum thickness required by galvanized coating.

6.10 Test Assembling

6.10.1 Test assembling shall adopt the horizontal type or vertical type. Prior to test assembling, the test assembling scheme shall be formulated, including the safety measures and quality control methods, etc..

6.10.2 Where assembling in segments is carried out, the number of segments assembled once shall not be less than 2; it shall be guaranteed that the segmented position is with assembling of connection segment, and each component number is carried out with test assembling.

6.10.3 During test assembling, the parts and components shall be at the free state; forcible assembling is forbidden.

6.10.4 Diameter of bolts used during test assembling shall be the same as that of the actually used bolts. The number of used bolts shall guarantee the positioning demand of elements; it shall not be less than 30% of total number of this group of bolts.

6.10.5 the modified parts and components must be assembled again.

6.10.6 Tolerance for test assembling shall be in accordance with those specified in Table 14.

6.10.7 The arrangement direction, spacing and type of shackles shall be in

fabrication length, shearing section perpendicularity, angle sheared edge perpendicularity, arc shoveled, chip heel, cutting corner, switching corner, hole shape, hole position, bending and deflection, etc.), quality of zinc coating (including appearance, thickness, adhesiveness and uniformity of zinc coating), assembly quality of weldment, weld quality (including appearance, overall size and internal quality of weld), and trial assembling (including positioning rate of component, through hole rate of concentric holes, and control dimension).

7.3 Inspection Requirements and Methods

7.3.1 Inspectors shall be specially trained for elementary theory and operating skills, and pass the examination and take the post with certificate.

7.3.2 Personnel engaged in non-destructive inspection shall be qualified by passing the assessment of the country-licensed professional assessment mechanism; his/her corresponding grading certificate shall be within the validity period; he/she shall be engaged in the non-destructive inspection and examination and verification work according to the qualified items and limits of authority through assessment.

7.3.3 Measuring range and accuracy of the inspection equipment and measuring instruments shall be able to meet the accuracy requirements of the measured items (Table 15), and shall be qualified by passing the measurement verification (calibration).

7.3.4 Inspection method

7.3.4.1 Dimensional inspection of parts and components

Dimensions of parts and components shall be inspected by using steel tape, steel ruler, angle ruler and caliper, etc.

7.3.4.2 Weld quality inspection of weldment

The external quality of weld shall be inspected by using magnifier and weld inspection ruler. The internal quality of weld generally shall be inspected by adopting ultrasonic inspection method; if the ultrasonic inspection cannot judge the defect, radiographic inspection method may be adopted.

7.3.4.3 Quality inspection of galvanized coating

Appearance inspection shall adopt the visual inspection method. The uniformity of galvanized coating shall inspected by adopting the copper sulfate test method (see Appendix A and Appendix E); the adhesiveness shall be inspected by drop-hammer test method (see Appendix B); the galvanized coating thickness shall be inspected by adopting test method with metal coating thickness tester (see Appendix C); in case of dispute, the dissolving and weighing method (see Appendix D and Appendix

E) shall be adopted as the referee test method to test the adhesion amount of galvanized coating.

7.3.4.4 Test assembling quality inspection

Positioning conditions of components shall be inspected visually; the through hole rate of concentric hole shall be inspected by using such hole tester of which the diameter is 0.3 mm larger than the nominal diameter of bolt; other dimensions shall be inspected by using steel tape.

7.3.4.5 Inspection on overall dimensions of steels

Angle-steel leg width shall be measured at three points on each edge in the length direction by using vernier caliper; the arithmetic mean value of each edge shall be taken respectively; the angle-steel thickness shall be measured at three points on each edge by using vernier caliper or ultrasonic thickness meter; the arithmetic mean value of each edge shall be taken respectively; the steel plate thickness shall be measured at three points and the arithmetic mean value shall be taken. During the test, the test points shall be uniformly distributed and their distance to edge shall not be less than 10 mm.

Table 15 Requirements for Main Inspection Equipment and Measuring Instruments

Inspection item	Main inspection instrument	Division value and resolution of measuring instrument
Appearance of steels and welds	Magnifier	5×
Overall dimensions and hole diameter of steels	Vernier caliper	0.02 mm
Steels thickness	Ultrasonic thickness meter	0.1 mm
	Vernier caliper	0.02
Length, and spacing between hole groups	Steel tape	1.0
Pitch of holes	Straight steel ruler	0.5
Hole directrix	Directrix caliper and caliper	0.02
Gap	Feeler gauge	0.1 mm
Overall size of weld	Weld inspection ruler	1.0 mm
Mechanical test	Material tester	1 kN
	Impact power tester	1 J
Internal quality of weld	Ultrasonic flaw detector	2 dB
Angle	Universal angle meter	2′
Zinc coating thickness	Metal coating thickness tester	1.0 μm
Chemical composition analysis	Corresponding analytical equipment	Meeting requirements of relevant standards

7.4 Sampling Scheme and Judgement Principles

7.4.1 Sampling Principles

7.4.1.1 Without special requirements, the general inspection level stated in GB/T 2828.1 (see Table 17 for inspection grade) shall be adopted.

7.4.1.2 Sampling scheme for items such as quality of steels, dimensions and quality of parts and components, and quality of weldment and weld: the single sampling plan for normal inspection stated in GB/T 2828.1 shall be adopted for the steel-tower products with voltage grade of or below 660 kV; the single sampling plan for tightened inspection stated in GB/T 2828.1 shall be adopted for the steel-tower products with voltage grade of or above 750 kV.

7.4.1.3 Quality of zinc coating and test assembling shall be adopted with the single sampling plan of distinguishing level I stated in GB/T 2829.

7.4.2 Inspection lot

Inspection lot may be composed by several on-production lots or part of the on-production lots. The size of the enterprise's delivery inspection lot shall be decided by the enterprise at discretion according to the actual conditions. The size of purchaser's acceptance inspection lot shall be agreed in the contract by the supplier and the purchaser.

7.4.3 Division of quality characteristics

Inspection items of products are divided into Category A and Category B according to the significance level of quality characteristics; the division conditions of quality characteristics are detailed in Table 16.

Table 16 Inspection Items and Division of Quality Characteristics

Item name		Rejectable item classification		Acceptance criterion /%	
		Category A	Category B		
Appearance of steels			√		
Overall dimensions of steels			√		
Material of steels		√			
Dimensions of parts and components	Primary material		√	Qualification rate of item	≥95
	Connecting piece		√		≥95
	Butt plate		√		≥90
	Web member		√		≥85
	Weldment		√		≥95
Weld appearance			√		≥95
Overall size of weld			√		≥95
Internal quality of weld		√			
Appearance of zinc coating			√		
Thickness of zinc coating			√		
Adhesiveness of zinc coating		√			
Uniformity of zinc coating		√			

Concentric hole rate of test assembling		√	≥96
Positioning rate of components in test assembling		√	≥99
Major control dimensions in test assembling	√		

7.4.4 Quality level

The quality level of the inspection items of transmission line tower products shall be selected in accordance with Table 17.

7.4.6 Judgement principles

7.4.6.1 Where the tested part or component appears any one of the following conditions, this part or component shall be judged as unqualified.

- The qualification rate of item is less than the specified value (see Table 16);
- The steel quality is unqualified or does not conform to the design requirements;
- The hole directions at the joint are opposite; the directrix of 50% or above holes is over-proof;
- The over-pickling is severe, and the acid corrosion of holes at joint is over-proof;
- The processing technology does not conform to this Standard or the design requirements;
- The dimensions of parts and components are over-proof due to the wrong setting-out;
- Relevant articles involved with the unconformity between control dimensions and the drawing.

7.4.6.2 Overall judgment

If any one among the Category A items is unqualified, then the product shall be judged as unqualified; if any one among the Category B items is larger than or equal to the rejection number (Re), then the product shall be judged as unqualified.

8 Packing, Marking, Transportation and Storage

8.1 General Requirements for Packing

8.1.1 Packing of angle-steel

8.1.1.1 Packing length, number of bundling coils and weight of angle-steel shall be convenient for packing, transportation and labeling.

8.1.1.2 The bending angle-steel and angle-steel weldment that cannot enter the package may be packed separately.

8.1.1.3 Bundling of package and bundle shall adopt the connection type with angle-steel frames and bolts or the bundling type with packing belts; the wrapping shall be subject to anticorrosive treatment.

8.1.1.4 The angle-steel bundle shall be regular at end, with clear stratum and basically consistent thickness.

8.1.2 Packing of connection plates should adopt the bolt penetration method.

8.1.3 The packing shall be firm and shall guarantee the package being without looseness during the transportation process; avoid mutual friction between angle-steels and between angle-steel and wrapping, and also damaging the galvanized coating.

8.2 Marking

In addition to meeting the contract requirements, marks shall be made at obvious position of the package to indicate the project name, tower type, nominal height, bundle No. and manufacturer name; the mark contents shall also meet the requirements of the transportation department.

8.3 Transportation and Storage

Attention shall be drawn that loading/unloading and placing sites shall not damage the product package or cause product deformation or galvanized coating damage.

Appendix A
(Normative)
Uniformity Test of Hot-dip Galvanized Coating – Method of Copper Sulfate Test

A.1 Preparation and consumption of copper sulfate solution

A.1.1 Preparation of copper sulfate solution: add 36 g of copper sulfate ($CUSO_4 \cdot 5H_2O$) into 100 mL of distilled water; heat to dissolve the copper sulfate; let it cool to ambient temperature; add 1 g of cupric hydroxide or cupric subcarbonate [$CU(OH)_2$ or $CuCO_3(OH)_2$] into every 1 L of solution; mix uniformly; keep it still for more than 24 h; filter the solution or suck out the upper clear solution for later use.

The density of copper sulfate solution at 18°C shall be 1.18 g/cm^3; otherwise, the solution shall be adjusted with copper sulfate solution or distilled water.

A.1.2 Consumption of copper sulfate solution: not less than 8 mL/cm^2 according to the test sample surface area.

A.1.3 The prepared copper sulfate solution may also be used for multiple tests, but for 15 times at most.

A.2 Preparation of test sample

Preparation of test sample shall be in accordance with those specified in Appendix E.

A.3 Test conditions

A.3.1 Containers used for test shall not have chemical reaction with copper sulfate solution, and shall be with adequate volume to immerse the test sample in solution; the distance from the outer edge of test sample to the wall of container shall not be less than 25 mm.

A.3.2 During the test, the temperature of copper sulfate solution shall be (18±2)°C.

A.4 Test procedures

A.4.1 Surface treatment of test sample: Wipe the prepared test sample with carbon tetrachloride, benzene or other organic solvent; rinse it with flowing water; wipe it dry with clean cloth, coat paint or paraffin onto the exposed part of test sample; then start the test.

A.4.2 Etch test: immerse the test sample passing through surface treatment into copper sulfate solution; do not agitate the solution or move the container at this time. Take out the test sample 1 min later; remove the deposit on test sample surface or in eyelets by hairbrush; rinse with flowing water; wipe it dry with clean cloth; then immediately conduct the next time of etching till the end point of etching.

A.5 Determination of etching end point and etch test times

Upon the above-mentioned test, the time when the base metal of test sample generates red metallic copper is taken as the etching end point of test. However, the following conditions shall not be taken as the etching end point:

a) Attached metallic copper exists within range of 25 mm away from the end of test

sample;

b) Attached metallic copper exists at the edges or corners of test sample;

c) Attached metallic copper exists at or around the scratch and bruise positions of test sample due to galvanizing;

d) After the attached metallic copper on test sample is scraped off by using such instrument without sharp blade, there still is metallic zinc on the test sample.

When determining the times of etch test, the time taken as the etching end point of test shall not be included.

A.6 Reagents

All reagents used shall be the analytical reagents.

Appendix C
(Normative)
Thickness Test of Hot-dip Galvanized Coating – Test Method by Metal Coating Thickness Tester

C.1 Thickness test of hot-dip galvanized coating

C.1.1 Where metal coating thickness tester is used, the metal coating thickness tester shall be corrected with standard thickness test piece before using.

C.1.2 During the test, the test points shall be uniformly distributed, their distance to edges shall not be less than 10 mm; the number of test points shall meet the following requirements:

a) Respectively one test point for three positions on each face of the angle-steel test sample, and totally 12 points on the four faces;

b) Respectively one test point for six positions on each face of the angle-steel test sample, and totally 12 points on the two faces.

The test results shall be calculated according to the arithmetic mean value of the data measured at each test point.

C.1.3 After the thickness determination of galvanized coating, the adhesion amount of galvanized coating shall be calculated according to the following formula:

$$P_A = \delta \times \rho$$

Where,

P_A - the adhesion amount of galvanized coating, g/m^2;

δ - the thickness of galvanized coating, μm;

ρ - the density of zinc (ρ=7.2), g/cm^3.

Appendix D
(Normative)
Adhesion Amount Test of Hot-dip Galvanized Coating – Dissolving and Weighing Test Method

D.1 Preparation and consumption of solvent

D.1.1 Preparation of solvent: dissolve 3.5 g of hexamethylenetetramine (urotropine) in 500 mL of concentrated hydrochloric acid (density: 1.19 g/cm^2); then dilute the solution to 1,000 mL with distilled water.

D.1.2 Consumption of solvent: not less than 10 mL/cm^2 according to the test sample surface area.

D.2 Preparation of test sample

Preparation of test sample shall be in accordance with those specified in Appendix E.

D.3 Test conditions

D.3.1 Containers used for test shall not have chemical reaction with the solvent, and shall be with adequate volume to completely immerse the test sample in solution.

D.3.2 During the test, the temperature of solvent shall not be higher than 38°C.

D.4 Test procedures

D.4.1 Surface treatment and pre-dissolving weighing of the test sample: wipe the prepared test sample with carbon tetrachloride, benzene or other organic solvent; rinse it with flowing water; wipe it dry with clean cloth; then clean the test sample with ethyl alcohol; let it dry thoroughly; weigh (accurate to 1% of the galvanized coating weight of test sample) it before dissolving.

D.4.2 Dissolving and post-dissolving weighing of the test sample: immerse the test sample passing through surface treatment into the solvent; observe the hydrogen evolution reaction on test sample surface; take the time when the hydrogen evolution rate is slow and stable as the end point of galvanized coating dissolving process. Take out the test sample; rinse it with flowing water; remove the surface attachment with scrub brush; then clean the test sample with ethyl alcohol; rapid dry it; dissolve it and weigh (accuracy: the same as D.4.1). After dissolving the test sample, measure the surface area of test sample (to the accuracy of 1% of the test sample surface area).

D.5 Calculation of test sample results

Adhesion amount of galvanized coating shall be calculated according to the following formula:

$$P_A = (m_1 - m_2)\ 10^6\ A^{-1}$$

Where,

P_A - the adhesion amount of galvanized coating, g/m^2;

m_1, m_2 - the weight of test sample before and after being dissolved, g;

A - the test sample surface area after being dissolved, mm^2.

Thickness of galvanized coating shall be calculated according to the following formula:

$$\delta = P_A \rho^{-1}$$

Where,

δ - the thickness of galvanized coating, μm;

P_A - the adhesion amount of galvanized coating, g/m^2;

ρ - the density of zinc (ρ=7.2), g/cm^3.

D.6 Reagents

All reagents used shall be the analytical reagents.

Appendix E
(Normative)
Adhesion Amount and Uniformity Test of Hot-dip Galvanized Coating - Sampling Method

E.1 Test sample size

The testing area of test sample shall not be less than 100 cm^2.

E.2 Sampling

Respectively cut off 5 cm from both ends of the test piece; then respectively take 3 test samples at both ends and the middle part of test piece. When processing test sample, the surface of galvanized coating shall not be damaged.

Appendix F
(Informative)
Color and Corresponding Temperature of Steel Surface

Table F.1 Color and Corresponding Temperature of Steel Surface

Color	Temperature /°C
Deep maroon	550~580
Maroon	580~650
Dark cherry red	650~730
Deep cherry red	730~770
Cherry red	770~800
Faint cherry red	800~830
Bright cherry red	830~960
Saffron yellow	960~1,050
Dark yellow	1,050~1,150
Brilliant yellow	1,150~1,250
White yellow	1,250~1,300

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