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Electric Power Industry Standard of the People's Republic of China

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Replace DL / T 680 — 1999

Specification for Electric Power Industry Wear-resistant Pipes

电力行业耐磨管道技术条件

(English Translation)

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Contents

Foreword

The major changes and supplements have been made to the technical contents in this revised version over DL/T 680—1999 *Specification for Wear-resistant Pipes* in the following aspects:

——The title of the standard has been changed from *Specification for Wear-resistant Pipes* into *Specification for Electric Power Industry Wear-resistant Pipes*.

——The chemical compositions of some grades have been modified.

——The designation of abrasion-resistant white cast iron has been modified.

——The property parameters of some grades have been modified and adjusted.

——The nominal diameter ranges of some circular wear-resistant pipes have been adjusted.

——The designation of some wear-resistant pipes has been adjusted.

——The abrasion-resistant white cast iron mono-metal pipe (KmTBCr2G) and abrasion-resistant white cast iron bimetal composite wear-resistant pipe (KmTBCr2—G) in the former standard have been removed.

——Some terms related to the wear-resistant pipes have been added.

——The abrasion-resistant white cast iron wear-resistant pipes (BTMCr8G, BTMCr12G, BTMCr30G) and abrasion-resistant white cast iron bimetal composite wear-resistant pipes (BTMCr8-G, BTMCr12-G, BTMCr30-G) have been added.

——The alloy steel composite wear-resistant pipes with hardened inner walls / pipes (NY45CrMnSi-G, NY55CrMnSi-G, NY65CrMnSi-G) have been added.

——The surfacing composite wear-resistant pipes (DNM-Ⅳ-G, DNM-Ⅴ-G) have been added.

——The ceramic composite wear-resistant pipes prepared by sleeving and casting methods (TCT-G, TCZ-G) have been added.

——The silicon carbide composite wear-resistant pipe combined with oxides (YSiC-G) and recrystallized silicon carbide composite wear-resistant pipe (RSiC-G) have been added.

This standard was proposed by China Electricity Council.

This standard is under jurisdiction of Standardization Technology Committee of Power Plant Metallic Materials in Electric Power Industry.

The chief drafting organizations of this standard include North China Electric Power University, Huadian Electric Power Research Institute, and Huludao Huaneng Industrial Ceramic Co., Ltd..

The organizations participating in the drafting of this standard include Nantong Gaoxin Antiwear Technology Co., Ltd., Jiangsu Huanai Lining Material Co., Ltd., Penglai Shuicheng Cast Basalt Pipes & Valves Co., Ltd., Chongqing Yuji Machinery Manufacturing Co., Ltd., Hebei Jiutong Wear and Corrosion Resistant Pipeline Co., Ltd., Anshan Taiyuan Industrial Co., Ltd., Chongqing Luoman Wear Resistant New Materials Co., Ltd., Zhengzhou Huatai Energy Saving Ceramic Co., Ltd., Xuzhou Zhongcai Tianyuan Heavy Machinery Co., Ltd., Tianjin Fuyide Electromechanical Equipment Co., Ltd., Inner Mongolia Keyun Environmental Protection Material Co., Ltd., Tianjin Tedian Metal Products Co., Ltd., Hebei Jingliang Power Equipment Co., Ltd., Beijing Jiake Xinxing Technology Co., Ltd., Cangzhou Boyang Pipeline Group Co., Ltd., Shang'an Power Plant of Huaneng Power International, Inc., Xi'an Thermal Power Research Institute Co., Ltd., National Experiment and Research Center for Wear Resistant Material of Power Industry, Hangzhou Huadian

Banshan Power Generation Co., Ltd., National Quality Supervision, Inspection and Testing Center for Metal Wear Resistant Parts of Power Industry, Harbin First Thermal Power Plant of Datang Heilongjiang Power Generation Co., Ltd., and Beijing Kangshenghongda Technology Co.,Ltd..

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This standard replaces the DL/T 680—1999 since the date of implementation.

The organizations responsible for this standard are North China Electric Power University and National Experiment and Research Center for Wear Resistant Material of Power Industry.

The former standard DL/T 680—1999 was first issued on 08/02/1999 and this is the first revised edition.

The opinions and suggestions in the implementation of this standard can be fed back to Standards Management Center of China Electricity Council (No.1, Ertiao Lane, Baiguang Road, Beijing, 100761).

Introduction

This standard was revised according to *The Notice about Making/Revising the First Batch of Standards for Energy Industry in* 2010 (GNKJ（2010） No.320), Issued by National Energy Administration.

The annual consumption of wear-resistant pipes is considerable in electric power industry of China, involving the transportations of pulverized coal, coal ash (coal cinder), limestone powder and gypsum slurry. This standard is modified to further ensure the safe and stable operation of power plants, improve efficiency, save energy and materials, reduce emissions and consumption, and promote the application of new wear-resistant pipes developed in recent years. It is the manufacturing standard for suppliers and the basis for selection, application and acceptance of wear-resistant pipes by power plants, electric power design institutes and other related organizations.

Specification for Electric Power Industry Wear-resistant Pipes

1 Scope

This standard specifies the classifications, grades, technical requirements, test methods, inspection rules and marking, packaging, storage and transportation of wear-resistant pipes.

This standard is applicable to the wear-resistant pipes which are used to convey pulverized coal, coal ash (coal cinder), limestone powder and gypsum slurry in electric power industry. In addition, it can be referenced for other pipes with wear-resistant requirements.

2 Normative references

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

GB/T 223.4 *Alloyed steel—Determination of manganese content—Potentiometric or visual titration method*

GB/T 223.5 *Steel and iron—Determination of acid-soluble silicon and total silicon content—Reduced molybdosilicate spectrophotometric method*

GB/T 223.11 *Iron, steel and alloy—Determination of chromium content—Visual titration or potentiometric titration method*

GB/T 223.18 *Methods for chemical analysis of iron, steel and alloy—The sodium thiosulfate separation iodimetric method for the determination of copper content*

GB/T 223.23 *Iron, steel and alloy—Determination of nickel content—The dimethylglyoxime spectrophotometric method*

GB/T 223.26 *Iron, steel and alloy—Determination of molybdenum content—The thiocyanate spectrophotometric method*

GB/T 223.59 *Iron, steel and alloy—Determination of phosphorus content—Bismuth phosphomolybdate blue spectrophotometric method and antimony phosphomolybdate blue spectrophotometric method*

GB/T 223.60 *Methods for chemical analysis of iron, steel and alloy—The perchloric acid dehydration gravimetric method for the determination of silicon content*

GB/T 223.67 *Iron, steel and alloy - Determination of sulfur content—Methylene blue spectrophotometric method*

GB/T 223.69 *Iron, steel and alloy—Determination of carbon contents—Gas-volumetric method after combustion in the pipe furnace*

GB/T 223.71 *Methods for chemical analysis of iron, steel and alloy—The gravimetric method after combustion in the pipe furnace for the determination of carbon content*

GB/T 223.72 *Iron, steel and alloy—Determination of sulfur content —Gravimetric method*

GB/T 229 *Metallic materials—Charpy pendulum impact test method* (ISO 148-1: 2006, MOD)

GB/T 230.1 *Metallic materials - Rockwell hardness test—Part* 1: *Test method* (*scales A*、*B*、*C*、*D*、*E*、*F*、*G*、*H*、*K*、*N*、*T*) (ISO 6508-1: 2005, MOD)

GB/T 241 *Metal materials—Tube—Hydrostatic pressure test*

GB/T 528 *Rubber, vulcanized or thermoplastic—Determination of tensile stress-strain properties* (ISO 37: 2005, IDT)

GB/T 531.1 *Rubber, vulcanized or thermoplastic—Determination of indentation hardness—Part* 1: *Duromerer method* (*Shore hardness*) (ISO 7619-1: 2004, IDT)

GB/T 1689 *Rubber vulcanized—Determination of abrasion resistance*

GB/T 2997 *Test method for bulk density, apparent porosity and true porosity of dense shaped refractory products* (ISO 5017: 1998, EQV)

GB/T 3001 *Refractory products—Determination of modulus of rupture at ambient temperature* (ISO 5014: 1997, MOD)

GB/T 3045 *Abrasive grains—Chemical analysis of silicon carbide* (ISO 9286: 1997, NEQ)

GB/T 3091 *Welded steel pipe for low pressure liquid delivery* (ISO 559: 1991, NEQ)

GB/T 3512 *Rubber, vulcanized or thermoplastic—Accelerated ageing and heat resistance tests* (ISO 188: 2011, IDT)

GB/T 4336 *Standard testmethod for spark discharge atomic emission—Spectrometric analysis of carbon and low-alloy steel* (*routine method*)

GB/T 5611 *Foundry terminology*

GB/T 6414 *Castings—System of dimensional tolerances and machining allowances* (ISO 8062: 1994, EQV)

GB/T 6569 *Fine ceramics* (*advanced ceramics, advanced technical ceramics*) — *Test method for flexural strength of monolithic ceramics at room temperature* (ISO 14704: 2000, MOD)

GB/T 8162 *Seamless steel tubes for structural purposes* (EN 10297-1: 2003, NEQ)

GB/T 8163 *Seamless steel tubes for liquid service* (EN 10216-1: 2004, NEQ)

GB/T 8259 *Specification for flexible joints of housing*

GB/T 8260 *Types and dimensions of flexible joints of housing*

GB/T 9114 *Hubbed screwed steel pipe flanges* (ASME B 16.5: 2009、EN 1092-1: 2007, MOD)

GB/T 9119 *Slip-on-welding plate steel pipe flanges* (ASME B 16.5: 2009、EN 1092-1: 2007, MOD)

GB/T 9121 *Loose plate steel pipe flanges with weld-on collar* (ASME B 16.5: 2009、EN 1092-1: 2007, MOD)

GB/T 9123 *Steel pipe blank flanges* (ASME B 16.5: 2009、EN 1092-1: 2007, MOD)

GB/T 12459 *Steel butt-welding seamless pipe fittings* (ASTM B 16.9: 2001, MOD)

GB/T 14203 *General rule for spark discharge atomic emission spectrometry*

GB/T 16534 *Fine ceramics* (*advanced ceramics, advanced technical ceramics*) - *Test method for hardness of monolithic ceramics at room temperature* (ISO 14705: 2008, MOD)

GB/T 17394.1 *Metallic materials—Leeb hardness test—Part* 1:*Test method*

GB/T 17394.4 *Metallic materials—Leeb hardness test—Part* 4:*Tables of hardness values conversation*

GB/T 18301 *Refractory products—Determination of resistance to abrasion at ambient temperature* (ISO 16282: 2007, MOD)

GB/T 20066 *Steel and iron—Sampling and preparation of samples for the determination of chemical composition* (ISO 14284: 1996, IDT)

GB/T 26651 *Abrasion-resistant steel castings*

GB/T 27979 *Alumina ceramic wear-resistant composite lining board*

GB 50474 *Technical code for heat-insulation and wear-resistant linings*

DL/T 681 *Specification for wear resistant parts of coal mill in coal-fired power plants*

DL/T 695 *Steel butt-welding fittings for power plant*

DL/T 902 *Technical requirements and test methods of abrasion resistant refractory material*

SY/T 5037 *Submerged arc-welded steel pipe for common fluid service pipeline*

JB/T 9378 *Leeb hardness testers*

YB/T 5201 *Dense refractory castables—Determination of cold modulus of rupture and cold crushing strength*

JC/T 260 *Testing methods for the properties of cast stone products—Resistance-to-abrasion test*

JC/T 263 *Testing methods for the properties of cast stone products—Bending strength test*

JC/T 848.1 *Alumina grinding ball*

EN 101 *Ceramic tiles—Determination of scratch hardness of surface according to mohs*

EN 14700 *Welding consumables—Welding consumables for hard-facing*

3 Terms and definitions

The following terms and definitions and those given in GB/T 5611 apply.

3.1

Wear

The loss of material on a surface as a result of objects moving and rubbing against each other.

3.2

Erosive wear

Wear caused by the impact of flowing medium containing or not containing solid particles against the surface of an object.

3.3

Abrasive wear

The loss of surface material as a result of the friction of object surface with solid particles, hard protuberances or hard metals.

3.4

Wear-resistant materials

Materials that can resist wear and prolong the service life of products.

3.5

Wear-resistant pipes

Pipes manufactured by wear-resistant materials.

3.6

Composite wear-resistant pipes

Wear-resistant pipes manufactured with the composition of base-material pipes and wear-resistant materials/pipes through a composite process.

4 Classifications of wear-resistant pipes

4.1 Varieties

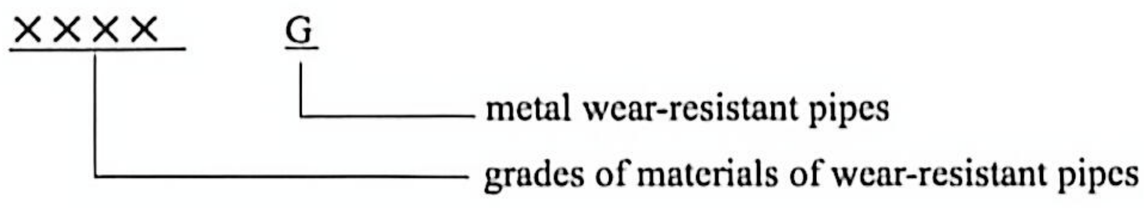
4.1.1 Varieties, grades of wear-resistant pipes and nominal diameter ranges of circular wear-resistant pipes are shown in Table 1. For application characteristic of wear-resistant pipes, see Appendix A.

Table 1 Varieties, grades of wear-resistant pipes and nominal diameter ranges of circular wear-resistant pipes

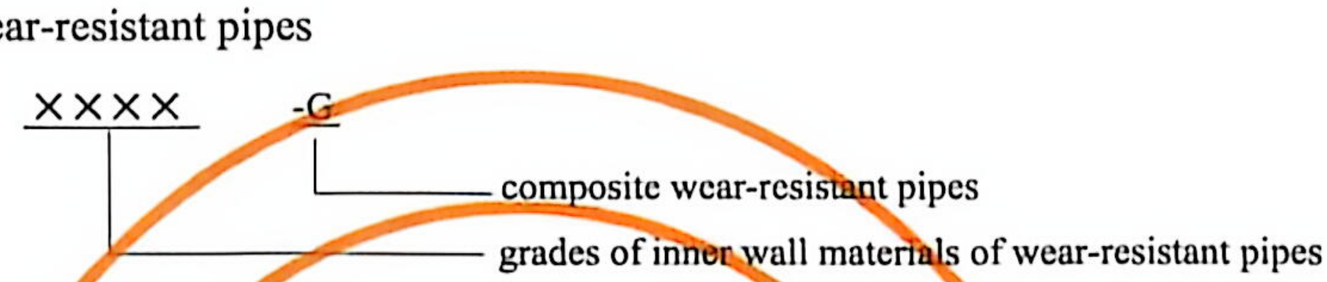
Varieties			Grades	Nominal diameter ranges mm
Metal wear-resistant pipes	Medium carbon low alloy cast steel wear-resistant pipes		ZG40CrNiMoG	DN100～DN1000
			ZG45Cr2MoG	DN100～DN1000
	Medium carbon medium alloy cast steel wear-resistant pipes		ZG40Cr5MoG	DN100～DN1000
			ZG42Cr2Si2MnMoG	DN100～DN1000
	Alloy steel wear-resistant pipes with hardened inner walls		NY45CrMnSiG	DN100～DN1000
			NY55CrMnSiG	DN100～DN1000
			NY65CrMnSiG	DN100～DN1000
	Abrasion-resistant white cast iron wear-resistant pipes		BTMCr30G	DN100～DN1000
			BTMCr26G	DN100～DN1000
			BTMCr20G	DN100～DN1000
			BTMCr15G	DN100～DN1000
			BTMCr12G	DN100～DN1000
			BTMCr8G	DN100～DN1000
Composite wear-resistant pipes	Bimetal composite wear-resistant pipes		NY45CrMnSi-G	DN100～DN1000
			NY55CrMnSi-G	DN100～DN1000
			NY65CrMnSi-G	DN100～DN1000
			BTMCr30-G	DN50～DN1000
			BTMCr26-G	DN50～DN1000
			BTMCr20-G	DN50～DN1000
			BTMCr15-G	DN50～DN1000
			BTMCr12-G	DN50～DN1000
			BTMCr8-G	DN50～DN1000
	Surfacing composite wear-resistant pipes		DNM-Ⅳ-G	DN≥100
			DNM-Ⅴ-G	DN≥100
	Ceramic composite wear-resistant pipes	Manufactured by aluminothermic process	TCR-G	DN30～DN1200
		Manufactured by lining method	TCC-G	DN≥200
		Manufactured by sleeving method	TCT-G	DN50～DN700
		Manufactured by casting method	TCZ-G	DN≥30
	Rubber composite wear-resistant pipes		XJ-G	DN50～DN1200
	High-temperature wear-resistant lining composite wear-resistant pipes		WM-G	DN≥40
	Cast basalt composite wear-resistant pipes		ZS-G	DN≥40
	Silicon carbide composite wear-resistant pipes	Combined with oxides	YSiC-G	DN≥30
		Recrystallized SiC	RSiC-G	DN20～DN750

4.1.2 Designation of wear-resistant pipes:

a) Metal wear-resistant pipes



b) Composite wear-resistant pipes



4.2 Shapes and sizes

4.2.1 Based on the shape, the wear-resistant pipes are classified into the following categories: straight pipes, bends (elbows), tees, crosses,five-way fittings reducing pipes, rectangle-circle connectors and profile pipes.

4.2.2 The nominal diameter ranges of circular wear-resistant pipes are given in Table 1. For any other specific requirements, agreement should be reached between the manufacturers and purchasers.

5 Technical requirements

5.1 Manufacturing methods

Wear-resistant pipes can be manufactured by suitable methods, such as melting, casting, hot extrusion, cold drawing, heat treatment, welding, inner surface materials modification, composite manufacturing, surfacing and cladding and so on. Other manufacturing methods can also be used under the agreement between the manufacturers and purchasers.

5.2 Surface quality

The inner surface of the wear-resistant pipes shall be flat, smooth and compact, and free from burr, raw edge, burning-on, unevenness, slag inclusion, cracks, porosity, cold lap, blowhole, expansion, flow and spalling etc. For TCR-G, ZS-G, WM-G, DNM-Ⅳ-G, DNM-Ⅴ-G and YSiC-G composite wear-resistant pipes, the inner wall defects formed in processing, such as tiny cracks, welding ripples and folds, are permitted, if these defects do not affect the use of the pipes.

The outer surface of the wear-resistant pipes shall be flat and smooth, and the anticorrosion coating shall be uniform and firm, free of bubbles and paint accumulations.

5.3 Dimensional tolerance

The dimensional tolerance of the wear-resistant pipes shall conform to the requirements of the product drawings and order contracts. If there are no special requirements, the dimensional tolerance of the metal wear-resistant pipes shall conform to CT 11 class which is regulated in GB/T 6414, and the dimensional tolerance of the steel pipes in the composite wear-resistant pipes shall conform to the provisions given in GB/T 3091, GB/T 8162 and GB/T 8163, while the dimensional tolerance of flexible joints of housing shall conform to the provisions given in GB/T 8260.

5.4 Pressure endurance capacity

For the hydraulic test of the wear-resistant pipes with pressure-bearing requirements, test pressure shall not be less than 1.25 times the working pressure, and the holding time shall last at least 15 min. The other requirements shall conform to the provisions given in GB/T 241.

5.5 Other requirements for the metal wear-resistant pipes

5.5.1 Chemical composition of the metal wear-resistant pipes

Chemical composition of the metal wear-resistant pipes shall conform to the requirements given in Table 2.

Table 2 Chemical composition of the metal wear-resistant pipes

Grades	Chemical composition (wt. %)								
	C	Mn	Si	S	P	Cr	Ni	Mo	Cu
ZG40CrNiMoG	0.35～0.45	0.40～1.00	0.40～0.80	≤0.035	≤0.035	0.50～2.00	0.30～2.00	0.20～0.80	—
ZG45Cr2MoG	0.40～0.48	0.40～1.00	0.80～1.20	≤0.035	≤0.035	1.70～2.00	≤0.50	0.80～1.20	—
ZG40Cr5MoG	0.35～0.45	0.50～1.20	0.40～1.00	≤0.035	≤0.035	4.00～6.00	≤0.50	0.20～0.80	—
ZG42Cr2Si2MnMoG	0.38～0.48	0.80～1.20	1.50～1.80	≤0.035	≤0.035	1.80～2.20	—	0.20～0.60	—
NY45CrMnSiG	0.40～0.50	1.40～2.00	0.20～1.00	≤0.030	≤0.030	≤1.00	≤0.30	≤0.30	≤0.30
NY55CrMnSiG	0.50～0.60	0.50～1.20	0.20～1.00	≤0.030	≤0.030	≤1.00	≤0.30	≤0.30	≤0.30
NY65CrMnSiG	0.60～0.70	0.90～1.20	0.20～1.00	≤0.030	≤0.030	≤1.00	≤0.30	≤0.30	≤0.30
BTMCr30G	1.80～2.20	≤3.00	≤1.20	≤0.06	≤0.06	28.00～32.00	≤1.50	≤1.50	≤2.0
BTMCr26G	2.10～3.30	≤2.00	≤1.20	≤0.06	≤0.06	23.00～30.00	≤1.50	≤1.50	≤1.20
BTMCr20G	2.10～3.30	≤2.00	≤1.20	≤0.06	≤0.06	18.00～23.00	≤2.50	≤1.50	≤1.20
BTMCr15G	2.10～3.60	≤2.00	≤1.20	≤0.06	≤0.06	14.00～18.00	≤2.50	≤1.50	≤1.20
BTMCr12G	2.10～3.60	≤2.00	≤1.50	≤0.06	≤0.06	11.00～14.00	≤2.50	≤1.50	≤1.20
BTMCr8G	2.10～3.60	≤2.00	1.50～2.20	≤0.06	≤0.06	7.00～10.00	≤1.00	≤1.50	≤1.20

Note 1: ZG denotes the cast steels, NY denotes the alloy steel composite wear-resistant pipes with hardened inner walls/ pipes, and BTM denotes the abrasion-resistant white cast iron.

Note 2: V, Ti, W, B, Nb, Re and other elements can be properly added according to the wear conditions and the requirements of the purchasers.

5.5.2 Mechanical properties of the metal wear-resistant pipes

Mechanical properties of the metal wear-resistant pipes shall conform to the requirements given in Table 3.

Table 3 Mechanical properties of the metal wear-resistant pipes

Grades	Impact absorption energy K_{N2} J	Surface hardness HRC	Grades	Impact absorption energy K_{N2} J	Surface hardness HRC
ZG40CrNiMoG	≥25	≥50	BTMCr30G	—	≥52
ZG42Cr2Si2MnMoG	≥25	≥50	BTMCr26G	—	≥58
ZG45Cr2MoG	≥25	≥50	BTMCr20G	—	≥58
ZG40Cr5MoG	≥25	≥44	BTMCr15G	—	≥58
NY45CrMnSiG	—	≥50	BTMCr12G	—	≥58
NY55CrMnSiG	—	≥53	BTMCr8G	—	≥56
NY65CrMnSiG	—	≥56	—	—	—

Note: K denotes the impact absorption energy, the subscript N represents the impact test specimen shall be unnotched and the subscript 2 represents the radius of pendulum hammer edge (mm).

5.6 Metallographic microstructures

Generally, metallographic microstructures are not used as the basis for product acceptance. If the purchasers have special requirements, agreement should be reached between the manufacturers and purchasers.

5.7 Other requirements for the composite wear-resistant pipes

5.7.1 The base materials of steel pipes, fittings and connectors shall conform to the following requirements:

a) According to the working pressure, the welding steel pipes or seamless steel pipes which are suitable for the working condition and safe for the operation should be used as the base materials of steel pipes. Their properties shall conform to the requirements given in GB/T 3091, GB/T 8162, GB/T 8163 or SY/T 5037.

b) Quality of fittings shall conform to the requirements given in GB/T 12459 or DL/T 695.

c) Quality of flanges shall conform to the requirements given in GB/T 9114, GB/T 9119 or GB/T 9121. Quality of flange covers shall conform to the requirements given in GB/T 9123 and the quality of flexible joints of housing shall conform to the requirements given in GB/T 8259.

d) For steel pipes, fittings and connectors, manufacturers shall provide quality certifications. If there is any doubt about the quality, the reinspection should be done. The products can be used only if the reinspection results satisfy the related requirements.

5.7.2 Thickness of the wear-resistant lining layer:

For the thickness of the wear-resistant lining layer, agreement should be reached between the manufacturers and purchasers, and the related contract should be executed.

5.7.3 Thickness tolerance of the wear-resistant lining layer:

Thickness tolerance of the wear-resistant lining layer shall conform to the requirements given in Table 4.

Table 4 Thickness tolerance of the wear-resistant lining layer

Grades	Thickness tolerance mm	Grades	Thickness tolerance mm
NY-G	±1.2	TCZ-G	±1.0
BTM-G	±1.2	XJ-G	±0.3
DNM-G	±1.5	WM-G	±2.0
TCR-G	±1.0	ZS-G	±3.0
TCC-G	±0.3	YSiC-G	±2.0
TCT-G	±1.0	RSiC-G	±0.5

5.7.4 Chemical composition and hardness of the inner wall wear-resistant layer of the abrasion-resistant white cast iron composite pipes:

a) Chemical composition of the inner wall wear-resistant layer of the abrasion-resistant white cast iron composite pipes shall conform to the requirements given in Table 2.

b) Hardness of the inner wall wear-resistant layer of the abrasion-resistant white cast iron composite pipes shall conform to the requirements given in Table 3.

5.7.5 Chemical composition and hardness of the inner wall surfacing layer of the composite wear-resistant pipes:

Chemical composition and hardness of the inner wall surfacing layer of the composite wear-resistant pipes shall conform to the requirements given in Table 5.

Table 5 Chemical composition and hardness of the inner wall surfacing layer of the composite wear-resistant pipes

Grades	Chemical composition (wt.) %									Surface hardness HRC
	C	Cr	Ni	Mn	Mo	W	V	Nb	B (Co)	
DNM-Ⅳ-G	4.50～5.50	20.00～40.00	≤4.00	0.50～3.00	≤2.00	—	—	≤10.00	B, Appro-priate amount	≥55
DNM-Ⅴ-G	4.00～7.50	10.0～40.00	—	≤3.00	≤9.00	≤8.00	≤10.00	≤10.00	B, Co Appro-priate amount	≥60

Note 1: D denotes the surfacing, NM denotes the wear-resistant alloys, and Ⅳ, Ⅴ denote the wear-resistant materials of different alloy systems.

Note 2: The grades of DNM-Ⅳ and DNM-Ⅴ are respectively equivalent to the grades of Fe 15 and Fe 16 given in the European standard EN 14700.

Note 3: The wear-resistant materials of Ⅰ, Ⅱ, Ⅲ, Ⅵ, Ⅶ alloy systems are given in DL/T 681.

5.7.6 Property requirements for the ceramic composite wear-resistant pipes:

a) Properties of the inner wall ceramic layer of the ceramic composite wear-resistant pipes manufactured with aluminothermic process shall conform to the requirements given in Table 6.

Table 6 Properties of the inner wall ceramic layer of the ceramic composite wear-resistant pipes manufactured with aluminothermic process

Bulk density kg/m^3	Vickers hardness HV
≥3800	≥1100

Note: The thickness of the inner wall ceramic layer of the ceramic composite wear-resistant pipes manufactureal with aluminothermic process shall not be less than 4.0 mm, or shall reach the value agreed by the manufacturers and purchasers.

b) Properties of the inner wall ceramic layer of the ceramic composite wear-resistant pipes manufactured with lining and sleeving methods shall conform to the requirements given in Table 7.

Table 7 Properties of the inner wall ceramic layer of the ceramic composite wear-resistant pipes manufactured with lining and sleeving methods

Bulk density kg/m^3	Rockwell hardness HRA	Wear loss cm^3
≥3600	≥82	≤5
Note 1: The thickness of the inner wall ceramic layer of the ceramic composite wear-resistant pipes manufactured with lining method shall not be less than 8.0 mm, or shall reach the value agreed by the manufacturers and purchasers. **Note 2:** The thickness of the inner wall ceramic layer of the ceramic composite wear-resistant pipes manufactured with sleeving method shall not be less than 12.0 mm, or shall reach the value agreed by the manufacturers and purchasers. **Note 3:** The shape, structure, size and fixed ways of a lining ceramic tile (block) of the composite wear-resistant pipes shall be agreed by the manufacturers and purchasers.		

c) The fixed ways and requirements for ceramic tiles (blocks) made with lining method: The fixed ways of ceramic tiles (blocks) made with lining method include arch self-locking, riveting and welding steel bowl, dovetail groove embedding and adhesive sticking and so on. There shall be no longitudinal joints in the direction of the flow of the medium. It shall be filled with high temperature bonding cement between the lining ceramic blocks and the inner wall of the steel base pipes fixed by arch self-locking, and the last piece of ceramics shall be inlaid with self-locking.

d) Properties of ceramic of the inner pipes manufactured by casting method shall conform to the requirements given in Table 8.

Table 8 Properties of ceramic of the inner pipes manufactured by casting method

Bulk density kg/m^3	Mohs hardness	Wear loss cm^3
≥3000	≥9	≤6
Note : The thickness of ceramic layer of the ceramic composite wear-resistant pipes shall not be less than 8.0 mm, or shall reach the value agreed by the manufacturers and purchasers.		

5.7.7 Property requirements for the rubber composite wear-resistant pipes:

Properties of lining material of the rubber composite wear-resistant pipes shall conform to the requirements given in Table 9.

Table 9 Properties of lining material of the rubber composite wear-resistant pipes

Tensile strength MPa	Elongation at break %	Tensile strength at 300% elongation MPa	Hardness (Shore A)	Wear loss $cm^3/1.6km$	Hot air aging 70℃×72h
≥14.70	≥400.0	≥8.0	60～70	≤0.20	≥0.9

5.7.8 Property requirements for the high-temperature wear-resistant lining composite pipes:

Properties of high-temperature wear-resistant lining materials shall conform to the requirements given in Table 10.Tortoise shell net manufacturing technology and other technologies shall conform to the requirements given in GB 50474.

Table 10 Properties of high-temperature wear-resistant lining materials

Bulk Density kg/m³	Modulus of rupture MPa	Compressive strength MPa	Wear loss cm³
≥2700	≥11.5, after heated at 815℃	≥85.0, after heated at 815℃	≤6

5.7.9 Property requirements for the cast basalt composite wear-resistant pipes:

Properties of the cast basalt lining materials shall conform to the requirements given in Table 11.

Table 11 Properties of the cast basalt lining materials

Bulk density kg/m³	Wear loss g/cm²	Flexural strength MPa	Mohs hardness
≥2900	≤0.08	≥58.8	≥7

5.7.10 Property requirements for the silicon carbide composite wear-resistant pipes:

a) Properties of the lining materials of silicon carbide combined with oxides shall conform to the requirements given in Table 12.

Table 12 Properties of the lining materials of silicon carbide combined with oxides

SiC %	Bulk density kg/m³	Wear loss cm³	Modulus of rupture MPa (110℃±15℃×24h)	Mohs hardness
≥80	≥2600	≤5	≥12	≥9

b) Properties of the recrystallized silicon carbide lining materials shall conform to the requirements given in Table 13.

Table 13 Properties of the recrystallized silicon carbide lining materials

SiC %	Bulk density kg/m³	Wear loss cm³	Flexural strength MPa	Mohs hardness
≥99	≥2650	≤2	≥75	≥9

5.8 Special requirements

For any special requirements on structures, connection types and so on, the relevant agreement should be reached between the manufacturers and purchasers.

6 Test methods

6.1 The inner and outer surface quality

The inner and outer surface quality of the wear-resistant pipes is determined by visual inspection and the corresponding measuring tools.

6.2 Geometric size

Geometric size is measured by the corresponding measuring tools, such as calipers, steel tape, sample plate, thickness gauge, etc.

6.3 Hydraulic test

The hydraulic test methods shall be in accordance with the provisions given in 5.4 of this standard.

6.4 Analysis of the metallic chemical compositions

Analysis of the metallic chemical compositions shall be in accordance with the provisions given in GB/T 223.4, GB/T 223.5, GB/T 223.11, GB/T 223.18, GB/T 223.23, GB/T 223.26, GB /T 223.59, GB/T 223.60, GB/T 223.67, GB/T 223.69, GB/T 223.71 and GB /T 223.72, GB/T 4336, GB/T 14203 and GB/T 20066.

6.5 Metallic mechanical properties

6.5.1 Rockwell hardness test methods for metals shall be in accordance with the provisions given in GB/T 230.1.The hardness of the products can be measured by a Leeb hardness tester and the Leeb hardness test methods shall be in accordance with the provisions given in GB/T 17394.1and GB/T 17394.4 or JB/T 9378.

6.5.2 Impact test methods for the metals shall be in accordance with the provisions given in GB/T 229.

6.6 Properties of the ceramic lining materials

6.6.1 Bulk density test methods shall be in accordance with the provisions given in GB/T 2997.

6.6.2 Vickers hardness test methods shall be in accordance with the provisions given in GB/T 16534, Rockwell hardness test methods in accordance with the provisions given in GB/T 27979, and Mohs hardness test methods in accordance with the provisions given in EN 101.

6.6.3 Wear resistance test methods shall be in accordance with the provisions given in DL/T 902.

6.6.4 Properties of a lining ceramic tile (block) test methods shall be in accordance with the provisions given in GB/T 27979 or JC/T 848.1.

6.7 Properties of the rubber lining materials

6.7.1 Test methods of tensile strength and elongation at break shall be in accordance with the provisions given in GB/T 528.

6.7.2 Shore hardness test methods shall be in accordance with the provisions given in GB/T 531.1.

6.7.3 Wear resistance test methods shall be in accordance with the provisions given in GB/T 1689.

6.7.4 Hot air aging test methods shall be in accordance with the provisions given in GB/T 3512.

6.8 Properties of the high-temperature wear-resistant lining materials

6.8.1 Bulk density test methods shall be in accordance with the provisions given in GB/T 2997.

6.8.2 Modulus of rupture and compressive strength test methods shall be in accordance with the provisions given in YB/T 5201.

6.8.3 Wear resistance test methods shall be in accordance with the provisions given in GB/T 18301.

6.9 Properties of the cast basalt lining material

6.9.1 Bulk density test methods shall be in accordance with the provisions given in GB/T 2997.

6.9.2 Wear resistance test methods shall be in accordance with the provisions given in JC/T 260.

6.9.3 Flexural strength test methods shall be in accordance with the provisions given in JC/T 263.

6.9.4 Mohs hardness test methods shall be in accordance with the provisions given in EN 101.

6.10 Properties of the silicon carbide lining material

6.10.1 Chemical compositions test methods shall be in accordance with the provisions given in GB/T 3045.

6.10.2 Bulk density test methods shall be in accordance with the provisions given in GB/T 2997.

6.10.3 Modulus of rupture test methods shall be in accordance with the provisions given in GB/T 3001.

6.10.4 Flexural strength test methods shall be in accordance with the provisions given in GB/T 6569.

6.10.5 Wear resistance test methods shall be in accordance with the provisions given in GB/T 18301.

6.10.6 Mohs hardness test methods shall be in accordance with the provisions given in EN 101.

7 Inspection rules

7.1 Delivery inspection

7.1.1 The inner and outer surface quality, size tolerance, chemical composition and inner wall hardness of the metal wear-resistant pipes and abrasion-resistant white cast iron bimetal composite wear-resistant pipes.

7.1.2 The inner and outer surface quality, size tolerance, chemical composition and inner wall hardness of the alloy steel composite wear-resistant pipes with hardened inner walls and bimetal composite wear-resistant pipes with hardened inner walls.

7.1.3 The inner and outer surface quality, size tolerance, chemical composition and inner wall hardness of the surfacing composite wear-resistant pipes.

7.1.4 The inner and outer surface quality, size tolerance, ceramic lining hardness of the ceramic composite wear-resistant pipes.

7.1.5 The inner and outer surface quality, size tolerance, rubber lining hardness of the rubber composite wear-resistant pipes.

7.1.6 The inner and outer surface quality, size tolerance, lining material bulk density of the high temperature wear-resistant lining composite wear-resistant pipes.

7.1.7 The inner and outer surface quality, size tolerance, cast basalt lining hardness of the cast basalt composite wear-resistant pipes.

7.1.8 The inner and outer surface quality, size tolerance, inside silicon carbide hardness of the silicon carbide composite wear-resistant pipes.

7.1.9 Wear-resistant pipes shall pass the quality inspection and be issued a product certificate and quality certificate by the quality inspection department before delivery.

7.2 Acceptance inspection

The quality of the wear-resisting pipes should be inspected item by item by users based on the relevant provisions of this standard.

7.3 Type inspection

7.3.1 Type inspection should cover all the items required by this standard.

Type inspection should be carried out in case of one of the following cases:

a) Trial production of new products.

b) Major changes on any of the product design, production processes and raw materials.

c) Production resumed after more than one year of shutdown.

d) Delivery inspection results are significantly different from those of the last type inspection.

c) Type inspection is required by national quality technical supervision and inspection agencies.

7.3.2 The samples for type inspection should be chosen randomly from the qualified products stored in the finished product warehouse, and the number of the samples should not be less than 3 pieces. If one test result is unqualified, the doubled samples should be chosen from the same batch to reinspect. If still unqualified, this test item is unqualified.

8 Marking, packaging, storage and transportation

8.1 Marking and certification

8.1.1 The following information should be marked on each piece of wear-resistant pipes:

a) Manufacturer name or trademark.
b) Product name and serial number.
c) Product specification.
d) Medium flow direction.
e) Production date.
f) Drop warning marks.

8.1.2 Each batch of wear-resisting pipes delivered should be attached with the product use instruction and product certificate/quality certificate, and the contents of the product certificate should be included :

a) Product name.
b) Product specification and quantity.
c) The codes and names of the adopted standard.
d) Grades of wear-resistant pipes.
e) Serial number of the contract.
f) Product quality inspection results, the inspector, and the stamp of the inspection department.
g) Name and address of the manufacturer.

8.2 Packaging, storage and transportation

8.2.1 Anti-corrosion treatment should be conducted on the outer surface of the wear-resistant pipes.

8.2.2 The wear-resistant pipes should be properly tied and packed using straw mat, straw ropes, straw bags, wooden cases, pallets, frames, steel hoops or elastic materials.

8.2.3 The storage field of the wear-resistance pipes should be flat, dry and ventilated. The wear-resistant pipes should be well placed to prevent from rust, collision, deformation and damage. Both ends of the pipes should be sealed when necessary.

8.2.4 The wear-resistant pipes should be handled with care during loading and unloading, lifting, transportation, installation and maintenance processes, and must not be violently collided, thrown, dropped and struck.

Annex A
(Informative)
Application characteristics of wear-resistant pipes

Application characteristics of wear-resistant pipes are shown in Table A.1.

Table A.1 Application characteristics of wear-resistant pipes

Grades	Application characteristics
ZG40CrNiMoG	Good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
ZG45Cr2MoG	Good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
ZG40Cr5MoG	Good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
ZG42Cr2Si2MnMoG	Good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
NY45CrMnSiG	Good wear resistance, high strength, weldable, suitable for pulverized coal, ash and slurry conveying pipes
NY55CrMnSiG	Good wear resistance, high strength, weldable, suitable for pulverized coal, ash and slurry conveying pipes
NY65CrMnSiG	Good wear resistance, high strength, weldable, suitable for pulverized coal, ash and slurry conveying pipes
BTMCr30G	Corrosion resistance, good wear resistance, low strength, non-weldable, and suitable for limestone powder, gypsum, ash and slurry conveying pipes
BTMCr26G	Very good wear resistance, low strength, non-weldable, suitable for pulverized coal and ash conveying pipes
BTMCr20G	Very good wear resistance, low strength, non-weldable, suitable for pulverized coal and ash conveying pipes
BTMCr15G	Very good wear resistance, low strength, non-weldable, suitable for pulverized coal and ash conveying pipes
BTMCr12G	Good wear resistance, low strength, non-weldable, suitable for pulverized coal and ash conveying pipes
BTMCr8G	Good wear resistance, low strength, non-weldable, suitable for pulverized coal and ash conveying pipes
NY45CrMnSi-G	Good wear resistance, high strength, weldable, suitable for pulverized coal, ash and slurry conveying pipes
NY55CrMnSi-G	Good wear resistance, high strength, weldable, suitable for pulverized coal, ash and slurry conveying pipes
NY65CrMnSi-G	Good wear resistance, high strength, weldable, suitable for pulverized coal, ash and slurry conveying pipes
BTMCr30-G	Corrosion resistance, good wear resistance, high strength, weldable, suitable for limestone powder, gypsum,ash and slurry conveying pipes
BTMCr26-G	Very good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
BTMCr20-G	Very good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
BTMCr15-G	Very good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
BTMCr12-G	Good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
BTMCr8-G	Good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
DNM-Ⅳ-G	Very good wear resistance, weldable, suitable for ash and pulverized coal conveying pipes

Table A.1 (Continued)

Grades	Application characteristics
DNM-V-G	Very good wear resistance, weldable, suitable for ash and pulverized coal conveying pipes
TCR-G	Very good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
TCC-G	Very good wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes with the working temperature below 150℃
TCT-G	Excellent wear resistance, good erosion wear resistance, high strength, weldable, suitable for pulverized coal and ash conveying pipes
TCZ-G	Good wear and corrosion resistance, high strength, weldable, suitable for pulverized coal, ash and corrosive slurry conveying pipes
XJ-G	Good erosion wear resistance, high strength, non-weldable, suitable for ash conveying pipes with the working temperature of −40℃～100℃
WM-G	Very good wear resistance, high strength, high temperature resistance, weldable, suitable for dry powder conveying pipes with the working temperature below 850℃
ZS-G	Very good wear resistance, high strength, weldable, suitable for pulverized coal, ash and corrosive medium conveying pipes
YSiC-G	Excellent wear resistance, high temperature resistance, corrosion resistance, weldable, suitable for ash and pulverized coal conveying pipes
RSiC-G	Excellent wear resistance, high temperature resistance, corrosion resistance, weldable, suitable for ash and pulverized coal bends and corrosive medium conveying pipes