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NATIONAL STANDARD

OF THE PEOPLE'S REPUBLIC OF CHINA

中华人民共和国国家标准

GB/T 151-2014

Supersedes GB 151-1999

Heat Exchangers

热交换器

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GB/T 151-2014

Heat Exchangers
热交换器

1 Scope

1.1 This standard specifies general requirements of metallic heat exchangers as well as materials, design, fabrication, inspection, acceptance, installation and use requirements of tube-shell heat exchangers.

1.2 General requirements of this standard are applicable to the tube-shell heat exchangers and the heat exchangers in other structural types. All the provisions of this standard are applicable to tube-shell heat exchangers.

1.3 The design pressure to which this standard applies:

- a) Design pressure of tube-shell heat exchangers is not greater than 35MPa;
- b) Design pressure of the heat exchangers in other structural types shall be determined according to the corresponding normative references.

1.4 The design temperature to which this standard applies:

- a) Steel shall not exceed the permissible service temperature range of the materials listed in GB 150.2-2011;
- b) Design temperatures of other metal materials shall be determined according to the permissible service temperature of the materials listed in corresponding normative references.

1.5 In this standard, applicable nominal diameters of tube-shell heat exchangers shall not be greater than 4,000mm, and the product of design pressure (MPa) multiplied by nominal diameter (mm) shall not be greater than 2.7×10^4 .

1.6 The tube-shell heat exchangers beyond the scope of 1.5 may be fabricated and constructed by reference to this standard.

1.7 This standard does not apply to the following heat exchangers:

- a) Direct fired heat exchangers;
- b) Flue-type exhaust (waste) heat boiler;
- c) Heat exchangers with failure risk due to neutron damage in the nuclear-energy plant;
- d) Non-metallic heat exchangers;
- e) Heat exchangers otherwise specified in the national standards or professional standards in the refrigeration and air conditioning industry.

1.8 Defined range of heat exchanger;

- a) Connection between the heat exchanger and the external pipe:

- 1) The first welded groove end face of girth joint;
- 2) The first threaded end face of threaded joint;
- 3) The first flange seal surface of flange connection;
- 4) The first seal surface of special connecting piece or pipe fittings connection.
- b) Pressure head, flat-cover and its fasteners of connecting pipe, manhole, and handhole, etc.;
- c) Attachment weld between non-pressure components and pressure components;
- d) Non-pressure components directly connected to the heat exchangers, e.g. support and subplate;
- e) Overpressure relief devices mounted to the heat exchangers.

2 Normative References

The following documents are indispensable for the application of this standard. For dated references, only the dated edition is applicable to this document. For undated references, the latest editions of the normative documents (including all the amendments) are applicable to this document.

GB 150.1-2011	Pressure Vessels - Part 1: General Requirements
GB 150.2-2011	Pressure Vessels - Part 2: Materials
GB 150.3-2011	Pressure Vessels - Part 3: Design
GB 150.4-2011	Pressure Vessels - Part 4: Fabrication, Inspection and Testing, and Acceptance
GB/T 1527-2006	Drawn Tube of Copper and Copper Alloys
GB/T 1804	General Tolerances-Tolerances for Linear and Angular Dimensions without Individual Tolerance Indications
GB/T 2882-2013	Nickel and Nickel Alloys Tube
GB/T 3625-2007	Titanium and Titanium Alloy Tube for Condensers and Heat Exchangers
GB 5310	Seamless Steel Tubes and Pipes for High Pressure Boiler
GB/T 5313-2010	Steel Plate with Through-thickness Characteristics
GB 6479	Seamless Steel Tubes for High-pressure Chemical Fertilizer Equipments
GB/T 6893-2010	Aluminum and Aluminum Alloy Cold Drawn (Rolled) Seamless Tubes
GB/T 8890-2007	Seamless Copper Alloy Tube for Heat-exchanger
GB 9948	Seamless Steel Tubes for Petroleum Cracking
GB 13296	Seamless Stainless Steel Tubes for Boiler and Heat Exchanger
GB 16749	Bellows Expansion Joints for Pressure Vessel
GB/T 21832	Austenitic - Ferritic (Duplex) Grade Stainless Steel Welded Tubes and Pipes
GB/T 21833	Austenitic - Ferritic (Duplex) Grade Stainless Steel Seamless Tubes and Pipes
GB/T 24590	Enhanced Tubes for Efficient Heat Exchanger

GB/T 24593	Welded Austenitic Stainless Steel Tubes for Boiler and Heat-exchanger
GB/T 26283-2010	Zirconium and Zirconium Alloy Seamless Tubes
GB/T 26929	Terminology for Pressure Vessels
GB/T 28713	(All Parts) Enhanced Heat Transfer Elements Used in Tube-shell Heat Exchangers
GB/T 29463	(All Parts) Gaskets Used in Tube-shell Heat Exchangers
GB/T 29465	Shell Flange-rear Head End of Floating Heat Exchangers
NB/T 47002	(All Parts) Explosion Welded Clad Plate for Pressure Vessels
NB/T 47003.1 (JB/T 4735.1)	Steel Welded Atmospheric Pressure Vessels
NB/T 47004 (JB/T 4752)	Plate Heat Exchangers
NB/T 47006 (JB/T 4757)	Aluminum Plate-fin Heat Exchanger
NB/T 47007 (JB/T 4758)	Air Cooled Heat Exchanger
NB/T 47011	Zirconium Pressure Vessels
NB/T 47013.10 (JB/T 4730.10)	Nondestructive Testing of Pressure Equipments - Part 10: Ultrasonic Time of Flight Diffraction Technique
NB/T 47014 (JB/T 4708)	Welding Procedure Qualification for Pressure Equipment
NB/T 47019	(All Parts) Purchase Technical Specifications for Boiler & Heater Exchanger Tubes/Pipes
NB/T 47020 (JB/T 4700)	Type and Specification for Pressure Vessel Flanges
NB/T 47021 (JB/T 4701)	A-type Socket-weld Flange
NB/T 47022 (JB/T 4702)	B-type Socket-weld Flange
NB/T 47023 (JB/T 4703)	Welding Neck Flange
NB/T 47024 (JB/T 4704)	Nonmetallic Gaskets
NB/T 47025 (JB/T 4705)	Spiral Wound Gaskets
NB/T 47026 (JB/T 4706)	Double-jacketed Gaskets
NB/T 47027 (JB/T 4707)	Fasteners for Pressure Vessel Flanges
NB/T 47041-2014 (JB/T 4710)	Steel Vertical Vessels Supported by Skirt
JB/T 4711	Coating and Packing for Pressure Vessels Transport
JB/T 4712.1	Vessel Supports - part 1: Saddle Support

JB/T 4712.3	Vessel Supports - Part 3: Lug Support
JB/T 4730	(All Parts) Nondestructive Testing of Pressure Equipment
JB 4732-1995	Steel Pressure Vessels-Design by Analysis (Confirmed in 2005)
JB/T 4734	Aluminum Welded Vessels
JB/T 4745	Titanium Welded Vessels
JB/T 4751	Spiral Heat Exchanger
JB/T 4755	Copper Pressure Vessels
JB/T 4756	Nickel and Nickel Alloy Pressure Vessels
HG/T 20592	Steel Pipe Flanges (PN Designated)
HG/T 20615	Steel Pipe Flanges (Class Designated)
TSG R0004-2009	Supervision Regulation on Safety Technology for Stationary Pressure Vessel

3 Terms and Definitions

For the purposes of this standard, the terms and definitions defined in GB 150.1-2011 and GB/T 26929 and the following ones apply.

3.1

Nominal diameter

DN

- a) As for the rolled and the forged cylinder, the inner diameter (mm) is regarded as the nominal diameter of tube-shell heat exchangers.
- b) As for the tube cylinder, the outer diameter (mm) is regarded as the nominal diameter of tube-shell heat exchangers.
- c) As for the kettle-type reboiler, the inner (or outer) diameter (mm) of the header is regarded as the nominal diameter.

3.2

Heat transfer area

A

- a) Calculated heat transfer area, in m^2 , is the external surface area calculated based on the outer diameter of heat exchange tube, deducting the length of the heat exchange tube not involved in heat transfer.
- b) Nominal heat transfer area, in mm^2 , is the calculated heat transfer area rounded off to an integer.

3.3

Nominal length

LN

The length (mm) of the heat exchange tube is regarded as the nominal length of tube-shell heat exchangers. As for straight heat exchange tube, it is the length of straight tube; as for U-shaped heat exchange tube, it is the straight length of U-tube.

3.4

Tubeside & shellside

- a) Tubeside - the medium flowing through the passage and the part connected through

with the passage inside the heat exchange tube

b) Tubeside - the medium flowing through the passage and the part connected through with the passage outside the heat exchange tube

c) Number of tubesides (N_t) - times of the medium flowing to and from along the length of heat exchange tube

d) Number of shellsides (N_s) - times of the medium flowing to and from along the length of heat exchange tube inside the shellsides

3.5

Grade I bundle

The steel bundle in which permissible deviation of outer diameter of heat exchange tube in accordance with those specified in Table 6-6, tube hole diameter and permissible deviation of tube sheet in accordance with those specified in Table 6-10, and tube hole diameter and permissible deviation of baffle and supporting plate in accordance with those specified in Table 6-22.

3.6

Grade II bundle

The steel bundle in which permissible deviation of outer diameter of heat exchange tube in accordance with those specified in Table 6-7, tube hole diameter and permissible deviation of tube sheet in accordance with those specified in Table 6-11, and tube hole diameter and permissible deviation of baffle and supporting plate in accordance with those specified in Table 6-23.

3.7

Strength expansion

The expansion that expansion strength of heat exchange tube and tube sheet meets the axial (pulling or compressing) mechanical and the temperature difference load design requirements and ensures the sealing performance of heat exchange tube.

3.8

Light expansion

Slight expansion for the purpose of eliminating the gap between heat exchange tube and tube sheet/hole

3.9

Strength weld

The welding that welding strength of heat exchange tube and tube sheet meets the axial (pulling or compressing) mechanical and the temperature difference load design requirements and ensures the sealing performance of heat exchange tube.

3.10

Seal weld

The welding that ensures tube-to-tubesheet joint free from leaking

3.11

Tubes welded to backside of tubesheet

The welding that forms butt joint or jogged joint by butt weld between heat exchange tube and tube sheet on the side of shellside

4 General Requirements

4.1 General Rules

4.1.1 Heat exchangers shall meet the general requirements of this standard and comply with the relevant laws, regulations and safety specifications issued by the country. For the declaration of conformity of this standard, see Appendix A.

4.1.2 Tube-shell heat exchangers shall meet the requirements of this standard; the heat exchangers in other structural types shall not only meet the general requirements of this standard but also satisfy the requirements of the following corresponding standards:

- a) JB/T 4751 *Spiral Heat Exchanger*;
- b) NB/T 47004 (JB/T 4752) *Plate Heat Exchangers*;
- c) NB/T 47006 (JB/T 4757) *Aluminum Plate-fin Heat Exchanger*;
- d) NB/T 47007 (JB/T 4758) *Air Cooled Heat Exchanger*.

4.1.3 The tube-shell heat exchangers made of other types of metal, e.g. aluminum, titanium, copper, nickel and zirconium or the pressure components shall not only comply with this standard but also meet the requirements of the following corresponding standards:

- a) JB/T 4734 *Aluminum Welded Vessels*;
- b) JB/T 4745 *Titanium Welded Vessels*;
- c) JB/T 4755 *Copper Pressure Vessels*;
- d) JB/T 4756 *Nickel and Nickel Alloy Pressure Vessels*;
- e) NB/T 47011 *Zirconium Pressure Vessels*.

4.1.4 Design organization and fabrication organization of heat exchangers shall establish sound quality management systems and guarantee effective operation of them.

4.1.5 The heat exchangers within the scope of TSG R 0004-2009 shall be subjected to the supervision by the safety supervision organizations for special equipment with regard to design, fabrication, installation and use.

4.1.6 As for the heat exchangers or pressure components to which the design and calculation methods in GB 150.3-2011, this standard and corresponding normative references do not apply, they may be designed according to the method specified in 4.1.6 of GB 150.1-2011.

4.1.7 As for the heat exchangers or pressure components having a design pressure lower than 0.1 MPa and vacuum degree lower than 0.02 MPa, they may be designed according to the relevant requirements of NB/T 47003.1 (JB/T 4735.1) and this standard.

4.2 Qualifications and Responsibilities

4.2.1 Qualifications

As for the heat exchangers within the scope of TSG R 0004-2009, their design and fabrication organizations shall hold corresponding special equipment permits.

4.2.2 Responsibilities

4.2.2.1 Responsibilities of the user or the design client

The user or the design client of heat exchangers shall propose design conditions (UDS - *User's Design Specification*) to the design organization in formal written form. The design conditions shall cover at least:

- a) Main standards and specifications on which the design is based;

- b) Operating parameters (including working pressure, working temperature range, liquid level, load on connecting pipe and cyclic load);
- c) Application place and its natural conditions (including ambient temperature, seismic fortification intensity, wind and snow loads);
- d) Components and characteristics of medium;
- e) Expected service life;
- f) Geometric parameters and nozzle orientation;
- g) Grade of steel bundle;
- h) Other necessary design conditions.

4.2.2.2 Responsibilities of design organization

Design organization of the heat exchangers shall be liable to the following ones as a minimum:

- a) Correctness and completeness of design documents;
- b) The design documents of heat exchangers consisting of strength calculation sheet, design drawings, technical requirements for fabrication, and risk assessment report (if required in relevant laws and regulations or by the design client) as a minimum, and also the instructions for installation, use and maintenance where necessary;
- c) The general design drawings for the heat exchangers within the scope of TSG R 0004-2009 being stamped with the design licensing stamp for special equipment;
- d) Preservation requirements for all the design documents of the tube-shell heat exchangers requiring preservation within the design service life and for the design documents of the heat exchangers in other structural types in accordance with the corresponding standards.

4.2.2.3 Responsibilities of fabrication organization

Fabrication organization of the heat exchangers shall be liable to the following ones as a minimum:

- a) Fabrication organization shall perform fabrication according to the requirements of the design documents, obtain the written document for consent of modification from the original design organization prior to making any modification to the original design where necessary, and record the modified part in detail;
- b) Prior to fabrication, fabrication organization shall prepare a sound quality plan which shall at least include the control point of fabrication process, inspection items and acceptable indexes for heat exchangers or elements;
- c) Inspection department from the fabrication organization shall perform inspection and test for the heat exchangers item by item according to the requirements of the standards, the drawings and the quality plan during fabrication process and upon completion, and issue corresponding reports. Besides, it shall be responsible for correctness and completeness of the reports it issued;
- d) Fabrication organization shall issue product quality certificates for the heat exchangers that pass the inspection;
- e) Fabrication organization shall at least preserve the following technical documents within its design service life for every tube-shell heat exchanger it fabricated:
 - 1) Quality plan;
 - 2) Fabrication flow diagram or fabrication dispatch;

- 3) Product quality certificates;
- 4) Welding procedure and heat treatment process documents;
- 5) Records on inspection and test items optional to the fabrication organization in the standard;
- 6) Check, inspection and test records during fabrication process and upon completion;
- 7) Original design drawings and as-built drawings;
- f) Preservation requirements for the fabrication technology documents of the heat exchangers in other structural types shall comply with corresponding standards.

4.3 Process Calculation

4.3.1 Design conditions

4.3.1.1 The user or the design client of heat exchangers shall propose the design conditions to the design organization in formal written form. The design conditions shall cover at least:

- a) Operating data, including flow, vapor fraction, temperature, pressure and thermal load;
- b) Physical property data, including medium density, specific heat, viscosity, heat conductivity coefficient or composition;
- c) Permissible resistance drop;
- d) Others, including operating flexibility, operating condition, and installation requirements (geometric parameters, nozzle orientation).

4.3.1.2 See Table B.1 of Appendix B for data of tube-shell heat exchangers.

4.3.2 Type selection and calculation

4.3.2.1 The following factors shall be taken into consideration for the type selection of heat exchangers:

- a) Reasonable selection for types and basic parameters of heat exchangers, so as to meet the requirements of heat transfer, safety reliability and energy efficiency;
- b) Economical efficiency and reasonable material selection;
- c) Installation, operation, maintenance and other requirements of heat exchangers satisfied.

4.3.2.2 In the process calculation, heat exchangers shall be optimized, so as to improve heat transfer efficiency and meet the requirements of process design conditions. See Appendix B for calculation of heat transfer without phase change for tube-shell heat exchangers. Vibration caused by fluid shall also be taken into consideration for the tube-shell heat exchangers where necessary, see Appendix C for calculation. See Appendix D for physical property data of common fluids; see Appendix E for fouling resistance; and see Appendix F for heat conductivity coefficients of metals.

4.4 General Design Requirements

4.4.1 Loads

4.4.1.1 The following loads shall be taken into consideration in the design:

- a) Internal pressure, external pressure or the maximum differential pressure;
- b) Acting forces caused by different expansion;
- c) The static pressure of liquid column, which may be negligible if it is lower than 5% of the design pressure.

4.4.1.2 The following loads shall also be taken into consideration where necessary:

- a) Deadweight of the heat exchanger and gravity load of the inside medium under

normal working condition or pressure-tight test condition;

- b) Gravity loads of auxiliary equipment and thermal insulation materials, lining, pipes, escalators, and platforms, etc.;
- c) Wind load, seismic load and snow load;
- d) Reactive force of support and other types of supporting elements;
- e) Acting force of connecting pipes and other components;
- f) Acting forces caused by temperature gradients;
- g) Impact loads, including the impact load generated by rapid pressure fluctuation, the counter force caused by fluid impact, etc.;
- h) Acting force in transportation or hoisting.

4.4.2 Design pressure or calculated pressure

Design pressure or calculated pressure shall be determined according to the following provisions:

- a) If heat exchangers are equipped with overpressure relief devices, the design pressure shall be determined according to the requirements of Appendix B of GB 150.1-2011;
- b) The design pressure for each side (pressure chamber) of heat exchangers shall be determined respectively according to the respective severest working conditions;
- c) If the heat exchangers may operate under negative pressure, the calculated pressure of elements shall be determined in consideration of the possible maximum pressure difference under the normal working conditions;
- d) The design pressure on the vacuum side shall be considered according to the bearable external pressure; if the safety control device (e.g. vacuum relief valve) is mounted, the design pressure shall be 1.25 times of the maximum inner and outer pressure difference or 0.1 MPa, whichever is less; if not, the design pressure shall be 0.1 MPa;
- e) As for the elements under the action of pressure of each side (pressure chamber) that ensure not exceeding the set differential pressure within the whole service life, they may be designed according to the differential pressure; otherwise, their calculated pressures shall be determined respectively according to the design pressure of each side (pressure chamber) and in consideration of the possible severest pressure combinations; in the case of differential-pressure-based design, differential pressure value shall be determined in consideration of the possible maximum differential pressure value that may appear in the pressure-tight test, the differential pressure based shall be defined in the design document, and the requirements for differential pressure assurance shall be proposed in the pressure-tight test.

4.4.3 Design temperature

Determination of design temperature shall conform to the following provisions:

- a) The design temperature of each side (pressure chamber) of heat exchangers shall be determined respectively according to their respective severest working conditions; if each part has different metal temperatures under working conditions, the design temperature may be designed respectively; the design temperature of shellside and that of tubeside are the same as the design temperature of shellside shell and header shell respectively;
- b) The design temperature shall not be less than the possible maximum temperature of the metal components under working conditions; if the metal has a temperature less than 0°C, its design temperature shall not be higher than the possible minimum temperature of the metal

components; under any circumstances, surface temperature of the metal components shall not exceed the permissible service temperature of the materials;

c) As for the elements under the action of temperature of the medium on both sides, the design temperature shall be determined according to their metal temperature;

d) Metal temperature of the elements shall be determined by the following methods:

1) Heat transfer calculation;

2) Measurement on the given similar heat exchangers;

3) Determination in accordance with medium temperature and in combination with external conditions.

4.4.4 Combinations of working conditions

The heat exchangers under different working conditions shall be designed according to the severest one; combinations of different working conditions shall also be taken into consideration where necessary, and the drawings or corresponding technical documents shall state the pressure and temperature values under the operating conditions and the design conditions of each working condition.

4.4.5 Additional thickness

4.4.5.1 The additional thickness shall be determined according to Formula (4-1):

$$C=C_1+C_2 \quad (4-1)$$

Where,

C—the additional thickness, mm;

C₁—the negative deviation of materials thickness, according to the requirements of 4.4.5.2, mm;

C₂—the corrosion allowance, according to the requirements of 4.4.5.3, 4.4.5.4 and 4.4.5.5, mm.

4.4.5.2 Negative thickness deviation of sheet material or tube material shall meet the requirements of corresponding material standards.

4.4.5.3 Corrosion allowance shall be taken into consideration since there is possibility that elements of heat exchangers weakened and thinned due to corrosion and mechanical wear:

a) As for the elements subjected to uniform corrosion and wear, the corrosion allowance shall be determined according to the expected service life and the corrosion rate of the medium on the metal material;

b) Different corrosion allowance may be adopted for different elements due to their difference in corrosion degree;

c) Carbon steel or low alloy steel heat exchangers using compressed air, vapor or water as the medium shall have a corrosion allowance not less than 1mm.

4.4.5.4 Considerations for corrosion allowance of elements of tube-shell heat exchangers as the following principles:

a) Corrosion allowance shall be taken into consideration for both sides of tube sheet, floating head flange and spherical cap head;

b) Corrosion allowance shall be taken into consideration for internal surface of header flat-cover, convex head, header and shell;

c) When slotting is made on tube sheet and header flat-cover, the metal above the lower surface of partition slot is regarded as the corrosion allowance, which shall be added

4.7.2 Category and requirements of pressure-tight test shall be noted in the drawings.

4.7.3 As for the heat exchangers designed according to differential pressure, the specific requirements for pressure rise and drop during pressure-tight test shall be noted in the drawings.

4.7.4 As for the tube-shell heat exchangers with tubeside design pressure higher than shellside design pressure, the test methods and pressure of tube head shall be noted in the drawings.

4.8 Leakage Test

4.8.1 Leakage test shall meet the requirements of 4.7 in GB 150.1-2011.

4.8.2 Category and requirements of leakage test shall be noted in the drawings.

5 Materials

5.1 General Provisions

5.1.1 Steel grade and standard, additional technical requirements, limited range (e.g. pressure and temperature) and permissible stress of steel pressure components for tube-shell heat exchangers shall meet the requirements of Appendixes A and D of GB 150.2-2011; for reference values of high-temperature property, see Appendix B of GB 150.2-2011.

5.1.2 As for the other metal materials, e.g. aluminum, titanium, copper, nickel and zirconium, for pressure components of tube-shell heat exchangers, their technical requirements, limited range (e.g. designation, pressure and temperature) and permissible stress shall meet the requirements of TSG R 0004-2009 and the normative references of this standard.

5.2 Cylinder and Head

The materials used for fabricating cylinder or head of tube-shell heat exchangers shall meet the relevant requirements of normative references GB 150.1-2011 and GB 150.2-2011.

5.3 Tube Sheet, Header Flat-cover and Flange

5.3.1 Forging

Steel forgings for fabricating tube sheet, header flat-cover and flange shall meet the requirements of Chapter 6 of GB 150.2-2011 and forging shall not be less than Grade II.

5.3.2 Sheet material

5.3.2.1 Sheet materials for fabricating tube sheet, header flat-cover and equipment flange shall meet the relevant requirements of GB 150.2-2011 as well as the normative references listed in GB 150.1-2011. When shouldered tube sheet, tubes welded to backside of tubesheet and header flat-cover (No. 11~14 flat-cover in Table 5-10 of GB 150.3-2011) are directly fabricated with rolled sheet materials, the through-thickness characteristic of carbon steel and low alloy steel shall not be lower than Grade Z35 in GB/T 5313-2010 and the additional inspection requirements shall be proposed in the design documents.

5.3.2.2 Surfacing or explosion welded clad tubesheet may be adopted. The explosion welded clad tubesheet, if adopted, shall meet the requirements of Class B1 in NB/T 47002.1~47002.4; surfacing clad tubesheet should be adopted for the heat exchange tube subjected to axial compression stress.

5.3.3 Lining

5.3.3.1 Header flat-cover and flange may be in the composite structure of (loose) lining (lining plate and bush ring).

5.3.3.2 Composite structure of lining shall not be used in the following situations:

- a) Design temperature higher than 300℃;
- b) Vacuum working condition exists in the working process;
- c) Medium toxicity is extremely or highly hazardous.

5.4 Heat Exchange Tube

5.4.1 Steel heat exchange tube shall meet the requirements of GB 150.2-2011 and the normative references in Chapter 4 of this standard. See Appendix G for the properties of common heat exchange tubes; see the following tube material standard for designations and requirements of common heat exchange tubes:

- a) GB/T 1527 *Drawn Tube of Copper and Copper Alloys*;
- b) GB/T 2882 *Nickel and Nickel Alloys Tube*;
- c) GB/T 3625 *Titanium and Titanium Alloy Tube for Condensers and Heat Exchangers*;
- d) GB 5310 *Seamless Steel Tubes and Pipes for High Pressure Boiler*;
- e) GB 6479 *Seamless Steel Tubes for High-pressure Chemical Fertilizer Equipments*;
- f) GB/T 6893 *Aluminum and Aluminum Alloy Cold Drawn (Rolled) Seamless Tubes*;
- g) GB/T 8890 *Seamless Copper Alloy Tube for Heat-exchanger*;
- h) GB 9948 *Seamless Steel Tubes for Petroleum Cracking*;
- i) GB 13296 *Seamless Stainless Steel Tubes for Boiler and Heat Exchanger*;
- j) GB/T 21832 *Austenitic - Ferritic (Duplex) Grade Stainless Steel Welded Tubes and Pipes*;
- k) GB/T 21833 *Austenitic - Ferritic (Duplex) Grade Stainless Steel Seamless Tubes and Pipes*;
- l) GB/T 24593 *Welded Austenitic Stainless Steel Tubes for Boiler and Heat-exchanger*;
- m) GB/T 26283 *Zirconium and Zirconium Alloy Seamless Tubes*;
- n) NB/T 47019.1~47019.8 *Purchase Technical Specifications for Boiler & Heater Exchanger Tubes/Pipes*.

5.4.2 It is allowed to use the enhanced heat transfer tube that conforms to the following standards, and the application scope and base materials shall also meet the requirements of GB 150.2-2011 and the relevant standards:

- a) GB/T 24590 *Enhanced Tubes for Efficient Heat Exchanger*;
- b) GB/T 28713.1 *Enhanced Heat Transfer Elements Used in Tube-shell Heat Exchangers -Part 1: Threaded Tubes*;
- c) GB/T 28713.2 *Enhanced Heat Transfer Elements Used in Tube-shell Heat Exchangers- Part 2: Stainless Steel Corrugated Tubes*;
- d) GB/T 28713.3 *Enhanced Heat Transfer Elements Used in Tube-shell Heat Exchangers - Part 3: Wavy Tubes*

5.4.3 Welded steel tube in GB/T 24593 and GB/T 21832 can be used as heat exchange tube only when they also meet the relevant requirements of 5.2 in GB 150.2-2011.

5.4.4 Zirconium and zirconium alloy seamless tubes can be used as heat exchange tubes only when they meet the requirements of tube materials for the heat exchangers for general industry.

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