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Construction of pressure vessel — General principles

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Health, Labour and Welfare and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee, as the result of proposal for revision of Japanese Industrial Standard submitted by Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently **JIS B 8265**:2000 is replaced with this Standard.

This revision was made in order to harmonize the standard with the technical rules of various mandatory regulations (four laws relating to pressure vessels including High Pressure Gas Safety Law, Industrial Safety and Health Law, Electricity Utilities Industry Law and Gas Utility Industry Law) as much as possible and to eliminate duplication with **JIS B 8270** [Pressure vessles (General standard)] series. Therefore, in conjunction with this revision, **JIS B 8270** [Pressure vessels (General standard)] series will be revised.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Ministers and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

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Construction of pressure vessel – General principles

Introduction This Japanese Industrial Standard, due to its establishment process, had many elements not sufficiently harmonized with various mandatory regulations. In this revision, in order to ensure more effective use of this Standard, it was intended to harmonize this Standard with those technical rules as much as possible and to eliminate duplication with other Japanese Industrial Standards relating to pressure vessels.

1 Scope

1.1 Applicable pressure vessels This Standard applies to the construction and fixtures of pressure vessels with the design pressure of less than 30 MPa. The pressure vessels refer to vessels which retain pressure exceeding the ambient pressure or contain fluid generating pressure, or to those subjected to external pressure (hereafter referred to as "pressure vessels"). However, following pressure vessels are excluded:

a) those within the scope of other Japanese Industrial Standards concerning pressure vessels (1);

b) those made of non-metallic materials;

c) those used for atomic energy;

d) those with riveted or soldered structure;

e) those exposed to direct fire;

f) those with special structures (2) or for special applications (3).

Notes (1) Examples are shown below.

Ex.1 **JIS B 8201** *Stationary steel boilers — Construction* (4)

Ex.2 **JIS B 8240** *Construction of pressure vessels for refrigeration*

Ex.3 **JIS B 8241** *Seamless steel gas cylinders*

Ex.4 **JIS B 8248** *Cylindrical layered pressure vessels*

Ex.5 **JIS B 8501** *Welded steel tanks for oil storage*

(2) Such as those with complicated shapes, flat-bottom cylindrical tanks for low temperature and tanks with membrane structure.

(3) Pressure sections of rotating or reciprocating machines such as oil or water pressure machines, pumps, compressors, turbines, internal combustion engines, water or pneumatic pressure cylinders.

(4) Waste heat boilers are covered by **JIS B 8201** and out of the scope of this Standard.

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1.2 Scope of pressure vessels

1.2.1 Scope of pressure vessels shall include the main body (shells, end plates and nozzles directly connected to them) and the sections shown in a) to c) below:

a) fixing sections of external piping,

   1) to the first circumference joint (excluding the welded joint), for welded joints;

   2) to the first screwed joint, for screwed joints;

   3) to the first flange surface, for bolted flanged joints;

b) sections to the welded joint, in case the fixtures are welded directly onto the pressured sections;

c) sections to the cover plate subjected to pressure such as manhole and hand hole (including welded joints, bolts and nuts and gaskets).

2 Normative references The standards listed in attached table 1 contain provisions which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of coming into effect is given to these referred standards, only the edition of the indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply.

3 Definitions For the purposes of this Standard, the definitions given in **JIS B 0190** and the following definitions apply:

a) **calculated thickness** thickness required for strength;

b) **thickness** generic term for nominal thickness or actual thickness;

c) **nominal thickness** nominal dimensions of thickness of such as plates and pipes.

4 Materials

4.1 Materials in general Materials in general shall be as follows.

a) **Materials** Materials shall be the specified materials listed in attached table 2.1.1, attached table 2.1.2, attached table 2.2 and attached table 3.1.

b) **Working temperature range of materials** The specified materials listed in attached table 2.1.1, attached table 2.1.2, attached table 2.2 and attached table 3.1 shall not be used exceeding the maximum temperature shown in these tables. The lower limit of working temperature shall be in accordance with the specifications separately defined.

4.2 Steel materials

4.2.1 Usege restriction of steel materials Use of steel materials shall be restricted as shown below.

a) **Usege restriction in general** Those steel materials containing over 0.35 % (cast analysis value) of carbon shall not be used in the welded structure.

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b) **Usege restriction of steel materials listed in attached table 2.1.1 and attached table 2.1.2** Use of steel materials listed in attached table 2.1.1 and attached table 2.1.2 shall be restricted as shown below.

1) Those materials based on **JIS G 3106** (excluding SM400A, SM490A and SM490YA) and **JIS G 3114** (excluding SMA400AW, SMA400AP, SMA490AW and SMA490AP) shall not be used for the shells, end plates and other similar sections of pressure vessels with the design pressure of over 3 MPa.

2) SM400A, SM490A and SM490YA of **JIS G 3101** and **JIS G 3106**, SMA400AW, SMA400AP, SMA490AW and SMA490AP of **JIS G 3114**, and those based on **JIS G 3457** shall not be used in the sections of pressure vessels listed below.

2.1) Shells, end plates and other similar sections of pressure vessels with the design pressure of over 1.6 MPa;

2.2) Pressure vessels with the design pressure of over 1 MPa, which have longitudinal welded joints on the shell, and which have welded joints on the end plates;

2.3) Shells, end plates and other similar sections of pressure vessels which have welded joints of which base metal thickness is over 16 mm;

2.4) Shells, end plates and other similar sections of pressure vessels intended for containing lethal substances or toxic substances.

3) Those based on **JIS G 3452** shall not be used for sections of pressure vessels listed below.

3.1) Those with the design pressure of over 1 MPa ;

3.2) Those with the design temperature of below 0 ℃ or over 100 ℃. However, in case containing compressed air, vapor or water, they can be used up to 200 ℃, and in case containing fluid with the design pressure of less than 0.2 MPa, they can be used up to 350 ℃ ;

3.3) Those intended for containing lethal substances, toxic substances or liquefied gas with the design pressure of over 0.2 MPa.

4.3 Allowable stress of materials

4.3.1 Allowable tensile stress Allowable tensile stress of materials at the design temperature shall be as follows.

a) Allowable tensile stress of steel materials shall be the values specified in attached table 2.1.1 and attached table 2.1.2.

b) Allowable tensile stress of nonferrous metal materials shall be the values specified in attached table 2.2,

c) Allowable tensile stress of bolt materials shall be the values specified in attached table 3.1.

d) In attached table 2.1.1, attached table 2.1.2, attached table 2.2 and attached table 3.1, allowable tensile stress of materials at the temperature from lower limit of

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working temperature up to 40 ℃ shall be the values in the columns for 40 ℃.

4.3.2 Allowable shearing stress Allowable shearing stress of materials at the design temperature shall be 0.8 times the value of the allowable tensile stress.

4.3.3 Allowable compression stress Allowable compression stress of materials at the design temperature shall be the smaller value of either the allowable tensile stress of materials at the design temperature or the allowable buckling stress obtained from the formula specified in **a)** or **b)** below according to the type specified in the following **a)** or **b)**.

a) **Cylindrical shells**

$$\sigma_{cr} = \frac{0.3Et}{D_m(1+0.004E/\sigma_y)}$$

where, σ_{cr} : Allowable buckling stress(N/mm^2)

E : Longitudinal elastic coefficient of the material at the design temperature (N/mm^2)

t : Calculated thickness of the shell (mm)

D_m : Mean diameter of the shell (mm)

σ_y : Yield point or the 0.2 % yield strength of the material at the design temperature (N/mm^2)

b) **Tubes** Allowable buckling stress shall be the value obtained from the formula given in **1)** when the following conditional equation is satisfied or **2)** when the following conditional equation is not satisfied.

Conditional equation $\sqrt{\frac{2\pi^2 E}{\sigma_y}} \leqq \frac{kl}{i}$

where k : a factor depending on the supporting method of the tube, given in the right columns of the following table according to the supporting of the tube in the left columns.

Supported by the tube plates	0.6
Supported by the tube plates and the baffle	0.8
Supported by the baffles	1.0

l : supporting span of the tube (mm)

i : radius-of-gyration of area (mm)

$i = \sqrt{I/a}$

I : geometrical moment of inertia of the tube (mm^4)

a : cross-section of the tube (mm^2)

E : σ_y is given in **4.3.3 a)**.

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1)

$$\sigma_{cr} = \frac{\pi^2 E}{2\left(\frac{kl}{i}\right)^2}$$

2)

$$\sigma_{cr} = \frac{\sigma_y}{2}\left(1 - \frac{\frac{kl}{i}}{2\sqrt{\frac{2\pi^2 E}{\sigma_y}}}\right)$$

where σ_{cr}, E, σ_y, k, l and i are given in a) and b).

4.3.4 Allowable bending stress Allowable bending stress of materials at the design temperature shall be 1.5 times the value of the allowable tensile stress. However, in the case when existance of other specifications, they shall apply.

4.4 Various properties of materials used in the design Various properties of materials used in the design shall be as follows.

a) Longitudinal elastic coefficient of the material is given in attached table 4.1.

b) Coefficient of linear expansion of the material is given in attached table 4.2.

c) Yield point or the 0.2 % yield strength of steel materials (excluding stainless steel) is given in attached table 5.1.

d) Yield point or the 0.2 % yield strength of stainless steel is given in attached table 5.2.

e) Yield point or the 0.2 % yield strength of stainless cast steel is given in attached table 5.3.

f) Yield point or the 0.2 % yield strength of nickel-chrome iron alloy is given in attached table 5.4.

g) Yield point or the 0.2 % yield strength of nonferrous metal materials is given in attached table 5.5.

5 Design

5.1 Design in general Quantity symbols of dimensions used in the design designate dimensions excluding corrosion allowances.

5.1.1 Minimum restricted thickness Minimum restricted thickness of shells and other sections subjected to pressure shall be the values listed below. However, bellows-type expansion joints, inner and outer tubes of double tube heat exchangers, and the heat-pipes of multi-tube heat exchangers with the nominal diameters no more than 6B shall be excluded.

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a) **Carbon steel or low alloy steel** 2.5 mm or more (3.5 mm or more when corrosion or wear is anticipated)

b) **High alloy steel or nonferrous metal** 1.5 mm or more (2.5 mm or more when corrosion or wear is anticipated)

5.1.2 Clad steel Strength of clad steel can include the strength of cladding metals by the following formula specified in **a)**. However, the clad steel shall be the specified material in **b)** below.

a) Allowable tensile stress of clad steel including the strength of cladding metal is given by the following formula:

$$\sigma_a = \frac{\sigma_b t_b + \sigma_c t_c}{t_b + t_c}$$

where σ_a : Allowable tensile stress of the clad steel at the design temperature (N/mm^2)

σ_b : Allowable tensile stress of the base metal at the design temperature (N/mm^2)

σ_c : Allowable tensile stress of the cladding metal at the design temperature (N/mm^2)

t_b : Thickness of the base metal (mm)

t_c : Thickness of the cladding metal (mm)

b) The clad steel shall be the material conforming to the following standards:

1) Type 1 of **JIS G 3601**

2) Type 1 of **JIS G 3602**

3) Type 1 of **JIS G 3603**

4) Type 1 of **JIS G 3604**

c) **Cladding by welding** When the quality of a clad section by welding is equivalent to or better than that of the cladding metal, that section may be assumed to be cladding metal.

5.1.3 Holes provided in pressure vessels Holes provided in pressure vessels shall be as follows.

a) Pressure vessels shall be provided with holes for inspection, repairing and cleaning, etc. However, following pressure vessels are excluded.

1) Those with the inner diameter of the shell of 300 mm or less.

2) Those with the inner diameter of the shell of 500 mm or less and equipped with two or more removable tubes with the outer diameter of 40 mm or more.

3) Those with removable end plates or cover plates whose sizes are not less than that of the hole specified in **b)**.

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4) Those which have no possibility of corrosion but require air-tight structure, to which two or more removable tubes with the outer diameter of 40 mm or more are fixed.

5) Those for heat exchangers or others which can be considered not to need holes for inspection, repairing and cleaning, etc., because of their structures, types or applications.

b) The number and the dimension of the hole in **a)** shall be as follows depending on the inner diameter of the shell.

1) When the inner diameter of the shell is over 300 mm up to and including 500 mm, two or more holes shall be provided, one or more of which shall be an ellipse with the major axis of 75 mm or more and the minor axis of 50 mm or more, or a circle with the diameter of 75 mm or more.

2) When the inner diameter of the shell is over 500 mm up to and including 1 000 mm, one manhole shall be provided shaped in an ellipse with the major axis of 375 mm or more and the minor axis of 275 mm or more, or a circle with the diameter of 375 mm or more, or an oval with the major axis of 400 mm or more and the minor axis of 250 mm or more. However, this does not apply when two or more holes are provided one or more of which is an ellipse with the major axis of 90 mm or more and the minor axis of 70 mm or more, or a circle with the diameter of 90 mm or more.

3) When the inner diameter of the shell exceeds 1 000 mm, one or more manhole(s) specified in **2)** shall be provided.

5.2 Shells and end plates

5.2.1 Shells subjected to inner pressure Shells subjected to internal pressure shall be as follows:

a) **Cylindrical shells** Calculated thickness of cylindrical shells is given in **2.2** of annex 1.

b) **Spherical shells** Calculated thickness of spherical shells is given in **2.3** of annex 1.

c) **Conical shells** Shapes of conical shells are given in figure 5.1. Calculated thickness of conical shells is given in **2.4** of annex 1.

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