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JAPANESE INDUSTRIAL STANDARD

Seamless Steel Gas Cylinders

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In the event of any doubt arising,
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Seamless Steel Gas Cylinders

B 8241-1989

1. Scope

This Japanese Industrial Standard specifies the seamless steel gas cylinders for high pressure gases, hereinafter referred to as the "cylinders", that have a water capacity exceeding 1.0 l but not exceeding 700.0 l.

Remarks 1. For the purpose of this Standard, the term "high pressure gases" means compressed gases and liquefied gases.

2. The units and numerical values given in { } in this Standard are based on the traditional unit system and are appended for informative reference.

2. Definitions

For the purpose of this Standard, the following definitions apply:

- (1) compressed gas A compressed gas under a pressure (gauge pressure, hereinafter the same rule applies) of 10 bar {10 kgf/cm²} or over at a temperature of 35°C.
- (2) liquefied gas A liquefied gas under a pressure of 2 bar {2 kgf/cm²} or over at a temperature of 40°C. Liquefied ethylene oxide and liquefied hydrogen cyanide are included in the liquefied gases in this Standard.
- (3) hydraulic test pressure The pressure to be applied to the hydraulic test of the finished cylinder and to be used for the thickness calculation of the cylinder.
- (4) maximum filling pressure The maximum value of pressure under which it is permitted to fill a cylinder with a permanent gas at a temperature of 35°C. For compressed gas, this is equal to 3/5 of the hydraulic test pressure of the cylinder. For liquefied gases, it is equal to 3/5 of the hydraulic test pressure given in Table 4.
- (5) calculated thickness of cylindrical shell Thickness set up by calculation so that the stress produced on the cylindrical shell of the cylinder under hydraulic test pressure does not exceed the allowable stress of the material to be used.
- (6) minimum thickness of cylindrical shell Thickness not less than the calculated thickness to be guaranteed by the cylinder manufacturer making allowances for the pads attendant upon cylinder production.

Applicable Standards and Reference Standard: See page 26.

3. Classification

The classification of the cylinders according to the materials used and heat treatments shall be as given in Table 1.

Table 1. Classification

Classification		Material used	Heat treatment
Carbon steel cylinder	Class 1	Carbon steel having a carbon content of 0.25 % or less	Annealing or normalizing
	Class 2	Carbon steel having a carbon content of 0.33 % or less	
Manganese steel cylinder	Class 1	Manganese steel	Either normalizing or normalizing and tempering
	Class 2		Quenching and tempering
Chromium molybdenum steel cylinder		Chromium molybdenum steel	Quenching and tempering
Nickel chromium molybdenum steel cylinder		Nickel chromium molybdenum steel	Quenching and tempering
Austenitic stainless steel cylinder	Class 1	Austenitic stainless steel	No heat treatment
	Class 2		Solution treatment
Austenitic ferritic stainless steel cylinder		Austenitic ferritic stainless steel	Solution treatment

4. Design

4.1 Minimum Thickness of Cylindrical Shell The thickness of the cylindrical shell of the cylinder shall be not less than the value calculated from the following formula using the allowable stress given in Table 2 (calculated thickness of cylindrical shell), provided that the minimum value for all the cylinders shall be the value given in Table 3.

$$t = \frac{D}{2} \left(1 - \sqrt{\frac{10S - 1.3P}{10S + 0.4P}} \right) \quad \text{or} \quad t = \frac{d}{2} \left(\sqrt{\frac{10S + 0.4P}{10S - 1.3P}} - 1 \right)$$

$$\left\{ t = \frac{D}{2} \left(1 - \sqrt{\frac{100S - 1.3P}{100S + 0.4P}} \right) \quad \text{or} \quad t = \frac{d}{2} \left(\sqrt{\frac{100S + 0.4P}{100S - 1.3P}} - 1 \right) \right\}$$

where t : calculated thickness of cylindrical shell (mm)

D : outside diameter (mm)

d : inside diameter (mm)

S : allowable stress (N/mm²) {kgf/mm²} (as specified in Table 2)

P : hydraulic test pressure (bar) {kgf/cm²} (as specified in Table 4)

Table 2. Allowable Stress for Cylinder

Classification		Allowable stress
Carbon steel cylinder	Class 1	Tensile strength x 5/12
	Class 2	
Manganese steel cylinder	Class 1	Tensile strength x 5/9
	Class 2	Yield point or proof stress x 5/6
Chromium molybdenum steel cylinder		Yield point or proof stress x 5/6
Nickel chromium molybdenum steel cylinder		Yield point or proof stress x 5/6
Austenitic stainless steel cylinder	Class 1	Numerical value of proof stress x 9/10 or tensile strength x 5/12 whichever is the smaller
	Class 2	
Austenitic ferritic stainless steel cylinder		Proof stress x 5/6

- Remarks 1. Either yield point or proof stress and tensile strength shall be the values guaranteed by the cylinder manufacturer.
2. Yield point or proof stress for designing the cylinders to be subjected to quenching and tempering shall be a maximum of 85 % of the tensile strength guaranteed by the cylinder manufacturer.

Table 3. Thickness of Cylindrical Shell

Unit: mm

Outside diameter D	Thickness
125 and under	1.5
Over 125	$D/250 + 1$

Table 4. Hydraulic Test Pressure and Filling Ratio

Classification of gases	Type of gas	Minimum hydraulic test pressure (bar) {kgf/cm ² }	Filling ratio
Compressed gases	Oxygen gas and other gases	5/3 times the maximum filling pressure	-
Liquefied gases	Carbon dioxide ⁽¹⁾	250 {250}	0.75
	Nitrous oxide ⁽¹⁾	250 {250}	0.75
	Carbon dioxide + nitrous oxide ⁽¹⁾	250 {250}	0.75
	Ethylene	225 {225}	0.29
	Freon 13	210 {210}	1.00
	Ethane	200 {200}	0.36
	Sulfur hexafluoride	200 {200}	1.10
	Carbon dioxide + ethylene oxide	200 {200}	0.75
	Ethylene tetrafluoride	140 {140}	0.90
	Xenon	130 {130}	1.23
	Hydrogen chloride	130 {130}	0.60
	Freon 13 B 1	50 {50}	1.27
	Ammonia	50 {50}	0.54
	Chlorine	50 {50}	1.25

Note ⁽¹⁾ Hydraulic test pressure for carbon dioxide, nitrous oxide and a mixture of these gases may be reduced to 200 bar {200 kgf/cm²} by agreement between the parties concerned with acceptance.

- Remarks 1. Hydraulic test pressure for liquefied gases other than those given in Table 4 and a mixed gas composed of a liquefied gas and a compressed gas shall generally be 5/3 times the pressure at 48°C.
2. The term "filling ratio" means the mass in kg of liquefied gas permitted to fill the cylinder 1 l of water capacity of the cylinder and calculated from the following formula:

The values given in Table 4 indicate the maximum value of filling ratio.

$$FR = \frac{G}{V}$$

where FR: filling ratio

V: water capacity of cylinder (l)

G: mass of liquefied gas to be put (kg)

4.2 Thickness of Head and Bottom Both the thickness of the head of the cylinder and that of the bottom of the convex type cylinder shall be more than the minimum thickness of the cylindrical shell.

The thickness of the bottom of the concave type cylinder in the seat, or the area in contact with the floor shall be not less than 2 times the calculated thickness of the cylindrical shell (which conforms to Table 3).

5. Performance

5.1 The performance of the cylinder to come forth in a tensile test and an impact test shall be as follows.

- (1) Either yield point or proof stress and tensile strength of the cylinder shall be not less than values guaranteed by the cylinder manufacturer. However, either yield point or proof stress of carbon steel cylinders class 1, class 2 and manganese steel cylinder class 1 shall not be specified.
- (2) For the manganese steel cylinder, chromium molybdenum steel cylinder and nickel chromium molybdenum steel cylinder which have been quenched and tempered, yield ratio shall be not more than 90 %.
- (3) Elongation and impact value of the cylinder shall be as given in Table 5. However, the impact test shall not be carried out for the austenitic stainless steel cylinder and the austenitic ferritic stainless steel cylinder.

Table 5. Mechanical Properties of Cylinders

Classification		Elongation %	Impact value (J/cm ²) {kgf · m/cm ² }	
			Mean value	Individual value
Carbon steel cylinder	Class 1	30 min.	60 {6.0} min.	45 {4.5} min.
	Class 2	25 min.		
Manganese steel cylinder	Class 1	20 min.	50 {5.0} min.	38 {3.8} min.
	Class 2	17 min.	70 {7.0} min.	53 {5.3} min.
Chromium molybdenum steel cylinder		17 min.	90 {9.0} min.	68 {6.8} min.
Nickel chromium molybdenum steel cylinder		17 min.	90 {9.0} min.	68 {6.8} min.
Austenitic stainless steel cylinder	Class 1	35 min.	-	-
	Class 2			
Austenitic ferritic stainless steel cylinder		18 min.	-	-

- Remarks 1. For the cylinders with the thickness of the cylindrical shell under 8 mm, the minimum value of elongation shall be computed by numerically subtracting 1.0 % from the value of elongation in Table 5 for each 1 mm or its fraction of deficiency from 8 mm in measured wall thickness.
2. The impact test may be omitted for the cylinders which cannot afford test pieces 3 mm in width provided they are quenched and tempered and have a tensile strength 900 N/mm² {90 kgf/mm²} or less for manganese steel cylinders; Card provided 950 N/mm² {95 kgf/mm²} or less for chromium molybdenum steel cylinders or nickel chromium molybdenum steel cylinders.

5.2 The cylinder shall be subjected to a flattening test specified in 11.4 under the conditions given in Table 6. The cylinder under test shall exhibit no evidence of defects or cracks in the shell wall. However, when the shape or configuration of the cylinder is unsuitable for the flattening test, the bend test specified in 11.5 may be substituted in place of the flattening test under the conditions given in Table 6. In this case, there shall be caused no defect nor crack on the bent part. The conditions of bending shall conform to Table 6.

Table 6. Conditions of Flattening and Bending

Classification		Flattening test	Bend test
		Distance between two wedges (T)	Diameter of bending former
Carbon steel cylinder	Class 1	5 t_m	3 t_m
	Class 2	6 t_m	4 t_m
Manganese steel cylinder	Class 1	7 t_m	5 t_m
	Class 2	8 t_m	6 t_m
Chromium molybdenum steel cylinder		8 t_m	6 t_m
Nickel chromium molybdenum steel cylinder		8 t_m	6 t_m
Austenitic stainless steel cylinder	Class 1	4 t_m	2 t_m
	Class 2		
Austenitic ferritic stainless steel cylinder		8 t_m	6 t_m

Remark: t_m in both the flattening test and in the bend test indicates the average thickness of the cylindrical shell and the average thickness of test pieces, respectively.

5.3 Cylinders shall be subjected to the type of hydraulic test specified in 11.6 corresponding to the classification given in Table 7 and the results shall satisfy the respective requirements listed below.

Further the pressure shall be not less than the hydraulic test pressure given in Table 4.

- (1) For the cylinders subjected to the hydraulic expansion measuring test or the representative hydraulic expansion measuring test, neither leakage nor abnormal expansion shall be observed, and the permanent expansion after relieving the test pressure shall not exceed 10 % of the total expansion under the test pressure.
- (2) For the cylinders subjected to the proof pressure test, neither leakage nor abnormal expansion shall be observed.