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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

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Fibre reinforced plastic pipes

Introduction This Standard is Japanese Industrial Standard which has been established on the basis of **ISO/DIS 7370** :1996, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings—Specifications for nominal sizes, diameter series, nominal pipe lengths and tolerances*, in which the parts (dimensions) corresponding to International Standard have been prepared without any technical modification, but the provisions of such items are supplemented, as type, performance, shape, dimensions, appearance, materials, test, inspection, marking, precautions for handling, expression of resulted figures, design plan of fiber reinforced plastic pipes, and specification of fiber reinforced plastic pipes for transportation of petroleum products, of which every item is not specified in corresponding International Standard.

1 Scope This Standard specifies the fiber reinforced plastic pipes (hereafter referred to as “pipes”) which are to be used for transportation of fluids.

The maximum working pressure shall be 2 MPa for liquid, and be 1 MPa for gas.

Remarks 1 The normative references to this Standard are as follows.

JIS B 7502 *Micrometer callipers*

JIS B 7507 *Vernier, dial and digital callipers*

JIS K 6900 *Plastics—Vocabulary*

JIS K 6919 *Liquid unsaturated polyester resin for fiber reinforced plastics*

JIS K 7010 *Vocabulary for fiber reinforced plastic*

JIS K 7012 *Glass-fiber reinforced thermosetting resin chemical-resistant tanks*

JIS K 7052 *Measuring method for fiber content of glass fiber reinforced plastics*

JIS K 7055 *Testing method for flexural properties of glass fiber reinforced plastics*

JIS K 7060 *Testing method for barcol hardness of glass fiber reinforced plastics*

JIS K 7070 *Testing method for chemical resistance of fiber reinforced plastics*

JIS K 7074 *Testing method for flexural properties of carbon fiber reinforced plastics*

JIS K 7075 *Testing method for carbon fiber content and void content of carbon fiber reinforced plastics*

JIS R 3411 *Textile glass chopped strand mats*

JIS R 3412 *Textile glass rovings*

JIS R 3415 *Textile glass tapes*

JIS R 3416 *Finished textile glass fabrics*

JIS R 3417 *Woven roving glass fabrics*

JIS R 6252 *Abrasive papers*

JIS Z 8401 *Rules for rounding off of numerical values*

2 The international Standard corresponding to this Standard is as follows.

ISO/DIS 7370 : 1996 *Glass-reinforced thermosetting plastics (GRP) pipes and fittings—Specifications for nominal sizes, diameter series, nominal pipe lengths and tolerances.*

Informative reference The mechanical performances, such as circumferential internal-pressure strength, axial tensile strength, and others, of pipes can be seriously changed owing to laminating structure of materials, therefore the pipes, which have various performances, other than the pipes mentioned here can be manufactured. When special requirements are referred to comply with the serviceability, it is permissible to decide by the agreement between the parties concerned with delivery.

2 Definitions For the purpose of this Standard, the definitions given in **JIS K 6900**, **JIS K 7010**, and **JIS K 7012**, and the following definitions apply.

- (1) **fiber reinforced plastics pipe** Pipe-type products which are made of composite material, thermosetting plastics reinforced with fiber base material, and which have corrosion resistant layer made by thermoplastic or thermosetting resin.
- (2) **straight pipe** Pipe which is straight toward its axis direction (see Fig. 5.1).
- (3) **straight pipe with taper** Straight pipe which has an appropriate taper at its near end on its outside (see Fig. 5.2).
- (4) **bell-mouth pipe** Straight pipe whose one end makes a bell mouth (see Fig. 5.3).
- (5) **tapered bell-mouth pipe** Straight pipe of which one end has an appropriate taper on its outside and the other end makes a bell mouth (see Fig. 5.4).
- (6) **limit value** When measuring 3.2 of Annex 1, the value is the reference strength to be used for deciding allowable stress, and here especially it means the strength decided with consideration of strength decrement by long term employment or ambient influence.
- (7) **circumferential internal-pressure strength** Making use of the internal pressure given when test piece is broken by the hydraulic pressure test of 9.8, 9.9, and 9.10, the circumferential internal-pressure strength can be calculated (see Table 4.1).
- (8) **axial tensile strength** Making use of the maximum load given when test piece is broken by the test of 9.11, the axial tensile strength of pipe can be calculated (see Table 3.2).
- (9) **axial tensile elastic modulus** When test piece is broken by the test of 9.11, the ratio of axial tensile strength to the strain corresponding to the tensile strength, which the ratio shall be within proportional limit (see Table 3.3).
- (10) **bending strength** When test piece is broken by the test of 9.12, the bending stress of pipe that was obtained by calculation.

- (11) **flatness elastic modulus** Making use of both the load at 5 % displacement and corresponding strain given when test piece is flatwise loaded by the test of 9.13, the elastic modulus about the flatness of the pipe can be calculated (see Table 3.4).
- (12) **surface layer** Anticorrosive layer directly contacting with target material, by which the pipe is given suitable anticorrosiveness.
- (13) **intermediate layer** Anticorrosive layer standing at outside of the outer layer, by which the pipe is given suitable structural strength.
- (14) **anticorrosive layer** The layer by which the pipe can be given with suitable anticorrosiveness.
- (15) **outer layer** Reinforced layer by which the pipe is given suitable strength.
- (16) **test internal pressure** Internal pressure applied to the pipe when destructive test is carried out with hydrostatic pressure.

3 Classification

3.1 Classification by anticorrosive-layer thickness and test internal pressure The pipes are classified by anticorrosive-layer thickness and test internal pressure as shown in Table 3.1.

Table 3.1 Type of pipes classified by anticorrosive-layer thickness and test internal pressure

Thickness of anticorrosive layer		Test internal pressure	
Division	Thickness mm	Division	Pressure MPa
Group 1	1.25	Class 1	3.0
		Class 2	4.0
		Class 3	5.0
		Class 4	6.0
		Class 5	8.0
		Class 6	10.0
		Class 7	15.0
		Class 8	20.0
Group 2	2.5	Class 1	3.0
		Class 2	4.0
		Class 3	5.0
		Class 4	6.0
		Class 5	8.0
		Class 6	10.0
		Class 7	15.0
		Class 8	20.0

Remarks 1 The standard thickness of anticorrosive layer is 1.25 mm and 2.5 mm, but thickness other than this can be adopted depending on its use.

2 The classification of fiber reinforced plastic pipes for transportation of petroleum products is shown in Annex 2.

3.2 Grouping by axial tensile strength Pipes are classified as shown in Table 3.2 by its axial tensile strength.

Table 3.2 Grouping by axial tensile strength of pipes

Axial tensile strength MPa	50, 100, 150, 200, 250, 300
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3.3 Grouping by axial tensile elastic modulus Pipes are classified as shown in Table 3.3 by its axial tensile elastic modulus.

Table 3.3 Grouping by axial tensile elastic modulus of pipes

Axial tensile elastic modulus MPa	5000, 10 000, 15 000, 20 000, 25 000, 30 000
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3.4 Grouping by flatness elastic modulus Pipes are classified as shown in table 3.4 by its flatness elastic modulus.

Table 3.4 Grouping by flatness elastic modulus of pipes

Flatness elastic modulus MPa	5000, 10 000, 15 000, 20 000, 25 000, 30 000
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Remarks The tensile characteristics of pipes has directionality, and furthermore they show different characteristics depending on resin, reinforcing material, laminating structure, and type of moulding method, therefore, the groupings shown in Table 3.2, 3.3, and 3.4 are respectively independent, and there is no relation between strength and elastic modulus.

4 Performance

4.1 Withstand pressure The performance of pipes is grouped by its circumferential internal pressure strength carried by hydraulic pressure test, and shall be as shown in Table 4.1.

Table 4.1 Circumferential internal pressure strength

Circumferential internal pressure strength MPa	Performance value	Applicable test clause
	50, 100, 150, 200, 250, 300	9.8, 9.9, or 9.10

4.2 Hardness The hardness of pipes is expressed by barcol hardness which has been measured by 9.5, and at least 30 in terms of Type A specified in JIS K 7060.

4.3 Thermal performance The thermal performance of pipes is different depending of employed resin, kind of reinforcing material, and moulding method.

4.4 Chemical resistance Chemical resistance of pipes shall be as follows.

- (1) The chemical resistance of pipes is mainly decided by selection of material of anticorrosive layer that is shown in 3.4 of Annex 1.

(2) The chemical resistance of resin used in anticorrosive layer of pipes shall conform to the following requirements when tested according to 9.7.

- (a) **Change of appearance** The appearance change of anticorrosive layer shown after each immersion test shall be grade 1 or grade 2 or less given in Table 3, 5.3 of JIS K 7012.
- (b) **Bending strength** Retaining percentage of bending strength after one year immersion test shall be at least 60 %, and there shall be no serious change during from 180 days to one year.
- (c) **Barcol hardness** The barcol hardness after each immersion test shall be at least 15.

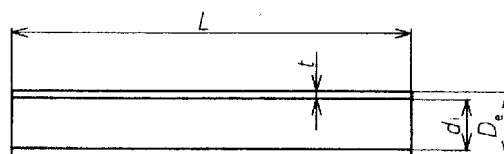
Remarks 1 Measure according to Type A specified in JIS K 7060.

- 2 At least 15 barcol hardness means the standard for the degree of hardening of unsaturated polyester resin and vinylester resin, which are mainly occupying the material of pipes. Therefore, when other resin than these materials is used, the specification of barcol hardness follows the agreement between the parties concerned with delivery.

5 Shape and dimensions

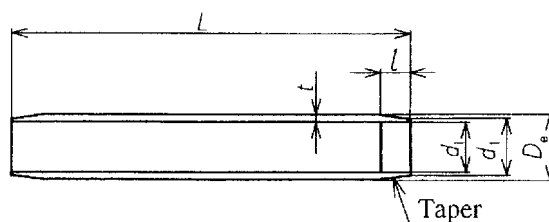
5.1 Shape Pipes shall be classified, depending on its shape, into straight pipe (Fig. 5.1), straight pipe with taper (Fig. 5.2), bell-mouth pipe (Fig. 5.3) and bell-mouth pipe with taper (Fig. 5.4).

The relation among the average outside diameter (D_m) of reinforced layer, average inside diameter (d_m) of reinforced layer, average radius (R_m) of reinforced layer, central diameter of reinforced layer (d_c), and thickness (t), found on the section of pipe, is as shown in Fig. 5.5.



D_e : outside diameter
 d_i : inside diameter
 t : thickness
 L : length

Fig. 5.1 Straight pipe



l : length of tapered connected part or length of connected part
 d_1 : minor bore of tapered connected part

Fig. 5.2 Straight pipe with taper

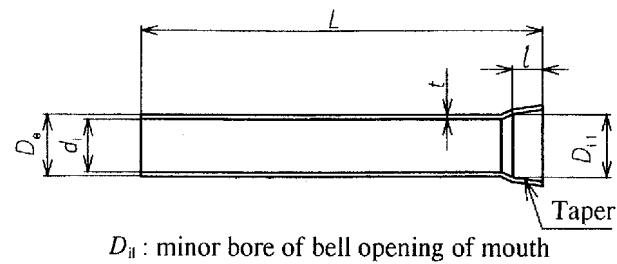


Fig. 5.3 Bell-mouth pipe

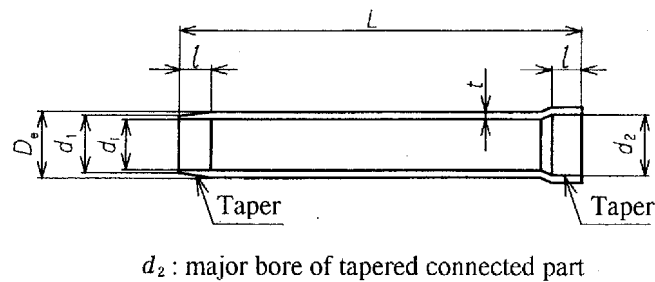
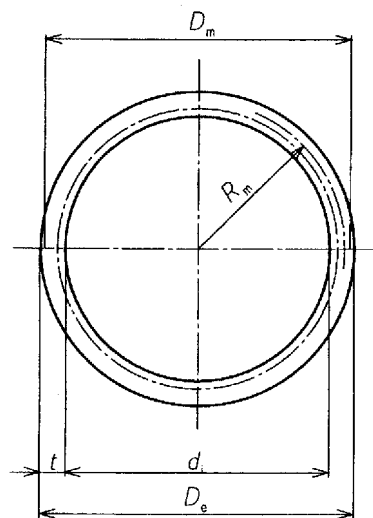


Fig. 5.4 Bell-mouth pipe with taper



D_m : average outside diameter of reinforced layer
 R_m : average radius of reinforced layer

Fig. 5.5 Section of pipe

The average outside diameter of reinforced layer (D_m) and the central diameter of reinforced layer (d_c) are calculated according to the following formula (a) and formula (b).

$$D_m = d_i + 2(t_1 + t_{\min}) \quad \dots\dots\dots (a)$$

$$d_c = D_m - t_{\min} = d_i + 2t_1 + t_{\min} = 2R_m \quad \dots\dots\dots (b)$$

where, t : thickness of pipe

$t_{\min}$: thickness of reinforced layer

t_1 : thickness of anticorrosive layer

d_c : central diameter of reinforced layer

5.2 Dimensions Dimensions shall be as follows.

- (1) **Inside diameter or outside diameter** The inside diameter or outside diameter of pipe are as shown in Table 5.1.

Table 5.1 Dimensions of pipe

Unit : mm

Nominal diameter DN	Inside diameter d_i	Outside diameter D_o	
	System A	System B1	System B2
25A	25	30	—
40A	40	45	48.3
50A	50	55	60.3
65A	65	70	73.0
75A	75	80	—
80A	80	86	88.9
100A	100	106	114.3
125A	125	132	139.7
150A	150	157	168.3
200A	200	208	219.1
250A	250	259	273.0
300A	300	310	323.9

Remarks 1 Nominal diameter 40A contains 36 mm and 38 mm in addition to inside diameter 40 mm.

- 2 Table 5.1 gives the correspondence to the nominal dimensions in **ISO/DIS 7370**, but necessarily contains whole dimensions. The whole nominal dimensions specified in **ISO/DIS 7370** are specified in Annex 3.

- (2) **Thickness** The thickness of pipe shall be agreed between the parties concerned with delivery.

The average thickness of pipe shall be not less than designed thickness (t) obtained according to formula (3) and formula (4) in 3.3 of Annex 1.

- (3) **Length** The length of pipe (L) shall be 3 m, 4 m or 5 m, or its multiple.

- (4) **Tolerance of dimension**

- (a) The tolerance of pipe length (L) shall be $\pm 0.5 \%$.
- (b) The tolerance of pipe inside diameter (d_i), which is inside diameter base, shall be larger one either ± 1 mm or $\pm 0.6 \%$ of nominal diameter.
- (c) The tolerance of pipe outside diameter (D_o), which is outside diameter base, shall be larger one either $+1.5$ mm, -0.5 mm or $\pm 0.6 \%$ of nominal diameter.
- (d) The minimum thickness ($t_{\min}$) of pipe reinforced layer shall be 80 % or more than designed thickness of reinforced layer.

6 Appearance Appearance shall be as follows.

- (1) **Inside surface** Inside surface shall be free from cracking, fissure, and inferior impregnation. Inside surface shall be smooth, and have no pit with 3 mm or larger diameter and 0.5 mm or more depth. Additionally, there shall be averagely 2 pits or less per 300 mm² each of whose size is less than 3 mm in diameter and less than 0.5 mm in depth, and the fiber on the surface shall be completely covered with resin from exposure. Bubbles shall be scarce enough to be used satisfactorily under corrosive surroundings.
- (2) **Outside surface** Outside surface shall be smooth, and free from exposed fiber or sharp projections.

7 Material

7.1 Resin The thermosetting resin, which is to be used for manufacturing of pipes, shall be mainly unsaturated polyester series resin or epoxy resin specified in **JIS K 6919**, but other thermosetting resins can be included. Additionally, the thermosetting resins to be used for improving anticorrosiveness of anticorrosive layer and weather resistance of outer-surface coated layer, are included.

- (1) **Resins for reinforced layer** Resins for reinforced layer shall be as follows.

- (a) Isophthalic acid series unsaturated polyester resin
- (b) Bisphenol series unsaturated polyester resin
- (c) Novolac type vinyl ester resin
- (d) Bisphenol type vinyl ester resin
- (e) Epoxy resin
- (f) Other thermosetting resins

- (2) **Resin for anticorrosive layer** Resin for anticorrosive layer shall be as follows.

- (a) Isophthalic acid series unsaturated polyester resin
- (b) Bisphenol series unsaturated polyester resin
- (c) Novolac type vinyl ester resin
- (d) Bisphenol type vinyl ester resin
- (e) Epoxy resin
- (f) Phenol resin
- (g) Furan resin
- (h) Thermoplastic resins

7.2 Fiber reinforcing material The fiber reinforcing material for manufacturing of pipes shall be as follows, and conforms to **JIS R 3411**, **JIS R 3412**, **JIS R 3415**, **JIS R 3416**, and **JIS R 3417**, otherwise glass fiber equal to or superior to this, or carbon fiber or organic fiber.

7.3 Additives Filling material or pigments can be added for the purpose to improve appearance, workability, performance, but they shall not impair the anticorrosiveness or strength.

8 Manufacturing method For manufacturing of pipes, either hand-lay up method or filament winding method shall be adopted. The following manufacturing methods, however, can be combinedly employed.

- (1) Drawing moulding
- (2) Centrifugal moulding
- (3) Spray up method

9 Test

9.1 Sample The shape and preparation method of test piece and its number shall be as shown in Table 9.1. Test piece shall be prepared by either cutting out from straight pipe, or by cutting out from the dummy part which has been additionally produced when moulding. When above both are impossible, however, laminated plate which was manufactured by the same composition and the same moulding method, can be available.

Table 9.1 Test piece

Test items	Shape and preparation method of test piece	Number of test pieces
Appearance	Standard size of pipe	—
Dimensions	Standard size of pipe	—
Fiber content	Cut out at least 2 g test piece from pipe.	3 pieces
Hardness	Pipe	10 spots
Acetone test		—
Chemical resistance test	Cut out from pipe or plate.	—
Tensile test	Cut out from pipe. (Fig. 9.8.1 to 9.8.3)	5 pieces
Bending test	Cut out from pipe or plate.	5 pieces
Flatness test	Pipe	3 pieces
Hydrostatic pressure test for short term		3 pieces
Repeated hydraulic pressure test for long term		At least 18
Hydrostatic pressure test for long term		At least 18

Remarks: Tensile test and bending test shall be done only for reinforced layer.

9.2 Appearance Appearance shall be observed by naked eyes, and confirm that it conforms to 6, and there is no defects giving influence on the performance of pipes.

9.3 Dimensions

9.3.1 Length, inside diameter, outside diameter, and thickness of pipes Measure the dimensions of length, inside diameter, outside diameter, and thickness of a pipe with a micrometer specified in JIS B 7502, a vernier caliper specified in JIS B 7507, a circum-

ferential measurer, or measuring instrument with equal or superior accuracy to; and the tolerance shall be within the range specified in (3) of 5.2.

9.3.2 Thickness of anticorrosive layer The measurement of thickness of anticorrosive layer shall be as follows.

- (1) **Measuring instrument** An optical comparator, magnifying 7 times to 10 times, with one scale of 0.1 mm or less and crossed lines.
- (2) **Method** Cut rectangularly the end of pipe, and remove roughness on the surface. Then, polish the edge of cut end with abrasive paper with from P220 to P800 grain size specified in **JIS R 6252**. In order to eliminate dusts of resin or glass, wash fully the polished surface with water, then set the bigger line of crossed lines between anticorrosive layer and reinforced layer on the section of the pipe, and measure the thickness of the anticorrosive layer. In this case, read the value from inner to pipe center, and measure the thickness of anticorrosive layer to the nearest 0.05 mm. Test results shall be expressed with the maximum, the minimum, and averaged value, which were measured at 4 points on the lines rectangularly crossed.

9.4 Resin content Resin content shall be measured according to **JIS K 7052** or **JIS K 7075**.

9.5 Hardness The measurement of barcol hardness shall follow **JIS K 7060**.

9.6 Acetone test Acetone test shall follow **JIS K 7012**.

9.7 Chemical resistance test Chemical resistance test shall follow **JIS K 7070**.

9.8 Hydrostatic pressure test for short term

9.8.1 Purpose The purpose of this test is to find circumferential internal pressure strength by means of hydrostatic pressure test for short term applied on the pipe.

9.8.2 Summary of test Owing to apply continuously hydraulic pressure on pipe, destroy the pipe in short term, and obtain the destroying internal pressure and circumferential internal pressure strength. Simultaneously, obtain the axially generated stress.

9.8.3 Apparatus Apparatus shall be as follows.

- (1) **Pressurizing mechanism** The apparatus by which test piece is loaded continuously with internal hydraulic pressure.
- (2) **Pressure gauge** Gauge has the needle showing the maximum value with $\pm 0.5\%$ accuracy, and the last read value shall be 60 % at the middle point of the scale. It is equipped with preventing device from shock. Or, use a transducer for pressure.
- (3) **Watch** Stopwatch
- (4) **Micrometer**
- (5) **Circumferential measurer**

9.8.4 Test piece Test piece shall be as follows.

- (1) **Test piece** In case of the pipe with 250 mm or less outside diameter, length of test piece shall be (3 times of outside diameter +250 mm) or longer; and in case of the pipe longer than 250 mm outside diameter, it shall be (outside diameter +1000 mm) or more.
- (2) **End point** The end point of test piece is capable of attaching a stopper for close sealing, which does not influence on pipe to be destroyed.

9.8.5 Internal pressure for test The internal pressure to apply to the test piece shall be as shown in Table 9.2 on every type of pipe. The pipe must withstand the test internal pressure.

Table 9.2 Test internal pressure for every type of pipe

Classification	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Test internal pressure MPa	3.0	4.0	5.0	6.0	8.0	10.0	15.0	20.0

9.8.6 Number of test pieces Number of test pieces are at least 3 pieces.

9.8.7 Method Testing method shall be as follows.

- (1) Measure the thickness of a test piece with a micrometer. To measure its outside diameter, use a circumferential measurer or tape measurer. Provided that in case of a test piece with 100 mm or less outside diameter, use a micrometer.

Never include the thickness corresponding to anticorrosive layer and the outermost resin layer.

- (2) Attach stoppers at both end points of the test piece, seal closely them, fill water inside the pipe, and deaerate air completely.
- (3) Apply continuously hydraulic pressure to the test piece, and if rupture, leakage, or oozing out is found, it is judged to be destroyed, and destructive internal pressure is measured. If the destruction happened within the distance $1.3 \times \sqrt{D_o \times t_{\min}}$ [D_o : outside diameter of pipe (mm), $t_{\min}$: the minimum thickness of reinforced layer (mm)] from the sealed end, test it again.

Complete the elevation of pressure within 2 minutes.

9.8.8 Calculation Calculate as follows.

- (1) **Circumferential internal pressure strength (S_H)** Calculate the circumferential internal pressure strength according to the following formula (1).

$$S_H = \frac{p \times d_c}{2t_{\min}} = \frac{p(D_m - t_{\min})}{2t_{\min}} \dots\dots\dots (1)$$

where, S_H : circumferential internal pressure strength (MPa)

p : test internal pressure (MPa)