Canadian General Standards Board

Office des normes générales du Canada

CGSB

ONGC

Standard for: Process Equipment: Reinforced Polyester, Chemical Resistant, Custom-Contact Molded

This standard applies to reinforced-polyester process equipment made by the Custom-Contact Method, and Auxiliaries, intended for use in aggressive chemical environments including but not limited to pipe, ducts and tanks.

41-GP-22

9 May 1969

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41-GP-22
May 1969
AMENDMENT NO. 3
March 1978
Supersedes Amendment No. 2

CANADIAN GOVERNMENT SPECIFICATIONS BOARD

Standard
for

PROCESS EQUIPMENT, REINFORCED POLYESTER, CHEMICAL RESISTANT, CUSTOM-CONTACT MOLDED

2. APPLICABLE PUBLICATIONS

*2.1.1 Change this paragraph to read:

2.1.1 American Society for Testing and Materials (ASTM)

C 581	Method of Test for Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures.
D 229	Method of Testing Rigid Sheet and Plate Materials Used for Electrical Insulation.
D 618	Standard Methods of Conditioning Plastics and Electrical Insulating Materials for Testing.
D 790	Standard Method of Test for Flexural Properties of Plastics.
D 883	Nomenclature Relating to Plastics.
D 2583	Method of Test for Indentation Hardness of Plastics by Means of a Barcol Impressor.
D 2584	Method of Test for Ignition Loss of Cured Reinforced Resins.

*2.1.3 Add the following paragraph:

2.1.3 Underwriters' Laboratories of Canada (ULC)

ULC-S102 Standard Test Method for Surface Burning Characteristics of Building Materials

*4. DETAIL REQUIREMENTS

*4.2 **Laminate** – Change this paragraph to read:

4.2.11 *Surface Flame Spread* – The surface flame spread rating of the laminate shall not exceed 75 when determined in accordance with ULC-S102. This restriction does not apply to the use of reinforced polyester pipe, ducts and tanks in industrial buildings or in areas protected by automatic sprinkler systems.

4.3 **Reinforced Polyester Round and Rectangular Ducts** – Add new paragraph:

4.3.10 *Use of Reinforced Polyester Round and Rectangular Ducts* – All reinforced polyester ducts shall be completely contained within the room in which the equipment is to be used; i.e., no reinforced polyester ducts shall be permitted to pass through any interior walls, floors or ceilings. This restriction does not apply to the use of reinforced polyester ducts in industrial buildings or in areas protected by automatic sprinkler systems.

4.4 **Reinforced Polyester Pipe** – Add new paragraph:

4.4.10 *Use of Reinforced Polyester Pipe* – All reinforced polyester pipe shall be completely contained within the room in which the equipment is to be used; i.e., no reinforced polyester pipe shall be permitted to pass through any interior walls, floors or ceilings. This restriction does not apply to the use of reinforced polyester pipe in industrial buildings or in areas protected by automatic sprinkler systems.

*Change since previous Amendment

4.5 **Reinforced-Polyester Tanks (Stationary Non-Pressure Vessels)** – Add new paragraph:

4.5.7 *Use of Reinforced Polyester Tanks* – All reinforced polyester tanks shall be completely contained within the room in which the equipment is to be used; i.e. no reinforced polyester tank shall be so located that any part of the tank protrudes through any interior walls, floors or ceilings. All exposed reinforced polyester tanks are restricted in use to noncombustible materials. This restriction does not apply to the use of reinforced polyester tanks in industrial buildings or in areas protected by automatic sprinkler systems.

6. INSPECTION

6.3.2 Change this paragraph to read:

6.3.2 *Tensile Strength* – Tensile strength shall be determined in accordance with ASTM D 229, except that the specimens shall be the actual thickness of the fabricated article, and the width of the reduced section shall be 1 inch. Other dimensions of specimens shall be as designated by ASTM D 229 for Type 1 specimens for materials over 1/2 inch to 1 inch inclusive. Specimens shall not be machined on the surface. Tensile strength shall be the average of five specimens tested at 0.20 to 0.25 in./min crosshead speed.

7. NOTES

7.5 Add new paragraph:

7.5 **Terminology** – Your attention is drawn to the fact that this standard refers only to custom-contact molded products, often described as "hand lay-up" products. The details in the standard for items such as wall thickness do not apply to filament wound FRP equipment. It is possible that a companion document to 41-GP-22 may shortly be issued, describing filament-wound products.

*7.6 Add new paragraph:

*7.6 **Surface Burning Characteristics** – Test method E 84 of the American Society for Testing and Materials, for determining the surface burning characteristics of building materials is similar in apparatus and procedure to method ULC - S102 specified in this standard. Data obtained from testing according to ASTM E 84 may be considered suitable as evidence of conformance to the requirement at the option of the authority having jurisdiction.

APPENDIX A

Delete Section A2, Fire Retardancy, and Section A3, Codes.

*Change since previous Amendment

COMMITTEE ON REINFORCED-POLYESTER
CHEMICAL-RESISTANT PROCESS EQUIPMENT

(Membership at date of approval by the Committee)

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Angell, C.H. (Consultant)	Charles H. Angell
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Standards Officer - P.M. Jones, CGSB

4.2.1 Primary Chemical-Resistant Surface - This surface shall be between 0.010 and 0.020 inch thick. It shall be a reinforced resin-rich surface.* It may be reinforced with glass surfacing veil, synthetic fibers, asbestos or other material as usage requires. It shall be free from cracks and crazing and have a smooth finish. Some waviness is permissible as long as the surface is smooth and continuous.

4.2.2 Internal Anti-Wicking Barrier - Not less than 0.100 inch of chemical-resistant laminate next to the inner surface shall be reinforced with not less than 20 per cent nor more than 30 per cent by weight of noncontinuous glass strand (par. 6.3.1), e.g., having fiber lengths from 0.5 to 2.0 inches.

4.2.3 Additional Structural Reinforcing Section - This layer or body of the laminate shall be of chemically resistant construction suitable for the intended use and providing the additional strength necessary to meet the tensile and flexural requirements. Where separate layers such as mat, cloth or woven roving are used, all layers shall be lapped at least 1 inch. Laps shall be staggered as much as possible. If woven roving or cloth is used, layers of chopped strand glass shall be placed as alternate layers.

4.2.4 Exterior Surface - When the exterior surface is subject to a corrosive environment, it shall consist of a chopped strand glass over which shall be applied a resin-rich coating as described in par. 4.2.1. Other methods of surface protection may be used as agreed upon between purchaser and supplier.

4.2.5 Cut Edges - All cut edges shall be coated with resin so that no glass fibers are exposed and all voids filled. Structural elements having edges exposed to the chemical environment shall be made with chopped strand glass reinforcement only.

4.2.6 Joints - Finished joints shall be built up in successive layers and be as strong as the pieces being joined and as crevice-free as is commercially practicable. The width of the first layer shall be not less than 2 inches. Successive layers shall increase uniformly to provide the specified minimum total width of overlay, which shall be centered on the joint (par. 4.2.1, 4.3.6.1, 4.4.6 and 4.5.5). Crevices between jointed pieces shall be filled with resin or thixotropic resin paste, leaving a smooth inner surface (par. 4.1.2). The interior of joints may also be sealed by covering with not less than 0.100 inch of reinforced resin-rich surface as described in par. 4.2.1 and 4.2.2.

4.2.7 Wall Thickness - The minimum wall thickness shall be as specified in the tables under the appropriate sections, but in no case shall it be less than 1/8 inch in the case of ducts and 3/16 inch in pipes and tanks regardless of operating conditions. Isolated small spots may be as thin as 80 per cent of the minimum wall thickness, but in no case greater than 1/8 inch below the specified wall thickness.

4.2.8 Mechanical Properties

4.2.8.1 In order to establish proper wall thickness and other design characteristics, the minimum physical properties for any laminate shall be as shown in Table 1 and par. 4.2.8.2. Laminates that do not meet the minimum values in Table 1 are considered acceptable provided they are made to afford the same over-all strength that would be obtained

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* This resin-rich surface layer will usually contain less than 20 per cent of reinforcing material. A specific limit is not included because of the impracticability of determining this value in the finished product.

with a laminate meeting the specified thickness. For example, if the specified thickness for a laminate is 1/4 inch, Table 1 requires a minimum tensile strength of 12,000 psi. By multiplying thickness times minimum tensile strength, a value of 3,000 pounds breaking load for a 1 inch wide specimen is obtained. A laminate having a tensile strength of 10,000 psi will therefore be acceptable for the 1/4 inch requirement if it has an actual thickness of at least 0.30 inch. The safety factors given in Tables 2, 3, 5, 7 and 8 should be adhered to when designing reinforced polyester equipment.

TABLE 1

Requirements for Properties of Newly Fabricated Reinforced-Polyester Laminates

Property at 73.4°F (23°C)	Thickness (in.)				Test Method
	1/8 to 3/16	1/4	5/16	3/8 and up	
	psi	psi	psi	psi	
Ultimate tensile strength, min.	9,000	12,000	13,500	15,000	Par. 6.3.2
Flexural strength, min.	16,000	19,000	20,000	22,000	Par. 6.3.3
Flexural modulus of elasticity (tangent), min.	700,000	800,000	900,000	1,000,000	Par. 6.3.4

4.2.8.2 Surface Hardness - The laminate shall have a Barcol hardness of at least 90 per cent of the manufacturer's minimum specified hardness for the cured resin, when tested in accordance with par. 6.3.5. This requirement applies to both interior and exterior surfaces.

4.2.9 Appearance - The finished laminate shall be as free as commercially practicable from visual defects such as foreign inclusions, dry spots, air bubbles, pinholes, pimples and delamination. The inner surface shall be free from cracks and crazing and have a smooth finish and an average of not more than 2 pits per square foot, providing the pits are less than 1/8 inch diameter and not more than 1/32 inch deep and are covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free from pits. Unless otherwise specified, ASTM D2563 visual acceptance level 3 shall be the minimum standard for acceptance.

4.2.10 By agreement between purchaser and supplier, a representative laminate sample may be used as the reference standard for determination of acceptable surface finish and visual defects (par. 4.2.1, 4.2.4 and 4.2.9).

4.3 Reinforced-Polyester Round and Rectangular Ducts *

4.3.1 Duct Size and Tolerances

4.3.1.1 Round Ducting - The size of round ducting shall be determined by the inside diameter, in inches. The standard sizes shall be 2, 3, 4, 6, 8,

* Rated at a minimum of 5 inch water vacuum and/or 50 inch water pressure (see Table 2).

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9 May 1969

CANADIAN GOVERNMENT SPECIFICATIONS BOARD

Standard
for

PROCESS EQUIPMENT: REINFORCED-POLYESTER, CHEMICAL RESISTANT, CUSTOM-CONTACT MOLDED

1. DEFINITION

1.1 This standard applies to reinforced-polyester process equipment made by the custom-contact method, and auxiliaries, intended for use in aggressive chemical environments including but not limited to pipe, ducts and tanks.

2. APPLICABLE PUBLICATIONS

2.1 The following publications are applicable to this standard:

2.1.1 American Society for Testing and Materials (ASTM)

C581 Method of Test for Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures.
D618 Standard Methods of Conditioning Plastics and Electrical Insulating Materials for Testing.
D638 Test for Tensile Properties of Plastics.
D790 Standard Method of Test for Flexural Properties of Plastics.
D883 Nomenclature Relating to Plastics.
D2583 Method of Test for Indentation Hardness of Plastics by Means of a Barcol Impressor.
D2584 Method of Test for Ignition Loss of Cured Reinforced Resins.
E84 Standard Method of Test for Surface Burning Characteristics of Building Materials.

2.1.2 United States of America Standards Institute (USASI)

B16.1 Cast Iron Pipe Flanges and Flanged Fittings.
B16.5 Steel Pipe Flanges and Flanged Fittings.

2.2 Reference to the above publications is to the issues in effect on the date of invitation to tender, unless otherwise specified.

3. GENERAL REQUIREMENTS

3.1 Terminology - Unless otherwise indicated, the plastics teminology used in this standard shall be in accordance with the definitions given in ASTM D883.

3.2 General Description - This standard describes glass-fiber-reinforced process equipment for chemical service. Other materials may be used for reinforcement of the surface exposed to the chemical environment. This standard is not intended to cover selection of the exact resin or reinforcement combination for use in specific chemical and structural conditions. For recommended chemical resistance test procedures, see Appendix A.

4. DETAIL REQUIREMENTS

4.1 Materials

4.1.1 Resin - The resin used shall be of a commercial grade and shall be evaluated as a laminate by test (see Appendix A for a recommended test), or known from previous service to be acceptable for the environment. Unless otherwise specified, the same resin will be used throughout the laminate.

4.1.2 Reinforcing Material - The reinforcing material shall be a commercial grade of glass fiber having a coupling agent that will provide a suitable bond between the glass reinforcement and the resin.

4.1.3 Fillers and Pigments - The resins used shall not contain fillers except as required for viscosity control or fire retardance. Up to 5 per cent by weight of thixotropic agent that will not interfere with visual inspection may be added to the resin for viscosity control. Resins may contain pigments and dyes by agreement between fabricator and purchaser, recognizing that such additions may interfere with visual inspection of laminate quality. Antimony compounds or other fire retardant agents may be added as required for improved fire resistance.

4.1.4 Surfacing Materials - Unless otherwise agreed upon between fabricator and purchaser, material used as reinforcing on the surface exposed to chemical attack shall be a commercial grade chemical-resistant glass having a coupling agent.

NOTE: The use of other fibrous materials such as acrylic, polyester fibers and asbestos may affect the values obtained for the Barcol hardness of the surface.

4.2 Laminate (see Figure I)

The laminate shall consist of the following:

(1) Primary chemical-resistant surface.
(2) Internal anti-wicking barrier.
(3) Additional structural reinforcing section if required to meet the properties shown in Table 1.
(4) Exterior surface.

NOTE: The compositions specified for (1) and (2) are intended to achieve optimum chemical resistance.

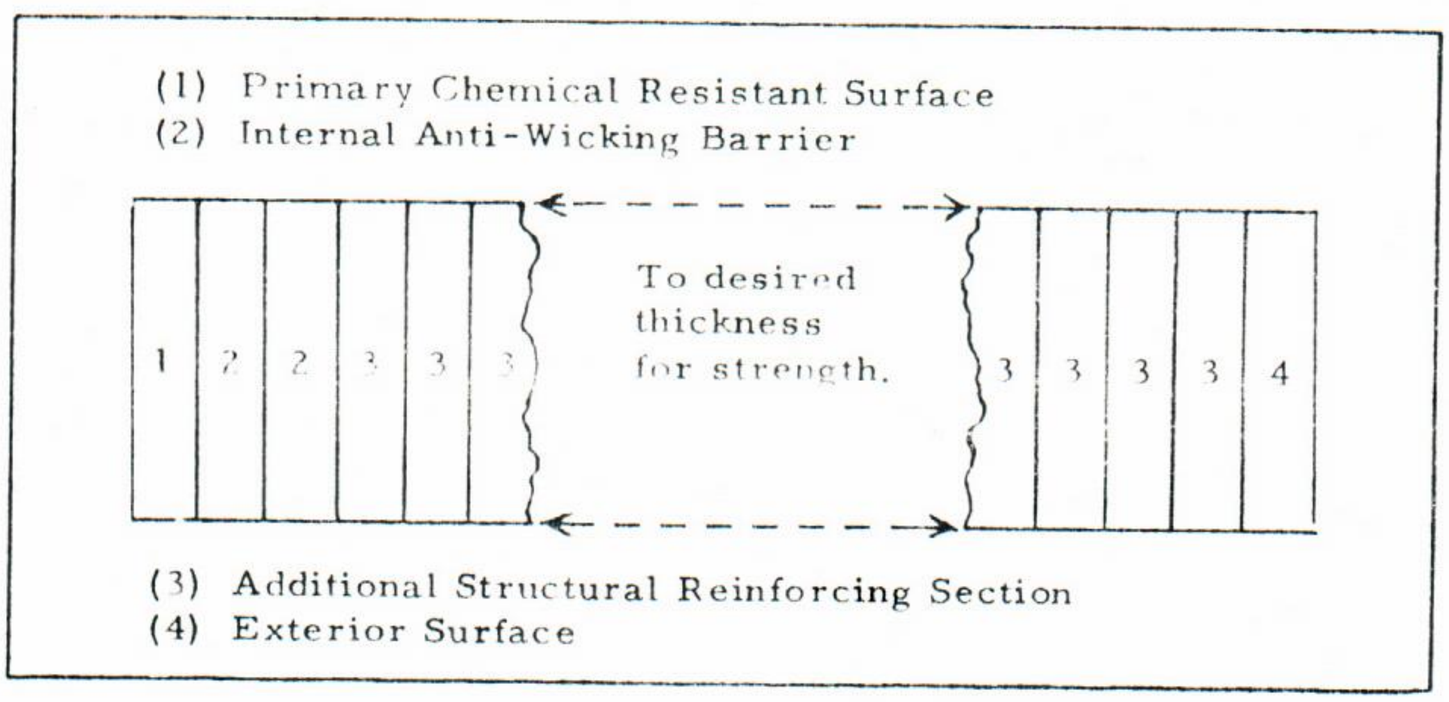


FIGURE I

10, 12, 14, 16, 18, 20, 24, 30, 36, 42, 48, 54 and 60 inches. Unless otherwise specified, the tolerance, including out-of-roundness, shall be ± 1/16 inch for ducting up to and including 6 inch diameter, and ± 1/8 inch or ± 1 per cent, whichever is greater, for ducting exceeding 6 inches in inside diameter.

4.3.1.2 Rectangular Ducting - The sizes of rectangular ducting shall be determined by the inside dimensions. There are no standard sizes for rectangular ducting. Unless otherwise specified, the tolerances on ordered sizes shall be ± 3/16 inch for dimensions of 18 inches and under, and ± 1 per cent for dimensions over 18 inches.

4.3.2 Lengths - Tolerances on over-all lengths shall be ± 1/4 inch unless arrangements are made to allow for field trimming.

4.3.3 Wall Thickness - The minimum wall thickness of round ducts shall be in accordance with Table 2. For rectangular ducts the minimum thickness shall be as in Table 2, substituting the longer side for the diameter. See also par. 4.2.7.

4.3.4 Squareness of Ends - Ends shall be square within ± 1/8 inch for round ducts through 24 inch diameter, and rectangular ducts through 72 inch perimeter; and ± 3/16 inch for larger sizes of both round and rectangular ducts.

4.3.5 Fittings - Tolerances on angles shall be ± 1° through 24 inches diameter, ± 7/8° for 30 inches diameter, ± 3/4° for 36 inches diameter, ± 5/8° for 42 inches diameter, and 1/2° for 48 inches diameter and above. Wall thickness of fittings shall be at least that of duct of the same size.

4.3.5.1 Ells - Standard ells shall have a centerline radius of 1.5 times the duct diameter.

4.3.5.2 Laterals - Standard laterals shall be 45°.

4.3.5.3 Reducers, Concentric or Eccentric - Length of standard reducers shall be 5 times the difference in diameters (D1 - D2). Minimum wall thickness shall be that required for the larger diameter duct as given in Table 2.

4.3.6 Straight Connections

4.3.6.1 Butt Joint - The strength of the butt joint shall be at least equal to that of the duct itself, and the joint shall be made in accordance with par. 4.2.6. Total minimum width of the joint shall be 3 inches for 1/8 inch thickness, 4 inches for 3/16 inch thickness and 6 inches for 1/4 inch thickness.

4.3.6.2 Bell and Spigot Joint - Straight duct shall be inserted into bell at least 1/6 of duct perimeter or 4 inches, whichever is less. The opening between the bell and spigot shall be sealed with thixotropic resin paste and overwrapped in such a manner as to provide strength at least equal to that of the duct.

4.3.7 Flanges

4.3.7.1 Flange Dimensions - Dimensions of reinforced plastic flanges for round ducts shall be in accordance with Table 2. Flange thicknesses and width [(O.D. - I.D.)/2] of flange faces for rectangular ducts shall correspond to those for round ducts having the same diameter as the longer side of rectangular ducts.

4.3.7.2 Flange Attachment - Duct wall at hub of flange shall be at least 1.5 times normal thickness and taper to normal thickness over a distance of at least one flange width. Fillet radius shall be at least 3/8 inch at point where the hub meets the back of the flange.

4.3.7.3 Face of Flange - Face of flange shall have no projections nor depressions greater than 1/32 inch and shall be perpendicular to centerline of duct within 1/2°. A camber of 1/8 inch with respect to the centerline, measured at the O.D. of the flange, shall be allowable. The face of the flange shall have a chemically resistant surface as described in par. 4.1.4 and 4.2.1.

4.3.7.4 Drilling - Standard flanges shall be supplied drilled, in accordance with Table 2, unless otherwise specified.

4.3.7.5 Flange Bolting - The bolt holes shall straddle centerline unless otherwise specified. Number of bolt holes and diameters of bolt holes and bolt circles shall be in accordance with Table 2 unless otherwise specified. Rectangular flange width and bolt spacing shall be the same as that for diameters corresponding to the longer sides.

TABLE 2

Reinforced-Polyester Round Duct Dimensions (1)

I.D.	Wall Thickness (min.)	Allowable Vacuum (2) (max.)	Allowable Pressure (2)	Nominal Flange Diameter (O.D.)	Flange Thickness	Bolt Circle Diameter	Bolt Hole Diameter	No. of Bolt Holes
inches	inch	inches of water	inches of water	inches	inch	inches	inch	
2	1/8	405	750	6-3/8	1/4	5	7/16	4
3	1/8	405	500	7-3/8	1/4	6	7/16	4
4	1/8	210	410	8-3/8	1/4	7	7/16	4
6	1/8	64	350	10-3/8	1/4	9	7/16	8
8	1/8	30	180	12-3/8	1/4	11	7/16	8
10	1/8	16	340	14-3/8	3/8	13	7/16	12
12	1/8	9	280	16-3/8	3/8	15	7/16	12
14	1/8	7	220	18-3/8	3/8	17	7/16	12
16	1/8	6	290	20-3/8	1/2	19	7/16	16
18	1/8	5	240	22-3/8	1/2	21	7/16	16
20	1/8	5	190	24-3/8	1/2	23	7/16	20
24	3/16	9	140	28-3/8	1/2	27	7/16	20
30	3/16	7	100	34-3/8	1/2	33	7/16	28
36	3/16	5	70	40-3/8	1/2	39	7/16	32
42	1/4	10	120	46-3/8	5/8	45	7/16	36
48	1/4	9	100	54-3/8	5/8	52	9/16	44
54	1/4	7	80	60-3/8	5/8	58	9/16	44
60	1/4	6	60	66-3/8	5/8	64	9/16	52

(1) 5 to 1 design factor of safety based on data in Table 1. Also based on 10-foot lengths between stiffener rings for vacuum service.

(2) These ratings are suitable for use up to 180° F (82.2°C) in pressure service and ambient atmospheric temperatures on vacuum service. For ratings at higher temperatures, consult the manufacturer.

4.3.8 Mechanical Properties of Ducts

4.3.8.1 Laminate - The minimum mechanical properties shall be in accordance with Table 1.

4.3.8.2 Deflection - Maximum deflection of a side of a rectangular duct shall not exceed 1 per cent of the width of the side under operating conditions. Ribs or other special construction shall be used if required to meet the deflection requirement.

4.3.9 Stacks - Special engineering consideration is required for structural design of stacks and the manufacturers should be consulted.

4.4 Reinforced-Polyester Pipe *

4.4.1 Size - The standard pipe size shall be the inside diameter in inches. Standard sizes are 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 30, 36 and 42 inches. The tolerance, including out-of-roundness, shall be ± 1/16 inch for pipe up to and including 6 inch inside diameter, and ± 1/8 inch or ± 1 per cent, whichever is greater, for pipe exceeding 6 inches in inside diameter. This measurement shall be made at the point of manufacture with the pipe in an unstrained vertical position.

4.4.2 Length - The length of each fabricated piece of pipe shall not vary by more than ± 1/8 inch from the ordered length unless arrangements are made to allow for trim in the field.

4.4.3 Wall Thickness - The minimum wall thickness of the pipe shall be in accordance with Table 3. See also par. 4.2.7.

TABLE 3

Reinforced-Polyester Pipe Wall Thickness

Pipe Size	Minimum pipe wall thicknesses at pressure ratings (1)					
	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
inches	inch	inch	inch	inch	inch	inch
2	3/16	3/16	3/16	3/16	3/16	3/16
3	3/16	3/16	3/16	3/16	1/4	1/4
4	3/16	3/16	3/16	1/4	1/4	1/4
6	3/16	3/16	1/4	1/4	5/16	3/8
8	3/16	1/4	1/4	5/16	3/8	7/16
10	3/16	1/4	5/16	3/8	7/16	1/2
12	3/16	1/4	3/8	7/16	1/2	5/8
14	1/4	5/16	3/8	1/2	5/8	3/4
16	1/4	5/16	7/16	9/16	11/16	
18	1/4	3/8	1/2	5/8	3/4	
20	1/4	3/8	1/2	11/16		
24	1/4	7/16	5/8	13/16		
30	5/16	1/2	3/4			
36	3/8	5/8				
42	3/8	3/4				

(1) The specified wall thicknesses are based upon a 10 to 1 safety factor for the tensile strengths listed in Table 1. These ratings are suitable for use up to 180°F (82.2°C); for ratings at higher temperatures consult the manufacturer. For vacuum service see par. 4.4.9.

* Rated from full vacuum to 150 psi (see Table 3).

4.4.4 Squareness of Ends - All unflanged pipe shall be cut square with the axis of the pipe within ± 1/8 inch up to and including 24 inches diameter, and to within ± 3/16 inch for all diameters above 24 inches.

4.4.5 Fittings

4.4.5.1 All fittings such as elbows, laterals, T's and reducers shall be equal or superior in strength to the adjacent pipe section and shall have the same diameter as the adjacent pipe. The dimensions of fittings shall be as shown in Figure II. Tolerance on angles of fittings shall be ± 1° through 24 inches in diameter and ± 1/2° for 30 inches diameter and above. Where necessary, minimum overlay widths may be less than those specified in Table 4, but the joint strength shall be at least equal to the strength of the adjacent pipe.

4.4.5.2 Elbows - Standard elbows shall have a centerline radius of one and one-half times the diameter. Standard elbows up to and including 24 inches shall be molded of one piece construction. Elbows of 30 inches diameter and larger may be of mitered construction using pipe for the mitered sections. The width of the overlay on the mitered joint may have to be less than the minimum specified in Table 4 to avoid interference on the inner radius, but the joint strength must be at least equal to the strength of the adjacent pipe. Mitered elbows 45° or less will be one-miter, two section. Elbows above 45° through 90° shall have a minimum of two miters. It will be permissible to incorporate a straight pipe extension on elbows.

4.4.5.3 Reducers - Reducers of either concentric or eccentric style shall have a length as determined by the diameter of the large end of the reducer, as indicated in Figure II.

4.4.6 Butt Joints - This type of joint shall be considered the standard means of joining pipe sections and pipe to fittings. The procedure used in making the butt joint shall be as outlined in par. 4.2.6. All pipe 20 inches in diameter and larger shall be overlayed both inside (when accessible) and outside. Pipe less than 20 inches in diameter shall be overlayed outside only, unless the joint is readily accessible. The minimum width of the overlay shall relate to wall thickness and shall be of the dimensions indicated in Table 4. The inside overlay is only for the purpose of sealing the joint and shall not be considered in meeting the strength requirement specified in par. 4.2.6.

TABLE 4

Minimum Total Widths of Overlays for Reinforced-Polyester Butt Joints

Pipe wall thickness, in.	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
Minimum total width of overlay, in.	3	4	5	6	7	8	9	10	11	12

4.4.7 Flanges

4.4.7.1 The use of flanges shall normally be kept to a minimum with the butt joint being used as the standard means of joining pipe sections. All flanges shall be of the minimum thickness given in Table 5 and accompanying illustration. The construction of the flanges is the same as that for laminates (par. 4.2).

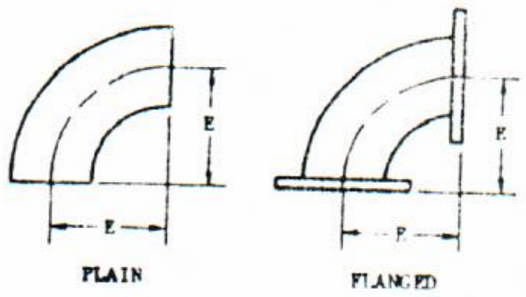
4.4.7.2 Flange Attachment - The minimum flange shear surface shall be four times the flange thickness indicated in Table 5. The thickness of flange hub reinforcement measured at the top of the fillet radius shall be at least one-half the flange thickness and shall be tapered uniformly over the length of the hub reinforcement. The fillet radius, where the back of the flange meets the hub, shall be 3/8 inch minimum.

4.4.7.3 Flange Face - The flange face shall be perpendicular to the axis of the pipe within 1/2° and shall be flat to ± 1/32 inch up to and including 18 inch diameter, and ± 1/16 inch for larger diameters. The face of the flange shall have a chemically resistant surface as described in par. 4.1.4 and 4.2.1.

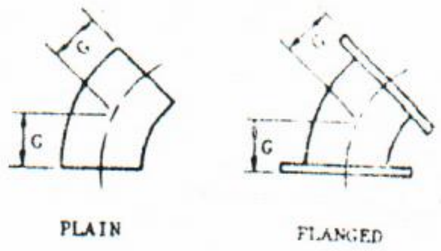
4.4.7.4 Other Flange Designs - Other flanges agreed upon between the fabricator and the user are acceptable provided that they produce a tight joint at twice the operating pressure.

4.4.8 Mechanical Properties of Pipe - The minimum mechanical properties of pipe shall be in accordance with Table 1.

4.4.9 Vacuum Service - In sizes from 2 through 18 inches, reinforced-polyester pipe and fittings having an internal pressure rating of 125 psi and flanges having a rating of 25 psi are suitable for full vacuum service. Special engineering consideration is required for larger pipe sizes or for operation at temperatures above ambient atmospheric.

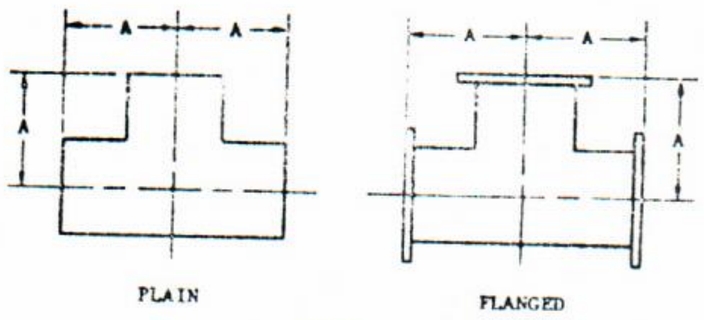


90° ELBOW

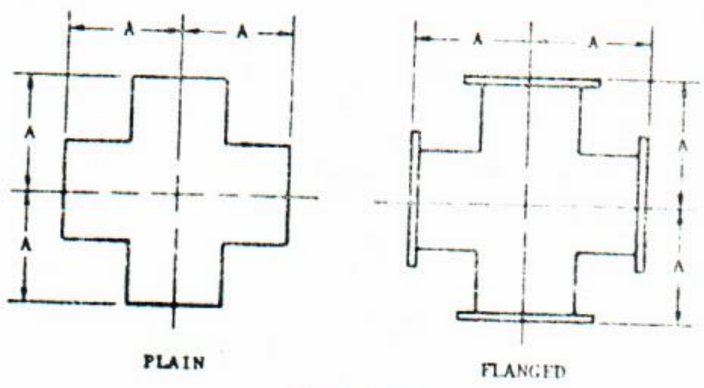


45° ELBOW

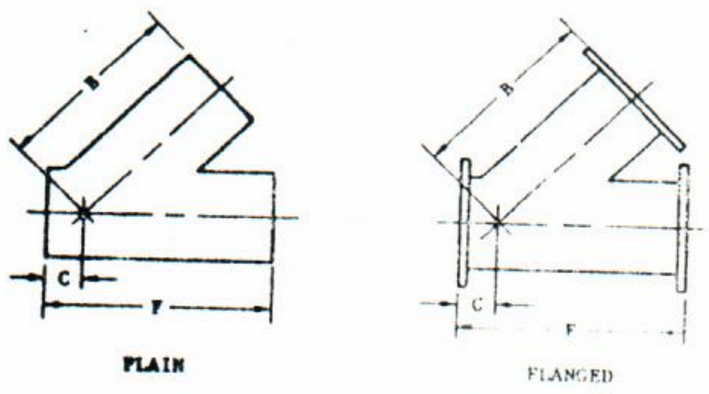
STUB FLANGE



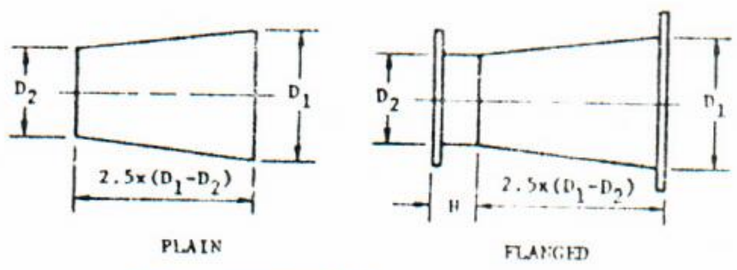
TEE



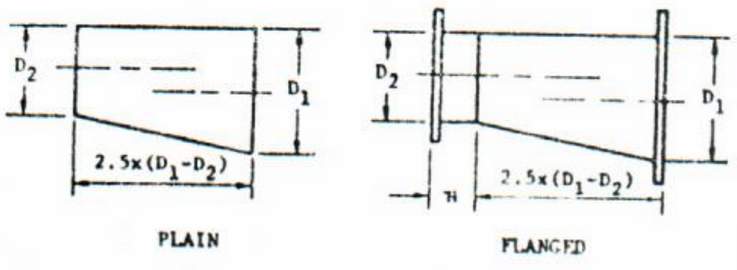
CROSS



45° LATERAL



CONCENTRIC REDUCERS



ECCENTRIC REDUCERS

Dimensions (inches)

D	A	B	C	E	F	G	H
2	6	10	6	4	16	1-5/8	6
3	7	12	6	6	18	2-1/2	6
4	8	14	6	6	20	2-1/2	6
6	10	16	8	9	24	3-3/4	8
8	12	20	10	12	30	5	8
10	14	24	10	15	34	6-1/4	10
12	16	26	12	18	33	7-1/2	10
14	18	30	12	21	42	8-3/4	12
16	20	32	14	24	46	10	12
18	21	36	14	27	50	11-1/4	12
20	22	38	16	30	54	12-1/2	12
24	24	42	18	36	60	15	12
30	30	52	20	45	72	18-5/8	15
36	33	62	22	54	84	22-1/2	15
42	36	72	24	63	96	26	15

STUB FLANGES — Adapted from American Standard for Stub Ends, B-16.9-1958.

ELBOWS — Adapted from American Standard Steel Butt Weld Fittings B-16.9-1958. (Long Radius Elbows) Exceptions are 2" & 3" Elbows where E = 2 x D

45° ELBOW — 2", 3" and 4" Sizes cannot be Flanged.

FIGURE II - Dimensions of Reinforced-Polyester Pipe Fittings.

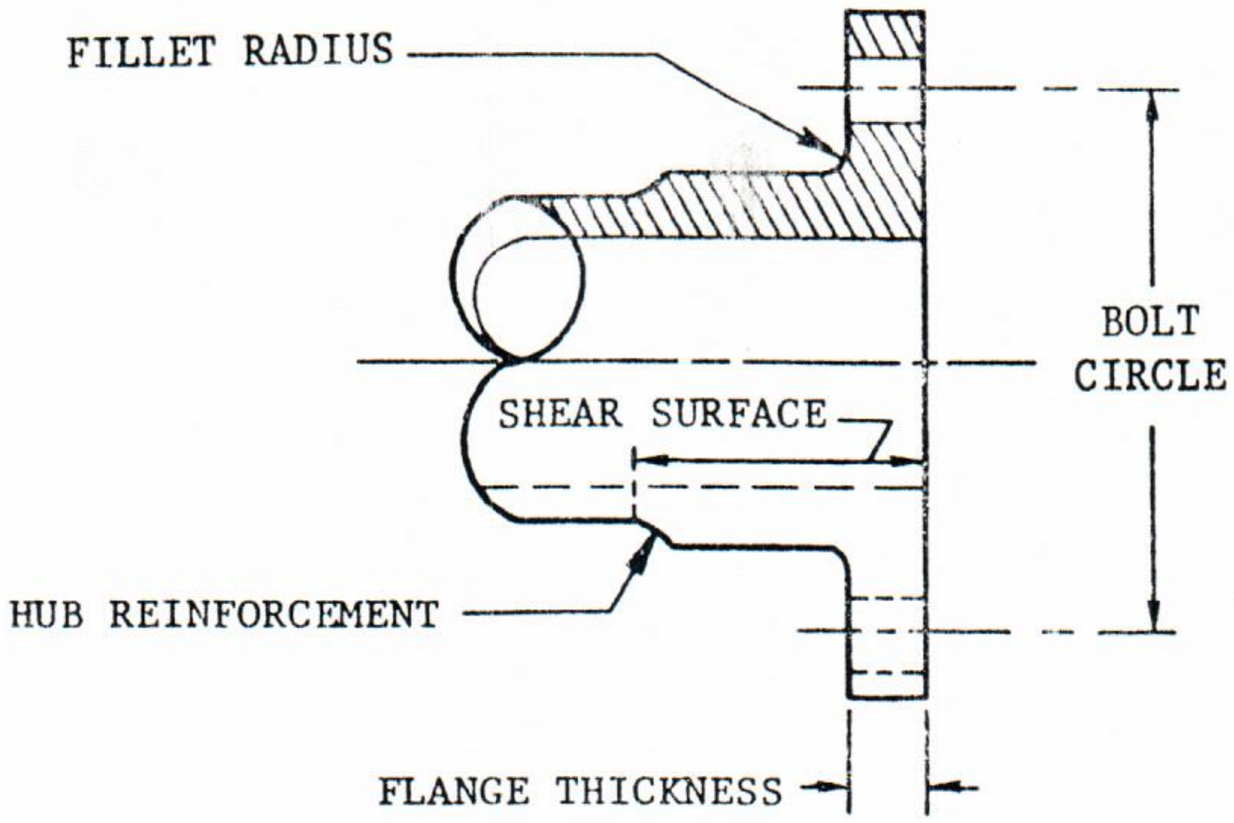


TABLE 5 - Minimum flange thickness for reinforced-polyester pressure pipe (1), (2), (3)

Pipe Size	MINIMUM FLANGE THICKNESS AT DESIGN PRESSURES:					
	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
in.	in.	in.	in.	in.	in.	in.
2	1/2	1/2	1/2	9/16	5/8	11/16
3	1/2	1/2	5/8	11/16	3/4	13/16
4	1/2	9/16	11/16	13/16	7/8	15/16
6	1/2	5/8	3/4	7/8	1	1-1/16
8	9/16	3/4	7/8	1	1-1/8	1-1/4
10	11/16	7/8	1-1/16	1-3/16	1-5/16	1-7/16
12	3/4	1	1-1/4	1-7/16	1-5/8	1-3/4
14	13/16	1-1/16	1-5/16	1-1/2	1-3/4	1-7/8
16	7/8	1-3/16	1-7/16	1-5/8	1-7/8	
18	15/16	1-1/4	1-1/2	1-3/4	2	
20	1	1-5/16	1-5/8	1-7/8		
24	1-1/8	1-1/2	1-7/8			
30	1-3/8	1-7/8				
36	1-3/4					
42	2					

(1) Based on flat-faced flanges with full-face soft gaskets.

(2) Flange dimensions (except thickness) and bolting correspond to the following standards:

2 inch through 24 inch sizes: USASI B-16.5 for 150 lb steel flanges.
30 inch through 42 inch sizes: USASI B-16.1 for 125 lb C.I. flanges.

(3) The above table is based on a safety factor of 8 to 1 and a flexural strength of 20,000 psi. This latter value is slightly under the minimum flexural strength for laminates of 3/8 inch and up (see Table 1), due to the manufacturing technique.

4.5 Reinforced-Polyester Tanks (Stationary Nonpressure Vessels)

4.5.1 Cylindrical Flat-Bottom Vertical Tanks

4.5.1.1 Standard tank sizes are 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11 and 12 feet in inside diameter.

4.5.1.2 Dimensions and Tolerances - The tank diameter shall be measured internally. Tolerance on the inside diameter, including out-of-roundness, shall be ± 1 per cent. Measurement shall be taken with tank in vertical position. Taper, if any, shall be added to the nominal diameter. Taper shall not exceed 1/2° per side. Tolerance on over-all height shall be ± 1/2 per cent, but shall not exceed ± 1/2 inch. The radius at bottom to wall shall be not less than $1\frac{1}{2}$ inch.

4.5.1.3 Wall Thickness - The minimum wall thickness shall be in accordance with Table 6. See also par. 4.2.6.

4.5.2 Horizontal Cylindrical Tanks

4.5.2.1 Sizes, Dimensions and Tolerances - These shall be the same as for vertical cylindrical tanks (par. 4.5.1). Standard end closures shall be standard convexed, domed heads with a maximum radius of curvature equal to the tank diameter. The knuckle radius shall be not less than 1-1/2 inches.

4.5.2.2 Support Cradle - For tanks 24 feet long and under, two support cradles shall be provided. The cradles shall be at least 6 inches wide supporting at least 120° of the tank circumference. Wear plates (reinforced areas) 12 inches wide covering 180° of support surface shall be provided when required. Laminate construction and minimum thickness shall be as agreed upon between fabricator and purchaser. Tanks longer than 24 feet require special design and support consideration.

4.5.2.3 Wall Thickness - The minimum wall thickness shall be in accordance with Table 7. See also par. 4.2.6.

4.5.3 Rectangular Tanks

4.5.3.1 Sizes - There are no standard sizes for rectangular tanks.

4.5.3.2 Dimensions and Tolerances - The length and width shall be measured internally. Tolerances on nominal dimensions of length and width shall be ± 1/4 inch or ± 1/4 per cent, whichever is greater. Over-all height tolerance shall be ± 3/8 inch. Taper is increasing and added to the nominal dimensions. Taper should not exceed 1/2° per side.

4.5.3.3 Side Wall - Deflection shall not exceed 1/2 per cent of span at any location when tested by filling with water.

4.5.3.4 Wall Thickness - Since the design of rectangular tanks is considerably more complex than that of cylindrical tanks, no simple chart of wall thickness can be given. The minimum wall thickness should, however, be similar to that for cylindrical tanks with consideration given to the height of the tank relative to loadings and the largest span relative to deflection. External ribs shall be used to prevent side wall deflection exceeding the tolerance in par. 4.5.3.3. See also par. 4.2.6.

TABLE 6

Minimum Wall and Bottom Thickness of Vertical Tanks Relative to Diameter and Distance from Top (1)

Distance From Top	Minimum wall and bottom thickness (in.) for tanks of diameter														
ft	2 ft	2½ ft	3 ft	3½ ft	4 ft	4½ ft	5 ft	5½ ft	6 ft	7 ft	8 ft	9 ft	10 ft	11 ft	12 ft
2	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
4	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16
6	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4
8	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16
10	3/16	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16
12	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8
14	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8
16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4	1/4	5/16	5/16	3/8	3/8	3/8	7/16
18	3/16	3/16	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	3/8	7/16	1/2
20	3/16	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	3/8	7/16	1/2	1/2
22	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8	7/16	1/2	1/2	9/16
24	3/16	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	7/16	1/2	1/2	9/16	5/8

(1) Based on a safety factor of 10 to 1 using the mechanical property data in Table 1 and a liquid specific gravity of 1.2. For tanks intended for service above 180°F (82.2°C), consideration in design should be given to the physical properties of the material at the operating temperature. Tanks with physical loadings, such as agitation, should be given special design consideration.

TABLE 7

Minimum Wall and Head Thicknesses for Reinforced-Polyester Horizontal Cylindrical Tanks Using Two Support Cradles (1)

Tank Length ft.	Minimum wall and head thickness (in.) for tanks of diameter							
	2 ft	3 ft	4 ft	5 ft (2)	6 ft (3)	8 ft (4)	10 ft (5)	12 ft (6)
8	3/16	3/16	1/4	1/4	5/16	5/16	7/16	9/16
10	3/16	1/4	1/4	5/16	5/16	3/8	7/16	9/16
12	3/16	1/4	1/4	5/16	5/16	7/16	1/2	5/8
14	1/4	1/4	5/16	5/16	3/8	1/2	9/16	3/4
16	1/4	5/16	5/16	3/8	3/8	9/16	11/16	13/16
18	1/4	5/16	3/8	7/16	7/16	5/8	13/16	15/16
20	5/16	5/16	3/8	7/16	1/2	11/16	7/8	1-1/16
22	5/16	3/8	3/8	1/2	9/16	3/4	15/16	1-3/16
24	5/16	3/8	7/16	1/2	5/8	13/16	1	1-1/4

(1) Based on 5 to 1 safety factor using the mechanical property data in Table 1, a liquid specific gravity of 1.2 and support cradles located 1/12 of tank length from each end. For tanks intended for service above 180°F (82.2°C), consideration in design should be given to the physical properties of the material at the operating temperature. Tanks with physical loadings, such as agitation, should be given special design consideration.

(2) Wear plates required for 8 foot tank length.

(3) Wear plates required for 8, 10 and 12 foot tank lengths.

(4) Wear plates required for tanks 8 to 18 feet long, inclusive.

(5) Wear plates required for tanks 8 to 20 feet long, inclusive.

(6) Wear plates required for all tank lengths.

4.5.4 Mechanical Property Requirements for Tanks - The minimum mechanical properties shall be as specified in Table 1.

4.5.5 Shell Joints - Where tanks are manufactured in sections and joined by use of a laminate bond, the joint shall be glass-fiber-reinforced resin at least the thickness of the heaviest section being joined. The reinforcement shall extend on each side of the joint a sufficient distance to make the joint at least as strong as the tank wall and shall be not less than the minimum joint widths specified in Table 8. The reinforcement shall be applied both inside and out, with the inner reinforcement considered as a corrosion resistant barrier only and not structural material. The inner reinforcement shall consist of a minimum of 3 ounces of glass per square foot, followed by a 0.010 to 0.020 inch of surfacing material (par 4.2.5).

TABLE 8

Minimum Total Widths of Overlays for Reinforced-Polyester Tank Shell Joints

Tank Wall thickness, in.	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4
Minimum of outside overlay width, in.	4	4	5	6	7	8	9	10	11	12
Minimum of inside overlay width, in.	4	4	5	5	6	6	6	6	6	6

4.5.6 Flanges

4.5.6.1 Flanged Nozzles - Flanges for liquid inlets and outlets shall meet the same requirements as for pipe (par 4.4.7.1 to 4.4.7.4 inclusive). At assembly there shall be a minimum dimension of 4 inches from the flange face to the tank. Where angular loadings are anticipated, the flange nozzle shall be supported by at least three gussets or by other suitable means of structural support.

4.5.6.2 Assembly of Flanges - Standard orientation shall have bolt holes straddling principal centerline of vessel unless otherwise specified.

4.5.6.3 Tolerances - Tolerances on flange construction shall be the same as for pipe flanges (par 4.4.7.1 and Table 5). Location of nozzles on the vessel shall be held to ± 1/8 inch.

5. PREPARATION FOR DELIVERY

5.1 Recommendations for the packaging, packing, shipping and installation of these products are contained in Appendix B to this standard.

5.2 Marking of the equipment shall be as agreed between the supplier and the purchaser.

6. INSPECTION

6.1 Tests shall be made on specimens cut from waste areas when possible; otherwise, the specimens shall be cut from flat laminates prepared in the same construction and by the same techniques as the process equipment. In all cases, the average value of the indicated number of specimens shall be used to determine conformance with the detailed requirements.

6.2 Conditioning - The test specimens shall be conditioned in accordance with Procedure A of ASTM D618.

6.3 Tests

6.3.1 Glass Content - The resin content shall be determined in accordance with ASTM D2584, except that the specimens tested shall be approximately 1 square inch in area and low-temperature pre-ignition prior to placement in muffle furnace is recommended (the glass content can be determined from this). The average for five specimens shall be considered to be the glass content.

6.3.2 Tensile Strength - Tensile strength shall be determined in accordance with ASTM D638, except that the specimens shall be the actual thickness of the fabricated article, and the width of the reduced section shall be 1 inch. Other dimensions of specimens shall be as designated by the ASTM standard for Type 1 specimens for materials over 1/2 inch to 1 inch inclusive. Specimens shall not be machined on the surface. Tensile strength shall be the average of five specimens tested at 0.20 to 0.25 in./min. crosshead speed.

6.3.3 Flexural Strength - Flexural strength shall be determined in accordance with Procedure A and Table 1 of ASTM D790, except that the specimens shall be the actual thickness of the fabricated article and the width shall be 1 inch. Other dimensions of specimens shall be as designated by the ASTM standard. Specimens shall not be machined on the surface. Tests shall be made with the resin-rich side in compression using five specimens.

6.3.4 Flexural Modulus - The tangent modulus of elasticity in flexure shall be determined by ASTM D790 (par 6.3.3).

6.3.5 Hardness shall be determined by ASTM D2583.

6.3.6 Additional Tests - Recommended test methods for the further testing of reinforced-polyester laminates are given in Appendix A.

7. NOTES

7.1 Ordering Data

Ordering and specifying data should include the following information:

(a) Chemical environment
(b) Chemical concentrations
(c) Temperature (maximum and minimum)
(d) Pressure (maximum operating)
(e) Pressure (design)
(f) Pressure (test)
(g) Location (indoor or outdoor)

(h) External loads
(i) Other considerations
- vibration
- thermal expansion and contraction
- gussets
- lift lugs
- pigmentation
- tank heaters
- method of support
- cleaning procedures

(j) Conformity with building and safety codes.

7.2 The following reference literature contains information on reinforced plastics science and technology that may be of assistance to users of this standard:

7.2.1 General Listing

SPI Annual Reinforced Plastics Preprint.
250 Park Avenue,
New York, N.Y.

British RP Technical Conference Preprint, yearly.
The British Plastics Federation,
47-48 Picadilly,
London, W.1., England.

7.2.2 Books

Adhesive Bonding of RP: H.A. Perry, 1959, McGraw-Hill Book Co., New York.

Fiberglas RP: R.H. Sonneborn, 1954, Reinhold Publishing Corporation, New York.

Filament Winding: D.V. Rosato and C.S. Grove, 1964. J. Wiley and Sons, Inc., New York.

Glass Reinforced Plastics: P. Morgan, 1954, Iliffe and Sons, Inc., New York.

Handbook of RP of SPI: S.S. Oleesky and J.G. Mohr, 1963, Reinhold Publishing Corporation, New York.

Glass Fiber Reinforced Plastics: A. De Dani, 1961, Interscience Pub., Division of John Wiley and Sons, New York, or
George Newnes Limited, London, England.

Marine Design Manual for Fiberglas Reinforced Plastics: Engineers of Gibbs and Cox, Inc., 1960, McGraw-Hill Book Company, New York.

Annual Proceedings of the Reinforced Plastic Division, Society of the Plastics Industry, Inc., 250 Park Avenue, New York.

Premix Moulding: Roger B. White, Reinhold Publishing Corporation,
Department J, 430 Park Avenue, New York.

Fiberglas Canada Limited: Fiberglas Reinforced Plastics Book 1, Book 2 and Book 3, 48 St. Clair Avenue West, Toronto 7, Canada.

7.3 The publications listed in par. 2.1.1 may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa., 19103, U.S.A.

7.4 The publications listed in par. 2.1.2 may be obtained from the United States of America Standards Institute, 10 East 40th Street, New York, N.Y., 10016, U.S.A.

Correspondence regarding this standard should be addressed to the Canadian Government Specifications Board, c/o Department of Supply and Services, Ottawa 4, Canada.

APPENDIX A

A1. CHEMICAL RESISTANCE

A1.1 Text - ASTM Designation C581, Tentative Method of Test for Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures *, is recommended for the evaluation of the chemical resistance of materials to be used in reinforced-polyester chemical-resistant process equipment. The reinforcing materials prescribed in the test laminate are only for the purpose of establishing a uniform basis for comparison. They may not necessarily represent the preferred materials for the particular environment. This procedure may be adapted to test or evaluate components, composition or fabrication variations and production samples. For information on the basis for selection of the standard test laminate, see Appendix of ASTM C581.

A1.1.1 The 10-mil surfacing mat referred to in par. 5.1.2.1 of ASTM C581 shall be made of chemical resistant glass (Type C or equal).

A1.1.2 The standard test laminate shall be cured at room temperature for 16 hours. Further cure shall be given at room or higher temperature, if necessary, to produce a Barcol hardness equal to the resin manufacturer's minimum specified hardness for the cured resin.

A1.2 Temperature - Tests may be conducted at any or all of the following temperatures: 23°C, 50°C, 70°C, 100°C (±2°C); reflux temperature; required service temperature.

A1.3 Reagents - The following reagents are suggested for use in obtaining general comparative chemical resistance data. The test solutions shall not be agitated; i.e., the exposures shall be under static conditions.

1. 25% sulphuric acid
2. 15% hydrochloric acid
3. 5% nitric acid
4. 25% acetic acid
5. 15% phosphoric acid
6. 5% sodium hydroxide
7. 10% sodium carbonate
8. saturated sodium chloride
9. 95% ethanol
10. 5-1/4% sodium hypochlorite **
11. 5% aluminum potassium sulfate
12. ethyl acetate
13. methyl ethyl ketone
14. monochlorobenzene
15. perchloroethylene
16. n-heptane
17. kerosene
18. toluene
19. 5% hydrogen peroxide **
20. distilled water **

A1.4 Time - The properties specified in A1.5 shall be determined for specimens immersed in the test solutions for 30 days, 90 days, 180 days and one year for one set of control specimens immediately following the curing period; and for another set after aging in air at the test temperature for the total test period.

A1.5 Properties - Thickness, Barcol hardness, flexural strength and modulus, and appearance shall be determined at each time interval. Appearance observations shall include any surface changes, color changes, obvious softening or hardening, crazing, delamination, exposure of fibers, or other effects indicative of complete degradation or potential failure. Calculation of percentage change in a property shall be based on the property value obtained immediately following the curing period.

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* This method is based on a test procedure developed by the Reinforced-Plastics Corrosion-Resistant Structures Subcommittee of the Society of the Plastics Industry, Inc.

** Replaced every 48 hours with fresh material.

A1.6 Report - Data shall be reported in tabular form for all parameters tested. The composition, including resin, accelerators, catalysts and reinforcements, and the fabricating and curing conditions of the laminate tested, shall be adequately described.

A2. FIRE RETARDANCY

The fire retardancy may be determined in accordance with ASTM Designation E84, Standard Method of Test for Surface Burning Characteristics of Building Materials.

A3. CODES

The products should comply with building and safety codes that are applicable where the product is installed as specified by the purchaser.

APPENDIX B

Recommended Standard Practice for Shipping and Installation of Reinforced-Polyester Chemical-Resistant Equipment

B1. DUCT

This recommended practice covers dimensional tolerances on duct subassemblies fabricated by the manufacturers prior to shipment. It also serves as a guide for shipping, installation and use of reinforced-plastic chemical-resistant ducting.

B1.1 Dimensional Tolerance of Subassembles

The dimensional tolerances of relatively simple duct subassembles such as the singular joining of elbows, laterals or tees to straight duct lengths shall follows those established under par. 4.3 of this standard, with reference to length, squareness and fitting tolerances. Consultation between customer and fabricator is advisable prior to the beginning of fabrication to establish the dimensional requirements of extensive factory-made duct subassemblies involving the mounting of multiple offsets and fittings. Tie-ins with either existing or new equipment may dictate close tolerances, and may require the use of special duct jigging fixtures. Field butt joints are advisable at changes of direction of subassemblies, and at other locations to facilitate the field installation.

B1.2 Shipping - Because of the lightness of fiber-glass-reinforced plastic, the chief determinants of the over-all dimensions of the subassemblies will be the dimensional shipping limitations and the access passage dimensions at the installation site. The over-all dimensions of the subassemblies shall be determined by the requirements of both the manufacturer and the customer. The manufacturer shall protect all flange faces, small diameter duct, and the more fragile appurtenances of the subassemblies with crating or other means for the shipment. Upon arrival at the installation site, the duct shall be carefully examined by the customer for damage in transit. Duct and subassemblies shall be unloaded with care and stored where they will be free from damage. Impact of a tool or other heavy object may result in fracture of the primary chemical resistant surface, and affect the service life of the duct. Large subassemblies shall be supported during unloading to prevent excessive deflection and overstressing.

B1.3 Installation - Duct systems shall be supported at the intervals specified by the manufacturer for the specific conditions. The design of hangers or supports shall be in accordance with the manufacturer's recommendations. Because the thermal coefficient of expansion of FRP duct is approximately two-and-one-half times that of steel, it is very important that allowances for thermal expansion of the duct be made. This can be provided by the bends that are in the duct system, or by expansion coupling installed where there are no bends to absorb the expansion. Hangers, sliding or roller-type supports must be provided to allow for the movement of the duct during expansion or contraction. Forced bending of duct to effect match-up of subassemblies shall not be allowed. Flexible connectors shall be used between duct and rotational equipment or vibratory mechanisms to dampen out vibrations. Care must be taken in the close proximity of FRP equipment that no steel welding, flame or arc cutting is done that might damage the duct.

B1.3.1 Joints - Bolts on flanged connections shall be tightened using the manufacturer's recommendation on torque. Washers are recommended under bolt heads and nuts. Field joining kits with instructions shall be provided by the manufacturer, unless otherwise agreed. In making butt joints in the field, all grease, moisture and other contamination shall be removed from the ends of the duct being joined before it is sanded.

B1.4 Limitations in Service -

The duct system shall only be used in the environment for which it was designed. The manufacturer's recommendation on support spacing usually allows for the weight of a certain amount of condensate in the duct. If condensation is likely to build up at a low point in the system, beyond that used in the design calculation, drains should be provided to allow for its removal. If the system is designed to allow for a graded vacuum requirement, as determined by the flow characteristics, provision shall be made to prevent an interruption of flow that would result in the entire system being placed under maximum vacuum. Otherwise, the entire system shall be designed for the maximum vacuum.

B2. PIPE

These recommendations include dimensional tolerances of piping subassemblies fabricated both in the manufacturers plant and in the field. Also included are sections dealing with suggestions on joining, supporting, allowing for system expansion, safety precautions, tools and supplies required and the proper handling and storage of the reinforced-polyester pipe and fittings.

B2.1 Dimensional Tolerances of Piping Subassemblies - The dimensional tolerances of relatively simple pipe subassemblies such as the singular joining of elbows or T's to straight pipe lengths shall follow those as established under par. 4.4 of this standard with reference to length, squareness and fitting tolerances. Consultation between customer and fabricator is advisable prior to the beginning of fabrication to establish the dimensional requirements of extensive factory made pipe subassemblies involving the mounting of multiple offsets and fittings. Assemblies of this type may require the use of special pipe jigging fixtures. All shop subassemblies may have a field butt joint located in each change of direction of the piping system or at any other locations deemed advisable for accuracy of the field installation.

B2.2 Packaging

Cut ends of piping should be protected for shipment.
Flange gasket face should have flange protectors.
Inside of pipe should be dry and free from foreign objects that could damage chemical-resistant interface.
All threaded fittings or openings in pipe headers should be plugged or capped.
Loose parts such as nuts, bolts and gaskets should be packaged to allow storage under field conditions.
All special fabrications that may have fragile inner liners should be crated and marked "FRAGILE".
Fabricator should mark pieces or subassemblies to agree with installation drawings.
Instructions for material handling, storage and installation procedures should be included.
If special equipment is required for unloading, fabricator should package in a manner to expedite handling in the field.

B2.3 Shipping

Pipe should be bundled and packaged with adequate dunnage to eliminate shifting or movement.
Fittings and loose parts should be crated and packed securely to eliminate damage.

B2.4 Field Handling and Storage

If crane or other special equipment is necessary for unloading, customer should be notified prior to shipment of material.
When mechanical equipment is used for unloading, two pickup points are required at approximately 1/3 of total length of pipe spacing.
Cloth straps are preferred for lifting. If other equipment is used such as cables or chains, supplemental protection is required.
Pipe should not be dropped. Pipe may be rolled under controlled conditions.
Pipe and fittings should be stored in a traffic-free area to eliminate accidental damage.

B2.4.1 Storage of Field Weld Materials - Resin and curing agent should be stored in a cool dry area maintaining an ideal temperature range of 40 to 75°F for maximum shelf life. Maximum storage temperature is 100°F. Materials should be protected from all sources of heat including sunlight. Reinforcement should be shipped in sealed polyethylene bags and stored in a dry area.

B2.5 Installation - Follow manufacturer's installation instructions for pipe preparation to meet field climatic conditions.

B2.5.1 Hanger Spacing - Hanger Supports - Hangers shall be band type hangers that will support a minimum of 180° of the pipe surface. The maximum pipe hanger spacing shall be in accordance with Table 9.

TABLE 9

Maximum Spacing of Pipe Hangers for
Reinforced-Polyester Pressure Pipe*

Pipe I.D.	Maximum pipe hanger spacing (ft.) at pressure ratings					
in.	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
2	6.0	6.0	6.0	6.0	6.0	6.0
3	6.5	6.5	6.5	6.5	8.0	8.0
4	7.0	7.0	7.0	8.5	8.5	8.5
6	8.0	8.0	9.0	9.0	10.0	10.5
8	8.5	10.0	10.0	10.5	11.0	11.5
10	9.5	10.5	11.5	12.0	12.5	13.0
12	10.0	11.5	12.5	13.0	13.5	14.0
14	11.5	12.5	13.0	14.0	15.0	15.5
16	12.0	13.0	14.0	15.5	16.5	17.0
18	12.5	14.5	15.0	16.0	16.5	17.5
20	12.5	15.0	15.5	17.0	18.0	18.5
24	8.5	15.0	17.0	18.5	19.0	
30	9.5	17.5	19.5	21.0		
36	10.5	19.5	21.0			
42	8.0	21.0	22.5			

* This table is based on uninsulated pipe containing liquids having a specific gravity of 1.3 and at a maximum temperature of 180°F. For services at temperatures above 180°F (82.2°C) consult the manufacturer relative to hanger spacing.

B2.6 Testing - If pressure testing of the installed pipe system is required, the recommended hydrostatic test pressures shall be 1-1/2 times the normal operating pressure for a minimum of 1 hour. Test should not be made less than 24 hours after makeup of last FRP field joint.

B2.7 Joining

B2.7.1 Butt Joints - The butt joint employing successive overlays of glass reinforcement and resin, as outlined in par. 4.2.6 and 4.2.7 of this standard, shall be considered the standard means of joining pipe sections and pipe to fittings.

B2.7.2 Field Weld Materials - Field welding kits, containing materials of sufficient quantity to complete the pipe installation, shall be supplied with the pipe by the manufacturer unless otherwise specified. Instructions outlining the proper number and width sequence of plies for each pipe size shall be provided with the kit. These instructions shall also include information covering the proper application of the materials and the methods of curing the polyester resin under normal and variable job conditions.

B2.7.3 Surface Preparation - To assure proper adhesion of the weld, all grease, oil, moisture or other contaminates must be removed from the surfaces to be joined. In addition, the surfaces must also be sanded or ground to remove the gloss from the pipe. This sanding procedure is of particular importance for properly bonding interior pipe welds. A faulty joint will result unless the two pieces of pipe being joined are securely held in place without movement during the entire welding and curing process. For greatest installation efficiency, the welding of the joints should be delayed until all or a large part of each pipe run has been fitted, hung and jigged in place.

B3. TANKS

This recommended practice is offered as a guide for shipping, handling and installation of reinforced-polyester chemical-resistant tanks in order to prevent damage and to assure that the tank will provide the maximum life in the intended service. Since there may be variation in design details of support cradles, lifting and hold-down lugs and method of shipping among tank manufacturers, the manufacturer's special instructions should be followed in all cases.

B3.1 Shipping - Tanks should be mounted on cradles if shipped horizontally, or on a suitable skid or pallet if shipped in the vertical position. The cradle or skid should be padded and secured to the bed of the vehicle in a manner that will prevent damage to the tank with normal handling. The tank should be secured to the cradle or skid so that there can be no movement of the tank in relation to the skid or cradle. A suitable stiffening member should be secured at the opening of open top tanks. Tanks should be loaded with at least 2 inches clearance between the tank, including fittings, and the bulkheads or bed of the vehicle. When two or more tanks are shipped at one time, there shall be sufficient clearance or padding between tanks to prevent contact in transit. Upon arrival at the installation site the tank(s) shall be carefully examined by the customer for damage in transit.

B3.2 Handling - The following normal precautions should be taken in handling the tank at the destination:

Proper rigging practice should be observed at all times. Hoisting-equipment operators shall attach a guide line to prevent tank from swinging without control. The tank should not be dropped or allowed to strike any other object. Damage caused by dropping or

striking other objects may result in cracking the inner corrosion resistant liner as well as the exterior of the tank. The tank should not be rolled or slid on rough surfaces and never rolled over a fitting.

In working around the tank, care should be exercised to prevent tools, scaffolding or other objects from striking or being dropped inside the tank. Soft-soled shoes should be worn by workmen entering the tank. Ladders used inside or outside in contact with the tank should be wooden or have cushion protection on both ends and should not be permitted to scratch or point-load the surface.

The use of a crane is recommended both in lifting and in erecting the tank. The clearance between the head shackle of the crane and the tank should at least equal the over-all length of the tank. If this is not possible, a spreader bar must be used to approximate the same angle in lifting.

If tanks are not equipped with lifting lugs, it is recommended that these tanks be lifted by use of canvas or rope slings (over 1 inch diameter) at each end of the tank. Tanks can be moved by positioning fork-lift trucks on either side of the tank, with forks padded. Under no conditions should chains or cables be put around the tank. Do not lift by using any fittings other than lifting lugs.

When the tank is stored on the ground prior to installation, it shall be placed on the shipping cradles and tied down so that it cannot roll due to winds or sloping elevation.

B3.3 Installation - Horizontal tank permanent support cradles shall conform to the manufacturer's recommended design.

B3.3.1 Vertical tanks shall be installed with continuous bottom support on a base having sufficient strength to support the weight of the tank under operating conditions without deflection. Full support of the bottom shall be obtained by one of the following methods:

If the surface of the pad and the bottom of the tank are flat and have no projections from the plane surface, the tank may be set on at least two layers of 30 lb. felt building paper. Other methods may be used as recommended by the manufacturer.

If the tank has a bottom drain, a hole shall be made in the pad with sufficient clearance so that the drain will not be in contact with the base at any point.

All connections to nozzles shall conform to Section B2 of this Appendix.

Valves and piping attached to the tank nozzles shall be independently supported.

When agitators, mixers and cooling/heating coils are to be used, follow the manufacturer's instructions.

B3.3.2 Erection of Vertical Tanks - Tanks shall be handled with a crane, as previously described, utilizing the lifting lugs provided. Do not attempt to lift tank by attaching to other fittings. Prior to hoisting the top end, a suitable protective pad material shall be placed under the bottom pivot point of the tank so that as the tank rises, the strain is taken on the pad. The hoist wire shall be connected to one top-lifting lug and the tank shall be raised carefully using guide ropes to prevent sudden swinging. When the tank is vertical, the other top-lifting lug (180° apart) shall be hooked up, lifting the tank evenly. All hold lugs supplied must be utilized to secure the tank to its pad.

B3.4 Limitations in Service - Tanks should be used only in the environment for which they were designed. Standard tanks are not designed for vacuum or pressure other than the liquid head. To prevent accidental pressure or vacuum, the tank should be positively vented to the atmosphere at all times. Materials should not be allowed to freeze in the tank.

The name of the Canadian Government Specifications Board was changed in 1980 to the Canadian General Standards Board.

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