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NBS Voluntary Product Standard
PS 15-69

PRODUCT STANDARDS

Product Standards are published voluntary standards that establish (1) dimensional requirements for standard sizes and types of various products, (2) technical requirements for the product, and (3) methods of testing, grading and marking these products. The objective is to define requirements for these products in accordance with the principal demands of the trade. *Product Standards* are published by the National Bureau of the U. S. Department of Commerce.

Development of a PRODUCT STANDARD

The Bureau's Office of Engineering Standards Services works closely with business firms, trade organizations, testing laboratories and other appropriate groups to develop such standards. (A group interested in developing a *Product Standard* may submit a written request to the Office of Engineering Standards Services, National Bureau of Standards). After determining that the desired standard would be technically feasible and in the public interest, a specific proposal is developed in consultation with interested trade groups and circulated for industry consideration and comments.

Subsequently, a Standard Review Committee is established to review the proposed standard for conformance with the Department of Commerce procedures. The committee includes qualified representatives of producers, distributors and users or consumers of the products. When approved by the committee, copies of the recommended standard are distributed for consideration and acceptance. When the acceptances show general agreement by all segments of the industry and when there is no substantive objection deemed valid by the National Bureau of Standards, the Bureau announces approval of the *Product Standard* and proceeds with its publication.

Use of a PRODUCT STANDARD

Product Standards are developed for the maximum use of industry by ensuring that producers, distributors and users or consumers cooperate in the development of a voluntary *Product Standard.* The adoption and use of a *Product Standard* is *voluntary*. *Product Standards* are used most effectively in conjunction with legal instrumentalities such as building codes, purchase orders and sales contracts. When a standard is made part of such a contract, compliance with the standards is enforceable by the buyer or seller along with other provisions of the contract. There is *no* governmental regulation or control involved.

Purchasers may order products that comply with *Product Standards* and determine for themselves that their requirements are met. More often, manufacturers refer to the standards in sales catalogs, advertising, invoices and labels on the product. Commercial inspection and testing programs are also employed for greater effectiveness together with grade labels, hallmarks and certificates. Such assurance of compliance promotes confidence and understanding between buyers and sellers.

EFFECTIVE DATE

Having been passed through the regular procedures of the Office of Engineering Standards Services, National Bureau of Standards and approved by the acceptors hereinafter listed, this Product Standard is issued by the National Bureau of Standards, effective

November 15, 1969. (See section 6.)

Lewis M. Branscomb, Director

Nat. Bur. Stand. (U.S), Prod. Stand. 15-69, 28 pages (June 1970)
CODEN : XNPSA

Custom Contact-Molded Reinforced-Polyester Chemical-Resistant Process Equipment

(This voluntary standard, initiated by the Society of the Plastics Industry, Inc., has been developed under *the Procedures for the Development of Voluntary Product Standards*, published by the Department of Commerce. See section 7, *History of Project*, for further information.)

1. PURPOSE

1.1. The purpose of this standard is to establish on a national basis the standard sizes and dimension and significant quality requirements for commercially available glass-fiber-reinforced chemical-resistant process equipment for chemical service. The information contained in this Product Standard will be helpful to producers, distributors and users and will promote understanding between buyers and sellers.

2. SCOPE

2.1. This Product Standard covers materials, construction and workmanship, physical properties and methods of testing reinforced-polyester materials for process equipment and auxiliaries intended for use in aggressive chemical environments, including but not limited to pipe, ducts and tanks. The Standard is based on the technology of fabrication by hand lay-up or contact pressure molding. Methods for identifying products that comply with the requirements of this Standard are included.

2.2. This Standard does not cover: (1) resins other than polyesters, (2) reinforcing materials other than glass fibers, (3) laminate constructions or, (4) filament wound fabrication methods. (The industry has initiated the development of additional standards to cover these items.)

3. REQUIREMENTS

3.1. General

3.1.1. Terminology – Unless otherwise indicated, the plastics terminology used in this Standard shall be in accordance with the definitions given in American Society for Testing and Materials (ASTM) Designation D883-69, *Standard Nomenclature Relating to* Plastics.[1]

3.1.2. 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 the appendix.

3.2. Materials

3.2.1. Resin – The resin used shall be of a commercial grade and shall either be evaluated as a laminate by test (see appendix for a recommended test or determined by previous service to be acceptable for the environment.

3.2.2. Fillers and pigments – The resins used shall not contain fillers except as required for viscosity control or fire retardants. Up to 5% 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 agreements 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.

[1] Later issues of the ASTM publications specified in this Product Standard may be used providing the requirements are applicable and consistent with the issue designated. Copies of ASTM publications are obtainable from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA. 19103.

3.2.3. 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.

3.2.4. 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 or polyester fibers and asbestos may affect the values obtained for the Barcol hardness of the surface.

3.3. Laminate – The laminate shall consist of an inner surface, an interior layer and an exterior layer or laminate body. The compositions specified for the inner surface and interior layer are intended to achieve optimum chemical resistance.

3.3.1. Inner surface- The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over two pits per square foot, providing the pits are less than 1/8 inch in diameter and not over 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 of pits. Between 0.100 and 0.020 inches of reinforced resin-rich surface shall be provided.[2] This surface may be reinforced with glass surfacing mat, synthetic fibers, asbestos or other material as usage requires.

3.3.2. Interior layer – A minimum of 0.100 inch of the laminate next to the inner surface shall be reinforced with not less than 20 percent nor more than 30 percent by weight of non-continuous glass strands (see 4.3.1), e.g., having fiber lengths from 0.5 to 2.0 inches.

3.3.3. Exterior layer – The exterior layer or body of the laminate shall be of chemically resistant construction suitable for the surface and providing the additional strength necessary to meet he tensile and flexural requirements. When separate layers such as mat, cloth, or woven roving are used, all layers shall be lapped a minimum of one inch. Laps shall be staggered as much as possible. If woven roving or cloth is used, a layer of chopped-strand glass shall be placed as alternate layers. The exterior surface shall be relatively smooth with no exposed fibers or sharp projections. Hand work finished is acceptable, but enough resin shall be present to prevent fiber show.

3.3.3.1. When the outer surface is subject to a corrosive environment, the exterior surface shall consist of a chopped-strand glass over which shall be applied a resin-rich coating as described in 3.3.1. Other methods of surface protections may be used as agreed between buyer and seller.

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

3.3.5. 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 two inches minimum. Successive layers shall increase uniformly to provide the specified minimum total width of overlay, which shall be centered on the joint. (See 3.3.1, 3.4.6.1 and 3.6.5) Crevices between jointed pieces shall be filled with resin or thixotropic resin paste, leaving a smooth inner surface. (See 3.3.1) The interior of joints may also be sealed by covering with not less 0.100 inch of reinforced resin-rich surface as described in 3.3.1 and 3.3.2.

3.3.6. Wall-thickness – The minimum wall thickness shall be as specified in the tables under the appropriate sections, but in no case shall 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 percent of the minimum wall thickness, but in no case more than 1/8 inch below the specified wall thickness.

[2] This resin-rich surface layer will usually contain less than 20 percent of reinforcing material. A specific limit is not included because of the impracticality of determining this value in the finished product.

3.3.7. Mechanical properties – 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 3.3.7.1. Laminates that do not meet the minimum value of table 1 are considered acceptable provided they are made to afford the same overall strength that would be obtained with a laminate meeting the specified thickness. For example, if the specified thickness for a laminate is 1/4 inch, reading from table 1 a minimum tensile strength of 12,000 psi is required. By multiplying thickness times minimum tensile strength a value of 3,000 pound 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 0.3 inch.

3.3.7.1 Surface Hardness – The laminate shall have a Barcol hardness of at least 90 percent of the resin manufacturer's minimum specified hardness for the cured resin when tested in accordance with 4.3.5. This applies to both interior and exterior surfaces.

3.3.8. Appearance – The finished laminate shall be as free as commercially practicable from visual defects as foreign inclusions, dry spots, air bubbles, pinholes, pimples and delamination

3.3.9. By agreement between buyer and seller, a representative laminate sample may be used for determination of acceptable surface finish and visual defects (see 3.3.1, 3.3.3 and 3.3.8).

3.4. Reinforced-polyester and rectangular ducting[3]

3.4.1. Duct size and tolerances

3.4.1.1. Round ducting – The size of round ducting shall be determined by the inside diameter in inches. The standard size shall be 2, 3, 4, 6, 8, 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 inside diameter and ± 1/8 inch or ± 1 percent, whichever is greater, for ducting exceeding 6 inches in inside diameter.

3.4.1.2. 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 percent for dimensions of over 18 inches.[4]

3.4.2. Lengths – Tolerances on overall lengths shall be ±1/4 inch unless arrangements are made to allow for field trimming.

3.4.3. Wall thickness – The minimum nominal thickness of round ducting shall be in accordance with table 2. For rectangular ducting, the minimum thickness shall be as specified in table 2, substituting the longer side for the diameter. See also 3.3.6.

3.4.4. Squareness of ends – Ends shall be square within ±1/8 inch for round ducting through 24-inch diameter and rectangular ducting through 72-inch perimeter: and ±3/16 inch for larger sizes of both round and rectangular ducting.

Table 1. *Requirements for properties of reinforced-polyester laminates*

Property at 73.4° F (23° C)	Thickness (inches)			
	1/8 to 3/16	1/4	5/16	3/8 and up
	psi	psi	psi	psi
Ultimate tensile strength minimum [1]	9,000	12,000	13,500	15,000
Flexural strength minimum [2]	16,000	19,000	20,000	22,000
Flexural modulus of elasticity (tangent) minimum[3]	700,000	800,000	900,000	1,000,000

[1] See 4.3.2.
[2] See 4.3.3.
[3] See 4.3.4.

[3] Rated from full vacuum to 150 psi (see table 3).
[4] See Footnote 9

Table 2. *Reinforced-polyester round duct dimensions* [1]

I.D. inches	Wall thickness (Min) inches	Allowable vacuum[2] inches of water	Allowable pressure [2] inches of water	Flange diameter (O.D.) inches	Flange thickness inches	Bolt circle dia. inches	Bolt hole dia. inches	No. of Bolt holes
2	0.125	405	750	6-3/8	1/4	5	7/16	4
3	0.125	405	500	7-3/8	1/4	6	7/16	4
4	0.125	210	410	8-3/8	1/4	7	7/16	4
6	0.125	64	350	10-3.8	1/4	9	7/16	8
8	0.125	31	180	12-3.8	1/4	11	7/16	8
10	0.125	16	340	14-3/8	3/8	13	7/16	12
12	0.125	9	280	16-3/8	3/8	15	7/16	12
14	0.125	7	220	18-3/8	3/8	17	7/16	12
16	0.125	6	290	20-3/8	1/2	19	7/16	16
18	0.125	5	240	22-3/8	1/2	21	7/16	16
20	0.125	5	190	24-3/8	1/2	23	7/16	20
24	0.187	5	140	28-3/8	1/2	27	7/16	20
30	0.187	7	100	34-3/8	1/2	33	7/16	28
36	0.187	5	70	40-3/8	1/2	39	7/16	32
42	0.250	10	120	46-3/8	5/8	45	7/16	36
48	0.250	9	100	54-3/8	5/8	52	9/16	44
54	0.250	7	80	60-3/8	5/8	58	9/16	44
60	0.250	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 other ratings at higher temperatures consult the manufacturer.

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

3.4.5.1. Ells – Standard ells shall have a centerline radius of one and one-half times the duct diameter.

3.4.5.2. Laterals – Standard laterals shall be 45°.

3.4.5.3. Reducers, concentric or eccentric – length of standard reducers shall be five times the difference in diameters (D_1–D_2). Minimum wall thickness shall be that required for larger diameter duct as given in table 2.

3.4.6. Straight connections

3.4.6.1. Butt joint – Strength of the butt joint shall be at least equal to that of the duct itself and shall be made in accordance with 3.3.5. Total minimum width of joint shall be three inches for 1/8-inch thickness, four inches for 3/16-inch thickness and six inches for 1/4-inch thickness.

3.4.6.2. Bell and spigot joint – Straight duct shall be inserted into bell at least one-sixth of duct perimeter or four inches, whichever is less, and overwrapped in such a manner as to provide strength at least equal to that of the duct. The opening between the bell and spigot shall be sealed with thixotropic resin paste.

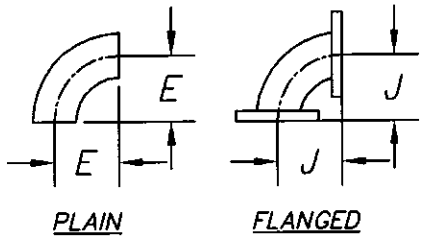
3.4.7. Flanges

3.4.7.1 Flange dimensions – Dimensions of reinforced plastic flanges for wound ducts shall be in accordance with table 2. Flange thickness 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 the rectangular ducts.

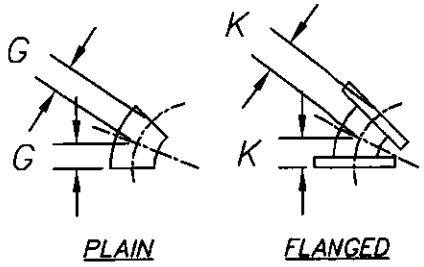
3.4.7.2. Flange attachment – Duct wall at hub of flange shall be at least one and one-half times the normal thickness and taper to normal thickness over a distance of at lease one flange width. Fillet radius shall be at least 3/8 inch at point where the hub meets the back of the flange.
3.4.7.3. Face of flange – Face of flange shall have no projections or depressions greater than 1/32 inch and shall be perpendicular to the centerline of the 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 chemical-resistant surface as described in 3.2.4 and 3.3.1.
3.4.7.4. Drilling – Standard flanges shall be supplied undrilled.
3.4.7.5. Flange bolting – The bolt holes shall straddle centerline unless otherwise specified. Unless otherwise specified, the number of bolt holes and diameters of bolt holes and bolt circles shall be in accordance with table 2. Rectangular flange width and bolt spacing shall be the same as that for diameters corresponding to the longer sides.
3.4.8. Mechanical properties of ducts
3.4.8.1.Laminate – the minimum mechanical properties shall be in accordance with table 1.
3.4.8.2. Deflection – Maximum deflection of a side on a rectangular duct shall not exceed one percent of the width of the side under operating conditions. Ribs or other special constructions shall be used if required to meet the deflection requirement.
3.4.9. Stacks – Special engineering consideration is required for structural design of stacks, and the manufacturers should be consulted.
3.5. Reinforced-polyester pipe [5]
3.5.1. Size – The standard pipe size shall be inside the diameter in inches. Standard sizes are 2, 3, 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 percent, whichever is greater, for pipe exceeding six inches in inside diameter. This measurement shall be made at the point of manufacture with the pipe in an unstrained vertical position.
3.5.2 Length – The length of each fabricated piece of pipe shall not vary more than ±1/8 inch from the ordered length unless arrangements are made to allow for trim in the field.
3.5.3. Wall Thickness – The minimum wall thickness of the pipe shall be in accordance with table 3. See also 3.3.6.
3.5.4 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-inch diameter and to within ±3/16 inch for all diameters above 24 inches.
3.5.5. Fittings – All fittings such as elbows, laterals, tees, 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 1. Tolerance on angles of fittings shall be ±1° through 24 inches in diameter and ±1/2° for 30-inch 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.
3.5.5.1 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-inch 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. Incorporation of straight pipe extensions on elbows is permissible.
3.5.5.2. Reducers – Reducers of either concentric or eccentric style will have a length as determined by the diameter of the large end of the reducer as indicated in figure 1.

[5] Rated from full vacuum to 150 psi (see table 3).

STANDARD FRP FITTING DIMENSIONS



90° ELBOW



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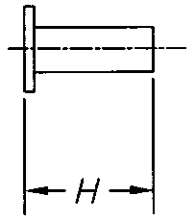
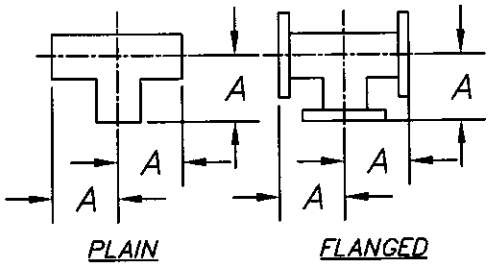
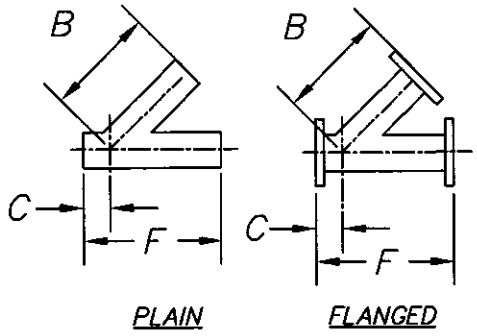


STUB FLANGE



TEE



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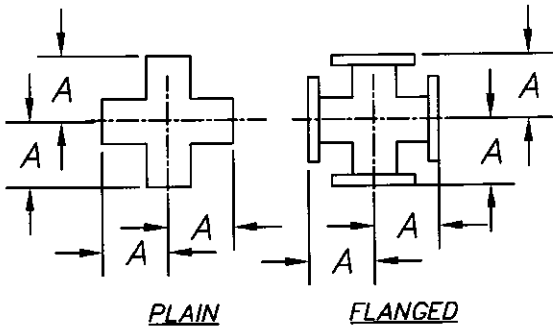
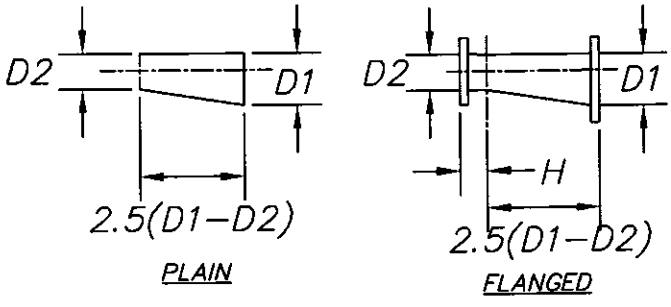
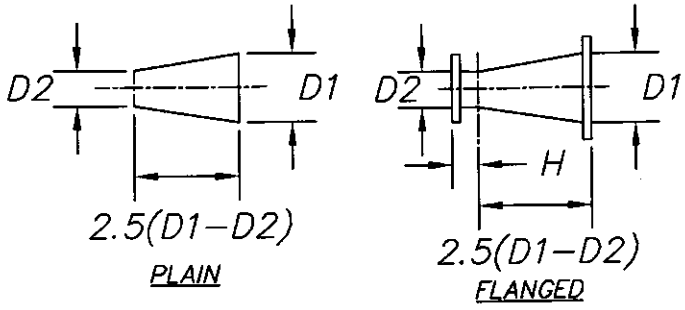


CROSS



ECCENTRIC REDUCER



CONCENTRIC REDUCER

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

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3.5.6. 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 will be as outlined in 3.3.5. All pipe 20 inches in diameter and larger shall be overlaid both insider, when accessible, and outside. Pipe less than 20 inches in diameter shall be outside overlaid. The minimum width of the overlay shall relate to wall thickness and shall be of the dimensions indicated in table 4. Inside overlaps may be made to seal the joint if necessary, but shall not be considered in meeting the strength requirement specified in 3.3.5.

3.5.7. Flanges – 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 flanges is the same as that for laminates. (See 3.3.)

3.5.7.1. Flange attachment – The minimum flange shear surface shall be four times the flange thickness indicated in table 5. The thickness of the 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 the length of the hub reinforcement. The fillet radius, where the back of the flange meets the hub, shall be 3/8-inch minimum.

3.5.7.2. 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 chemical resistant surface as described in 3.2.4 and 3.3.1.

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TABLE 3. *Reinforced-polyester pipe wall thickness*

Pipe size	Minimum Pipe wall thicknesses[1] at pressure ratings:					
	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*
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 strength 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 3.5.9.

3.5.7.3. 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 pressures established for standard joints.

3.5.8. Mechanical properties of pipe – The minimum mechanical properties of pipe shall be in accordance with table 1.

TABLE 4. *Minimum total widths of overlays for reinforced-polyester butt joints.*

Pipe wall thickness, inches ...	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, inches ...	3	4	5	6	7	8	9	10	11	12

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

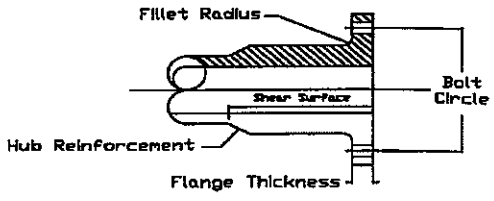
Table 5. *Minimum flange thickness for reinforced-polyester pressure pipe* [1] [2] [3]

Pipe size	Minimum flange thickness at design pressures:					
	25 psi	50 psi	75 psi	100 psi	125 psi	150 psi
Inches	Inches	Inches	Inches	Inches	Inches	Inches
2	½	½	½	9-16	5/8	11/16
3	½	½	5/8	11/16	¾	13/16
4	½	9/16	11/16	13/16	7/8	15/16
6	½	5/8	¾	7/8	1	1-1/16
8	9/16	¾	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	¾	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	1515/16	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: USA Std. B16.5 for 50 lb steel flanges.
30-inch through 42-inch sizes: USA Std. B16.1 for 125 lb C.I. flanges.

[3] This 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.



3.5.10. Recommended installation practice

3.5.10.1. Pipe hangers and spacing – Hangers shall be band type hangers contacting a minimum of 180° of the pipe surface. The maximum pipe hanger spacing shall be in accordance with table 6.

3.5.10.2. Underground installation – Special consideration must be given to installing pipe underground. It is recommended that the manufacturer be consulted for installation procedures.

3.5.10.3. Expansion – Since the expansion rate of this plastic pipe is several times that of steel, proper consideration should be given to any pipe installation to accommodate the overall linear expansion.

3.5.10.4. Bolts, nuts, and washers – Bolts, nuts, and washers shall be furnished by the customer. Metal washers shall be used under all nut and bolt heads. All nuts, bolts, and washers shall be of materials suitable for use in the exterior environment.

3.5.10.5. Gaskets – Gaskets shall be furnished by the customer. Recommended gasket material shall be a minimum of 1/8 inch in thickness with a suitable chemical resistance to the service environment. Gaskets should have a Shore A or Shore A2 hardness of 40 to 70.

Table 6. *Maximum spacing of pipe hangers for reinforced-polyester pressure pipe* [1]

Pipe I.D.	Maximum pipe hanger spacing at pressure ratings:					
	25 psi	50psi	75 psi	100 psi	125 psi	150 psi
Inches	Feet	Feet	Feet	Feet	Feet	Feet
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	7.0	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			

[1] The above 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.

4. INSPECTION AND TEST PROCEDURES

4.1. Specimens – 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.

4.2. Conditioning – The test specimens shall be conditioned in accordance with Procedure A of ASTM Designation D618-61, *Standard Methods of Conditioning Plastics and Electrical Insulating Materials for Testing*[7].

4.3. Tests

4.3.1. Glass content – The glass content shall be determined in accordance with ASTM Designation D2584-67T, *Tentative Method of Test for Ignition Loss of Cured Reinforced Resins*[8], 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 average for five specimens shall be considered to be the glass content.

4.3.2. Tensile strength – Tensile strength shall be determined in accordance with ASTM Designation D638-68, *Standard method of Test for Tensile Properties of Plasics*[7], except that the specimens shall be the actual thickness of the fabricated article and the width shall be one inch. Other dimensions of specimens shall be as designated by the ASTM standard for Type I specimens for materials over 1/2 inch to one 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 speed.

4.3.3. Flexural strength – Flexural strength shall be determined in accordance with Procedure A and table 1 of ASTM Designation D790-66, *Standard Method of Test for Flexural Porperties of Plastics*[7], except that the specimens shall be the actual thickness of the fabricated article and the width shall be one inch. Other dimensions os 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.

4.3.4. Flexural modulus – The tangent modulus of elasticity in flexure shall be determined by ASTM Method D790-66 (see 43.3.).

4.3.5. Hardness – The hardness shall be determined in accordance with ASTM Designation D2583-67, *Standard Method of Test for Indentation Hardness of Plastics by Means of a Barcol Impressor*[8], Calibration of the barcol instrument shall be verified by comparing with blank specimens having known readings of 85 to 87 and 42 to 46. Ten readings on the clean resin-rich surface shall be made. After eliminating the two high or two low readings, the average of the remainder shall be the reported hardness reading.

4.3.6. Additional tests – Recommended test methods for the further testing of reinforced-polyester laminates are given in the appendix. These test methods are included as recommendations and are not to be considered as requirements from the standpoint of determining compliance with the Standard.

[7] See footnote 1.
[8] See footnote 1, page 1.