SPECIFICATION: **Flame Guard**

FlameGuard®
Fire Retardant FRP Duct/Pipe

Standard Class 1 Fire Retardant Vinyl Ester
Fiberglass Duct & Duct Fittings

CUSTOMER / PROJECT: _____

REQUIREMENTS

1.0 GENERAL

The Flame Guard fiberglass reinforced plastic duct (FRP Duct) system shall be specifically designed and constructed to comply with the SMACNA FRP Duct Construction Manual, U.S. Bureau of Commerce Standard PS-15-69, and the following minimum conditions: Corrosion resistance to hydrogen sulfide, chlorine, mercaptans and other gases commonly encountered in industrial chemical and waste water treatment plants.

2.0 MATERIALS

2.1 **RESIN** - The resin used shall be a corrosion resistant, Class 1 fire retardant vinyl ester such as Ashland Chemicals Hetron 992, Derakane 510-B, AOC K-022, or equal.

2.2 **FILLERS AND PIGMENTS** - The resins used shall not contain fillers except as required for viscosity control or fire retardance. Up to 5 percent 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 Composites USA, Inc. and purchaser, recognizing that such additions may interfere with visual inspection of laminate quality.

2.2.1 Antimony compounds or other fire retardant agents may be added for improved fire resistance, as required, to meet flammability specifications. Standard product contains 3% antimony to provide a class 1 flame performance of <25 as measured by ASTM E-84.

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.

2.4 **SURFACING MATERIALS** - Unless otherwise agreed upon between Composites USA, Inc. and purchaser, material used as reinforcing on the surface exposed to chemical attack shall be either a commercial grade chemical-resistant glass having a coupling agent, or a synthetic veil material such as Nexus polyester. Alternate surfacing materials suitable for use include Halar fluoropolymer for premium corrosion resistance, or carbon/ graphite for imparting an electrically conductive surface for static dissipation. Where static electricity has been determined to be a problem, the inner surface shall be grounded with a maximum resistance to ground of 106 ohm.

2.5 **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. - 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. The combination of the inner surface and the interior layer is generally referred to as the corrosion liner.

2.6 **INNER SURFACE** - The inner surface shall be free of cracks and crazing with a smooth finish. Any pitting will average not more than 2 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 0.010 and 0.020 inches of reinforced resin-rich surface shall be provided. This surface will be reinforced with C-veil glass surfacing mat, Nexus polyester veil, or a combination of both, unless otherwise specified and agreed between Composites USA and customer.

2.6 **INTERIOR LAYER** - A layer 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 (having fiber lengths from 0.5 to 2.0 inches).

2.7 **EXTERIOR LAYER** - The exterior layer or body of the laminate shall be of chemically resistant construction suitable for the service 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 a minimum of 1 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. Filament wound reinforcement may be used in this layer to achieve the structural requirements.

2.7.1 The exterior surface shall be relatively smooth with no exposed fibers or sharp projections. Hand work finish is acceptable, but enough resin shall be present to prevent fiber show. The finished product is to have a Class 1 flame (<25) spread throughout, unless otherwise specified. The exterior of the duct shall be protected from the effect of U.V. degradation through either the addition of U.V. inhibitor in the resin top coat or the application of a pigmented paint or gel coat system.

2.8 **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.

2.9 **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 2 inches minimum. Successive layers are to increase uniformly and provide the specified minimum total width of overlay, which shall be centered on the joint. Crevices between jointed pieces shall be filled with resin or thixotropic resin paste, leaving a smooth inner surface (See INNER SURFACE). The interior of joints may also be sealed by covering with a reinforced resin-rich surface as described in **INNER SURFACE** and **INTERIOR LAYER**, if accessible and agreed upon by Composites USA and customer.

2.10 **WALL THICKNESS** - The minimum wall thickness shall be as specified in table 3. Isolated small spots may be as thin as 80 percent of the minimum wall thickness, but in no case more that 0.13 inch below the specified wall thickness.

2.11 **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. This applies to both interior and exterior surfaces.

2.12 **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.

3.0 DUCT SIZES AND TOLERANCES

3.1 **SIZE** - The standard duct size shall be the inside diameter in inches. Standard sizes are 0.75, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 42, 48, 54, 60, 72 inches. Sizes larger than 38" up to and including 288” diameter are available in any increment on our adjustable mandrels, using mitered elbows. The tolerance including out-of-roundness shall be 0.063 inch for duct up to and including 6-inch inside diameter, and 0.13 inch or +1 percent, whichever is greater, for duct exceeding 6 inches inside diameter. This measurement shall be made at the point of manufacture with the duct in an unstrained vertical position.

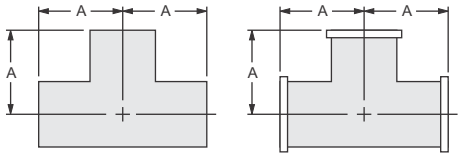
3.2 **LENGTH** - The length of each fabricated piece of duct shall not vary more than +1/8 inch from the ordered length unless arrangements are made to allow for trim in the field. Standard lengths are nominal 20 ft on sizes above 1.5".

3.3 **WALL THICKNESS** - The minimum wall thickness shall be in accordance with Table 3.

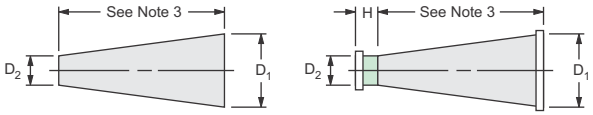
3.3 **RECTANGULAR DUCT** - The size of rectangular duct shall be determined by the inside dimensions. There are no standard sizes for rectangular duct. Unless otherwise specified, the tolerances on rectangular duct shall be +/- 0.19" on sizes up to 18", and +/- 1% on sizes over 18". For rectangular duct, the largest flat panel shall be designed to withstand the specified loading conditions and not exceed the design limitations for deflection. Unless otherwise specified, the minimum thickness shall be as shown in Table 3, substituting the longer side of the rectangular duct for the diameter.

TABLE 1: Standard Duct and Pipe Fitting Dimensions (all dimensions in inches)

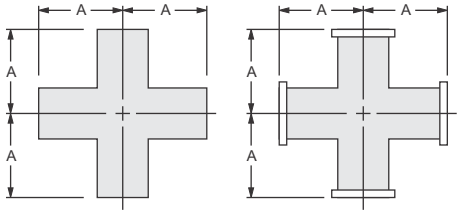
TEE



CONCENTRIC REDUCER



CROSS



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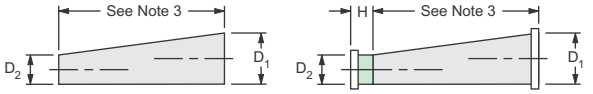
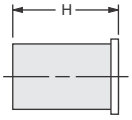
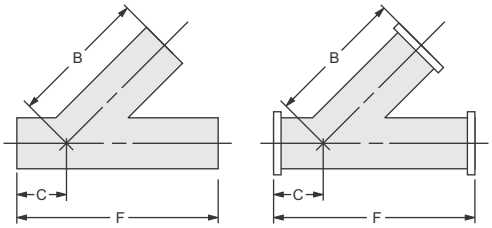


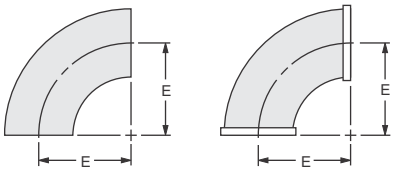
STUB FLANGE



45 DEGREE LATERAL



90 DEGREE ELBOW



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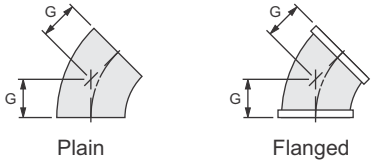

Dia.	A	B	C	E	F	G	H
1-1/2	6	10	6	3	16	1-1/4	6
2	6	10	6	4	16	1-5/8	6
3	7	12	6	4-1/2	18	1-7/8	6
4	8	14	6	6	20	2-1/2	6
6	10	16	8	9	24	3-3/4	8
8	12	20	10	12	30	5	8
10	14	24	10	15	34	6-1/4	10
12	16	26	12	18	38	7-1/2	10
14	18	30	12	21	42	8-3/4	12
16	20	32	14	24	46	10	12
18	21	36	14	27	50	11-1/4	12
20	22	38	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	22-3/8	15
42	36	72	24	63	96	26	15
48	42	82	30	72	108	29-7/8	18
54	48	92	36	81	120	33-1/2	18
60	54	102	42	90	132	37-1/4	18
72	66	122	54	108	144	44-3/4	18

Note:
1. Standard elbow radius is 1.5:1, face to centerline (long radius). Short radius (1:1) is also available.
2. Due to dimensional interferences, flanged elbows below 6" diameter require stub flanges joined to plain end elbows.
3. Standard reducer length is 2.5 x the diameter difference for pipe (5 x difference for duct).
4. Custom dimensions and assembly for all fitting styles available.

3.4 **SQUARENESS OF ENDS** - All non-flanged duct shall be cut square with the axis of the duct within 0.13 inch up to and including 24 inch diameter and to within 0.19 inch for all larger diameter duct.

3.5 **FITTINGS** - 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 Tables 1 and 3. Tolerance on angles of fittings shall be +/-1o through 42 inches in diameter and +/- 0.5 o for 48-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.

3.6 **ELBOWS** - Standard elbows shall have a centerline radius of one and one half times the diameter. Standard elbows up to and including 48 inches shall be continuous sweep molded of one piece construction. Elbows greater than 48 inch diameter and those with a non-standard throat radius larger may be of molded or 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. Unless otherwise specified, mitered elbows 45o or less will be single-miter, two gore., while elbows above 45o and through 90o shall have a minimum of three gore construction. Incorporation of straight pipe extensions on elbows is permissible.

3.7 **REDUCERS** - Reducers of either concentric or eccentric style will have a length as determined by the ratio of the diameters of the reducer as indicated in Table 1. Reducer lengths of 5X the diameter difference is generally recommended, although alternate reducer lengths are acceptable and often required due to customer layout requirements.

TABLE 2: Requirements for properties of reinforced vinyl ester laminates.

Contact Molded Properties at 73.4°F (23°C)	Thickness (inches)			
	1/8 - 3/16	1/4	5/16	3/8 & up
Ultimate tensile strength - minimum (psi)	9,000	12,000	13,500	15,000
Flexural strength - minimum (psi)	16,000	19,000	20,000	22,000
Flexural modulus of elasticity, tangent minimum (psi)	700,000	800,000	900,000	1,000,000
Filament Wound Modulus (Hoop & Axial, Resultant)(psi)	1,100,000	1,600,000	1,700,000	1,700,000

Note: Filament wound resultant modulus based upon ASME RTP-1 calculation methodology.

3.8 **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 is as follows: The 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 2 inches minimum. Successive layers shall increase uniformly to provide the specified minimum total width of the overlay, which shall be centered on the joint.

Crevices between jointed pieces shall be filled with resin or thixotropic resin paste leaving a smooth inner surface. When accessible and when required by operating or design conditions, duct joints may be overlaid both inside and outside. The minimum width of the overlay shall relate to wall thickness and shall be of the dimensions indicated in table 4 for hand lay up construction. Inside overlays may be made to seal the joint if necessary, but shall not be considered in meeting the strength requirement specified.

3.9 **FLANGES** - The use of flanges shall normally be kept to a minimum with the butt joint being used as the standard means of joining duct sections. All flanges shall be field drilled, meeting the minimum thickness given in Table 3.

TABLE 3: Reinforced polyester or vinyl ester duct dimensions, dimensions in inches and inches water column, except support spacing which is in feet.

Duct Internal Diameter	Wall Thickness	Allowable Vacuum	Allowable Pressure	Flange O.D.	Flange Thickness	Bolt Circle	Bolt Hole Diameter	No. of Bolt Holes	Support Spacing
2	0.125	405	3115	6.38	0.25	5	0.44	4	7
3	0.125	406	2075	7.38	0.25	6	0.44	4	8
4	0.125	210	1560	8.38	0.25	7	0.44	8	9
6	0.125	64	1040	10.38	0.25	9	0.44	8	9
8	0.125	30	780	12.38	0.25	11	0.44	8	9
10	0.125	16	623	14.38	0.25	13	0.44	12	9
12	0.125	9	518	16.38	0.38	15	0.44	12	8
14	0.125	7	45	18.38	0.38	17	0.44	12	8
16	0.125	6	389	20.38	0.38	19	0.44	16	8
18	0.125	5	346	22.38	0.50	21	0.44	16	8
20	0.125	5	311	24.38	0.50	23	0.44	20	8
24	0.187	9	389	28.38	0.50	27	0.44	20	10
30	0.187	7	309	34.38	0.50	33	0.44	28	9
36	0.187	5	255	40.38	0.50	39	0.44	32	9
42	0.250	10	368	46.38	0.50	45	0.44	36	11
48	0.250	9	233	54.38	0.63	52	0.44	44	10
54	0.250	7	206	60.38	0.63	58	0.44	44	10
60	0.250	6	185	66.38	0.63	64	0.44	52	10
72	0.313	12	240	78.38	0.75	76	0.44	60	11

1. The specified wall thickness are based upon a 10 to 1 safety factor for the contact molded tensile strength listed in Table 2. Filament wound duct will generally result in higher allowable pressures and vacuum ratings with the same factors of safety.
2. These ratings are suitable for use up to 180°F (82.2°C); for ratings at higher temperatures, consult the manufacturer.
3. Vacuum ratings are based upon duct stiffening ribs on 10'-0" centers.
4. Allowable pressures are governed by the lower of the (CUSA 1/2" minimum) flange or duct allowable pressure.
5. Standard flanges are supplied undrilled in accordance with PS-15-69.
6. Support spacing is typical based upon deflection, stress and cylinder buckling analysis. Consult the factory for specific guidance.

3.10 **FLANGE ATTACHMENT** - The minimum flange shear surface shall be four times the flange thickness indicated in Table 3. 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 0.37 inch minimum.

3.11 **FLANGE FACE** - The flange face shall be perpendicular to the axis of the pipe within 0.5o and shall be flat to 0.032 inch up to and including 18-inch diameter and 0.062 inch for larger diameters. The face of the flange shall have a chemical resistant surface as described in **SURFACING MATERIALS** and **INNER SURFACE.**

TABLE 4: Minimum total widths of overlays for reinforced-vinyl ester butt joints.

Duct 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

4.0 RECOMMENDED INSTALLATION PRACTICE

4.1 **DUCT HANGERS AND SPACING** - Hangers shall be band type hangers contacting a minimum of 180o of the duct surface, or trapeze hangers in the case of rectangular duct. The maximum duct hanger spacing shall be in accordance with Table 3 above, unless specifically engineered for the application.

4.1.1 All duct shall be securely hung and anchored to the building structure, isolated from vibration. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true to shape and to prevent buckling.

4.1.2 Unless otherwise engineered, all ductwork shall be in accordance with the SMACNA Thermoset FRP Duct Construction Manual.

4.1.3 Strap hangers where used, shall meet the requirements of SMACNA Table 7-1, 2” wide by 1/8” thick for duct up to 22” diameter, 3” wide by 3/16” thick for duct over 22” and up to 60” diameter, and 4” wide by 3/16” thick for duct over 60” diameter.

4.1.4 Trapeze hangers where used, shall meet the requirements of SMACNA Table 7-3. Angle size is dependent upon the load carried (Kips (=1000 lbs) x distance between hangers in inches). Recommended angle sizes and load limits are as follows:

1 x 1 x 1/8”, 1.9 Kip-in.
1.5 x 1.5 x 1/8”, 4.3 Kip-in.
2 x 2 x 1/8”, 7.9 Kip-in.
2 x 2 x 3/16”, 11.4 Kip-in.
2 x 2 x 1/4”, 14.8 Kip-in.
2.5 x 2.5 x 1/4”, 22.9 Kip-in.
3 x 3 x 1/4”, 34.6 Kip-in.
4 x 4 x 1/4”, 63.0 Kip-in.
4 x 4 x 3/8”, 91.2 Kip-in.

4.1.2 Maximum allowable loads on the hanger rods are not to exceed those in SMACNA Table 7-4, with ¼" rods rated for a maximum of 240 lb, 5/16" rods for 380 lb, 3/8" rods at 610 lb, ½" rods at 1330 lb, 5/8" rods at 1810 lb, and ¾" rods at 2710 lb.

4.2 **UNDERGROUND INSTALLATION** - Special consideration must be given to installing pipe or duct underground. It is recommended that Composites USA, be consulted for design and installation procedures.

4.3 **EXPANSIONS** - Since the expansion rate of polyester or vinyl ester fiberglass (12-15 x 10-6 in/in/oF) is usually greater than that of steel or stainless steel (6-10 x 10-6 in/in/oF), proper consideration should be given to any duct installation to accommodate the overall linear expansion. Consult Composites USA when in doubt.

4.4 **MECHANICAL PROPERTIES OF DUCT** - The minimum mechanical properties of duct shall be in accordance with Table 2.

4.5 **VACUUM SERVICES** - Minimum vacuum handling capability for standard Composites USA duct and fittings are given in Table 3. Special engineering consideration is required for larger pipe sizes and for operation at temperatures above ambient atmosphere temperature. Complete engineering analysis can be performed on systems as required, with designs up to and including full vacuum.

4.6 **BOLTS, NUTS, AND WASHERS** - Bolts, nuts, and washers shall be furnished by the customer, unless otherwise agreed in the purchase order acceptance. 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.

4.7 **GASKETS** - Gaskets shall be furnished by the customer, unless otherwise agreed in the purchase order acceptance. Recommended gasket materials 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.

5.0 SPECIAL REQUIREMENTS:

5.1 **BUTTERFLY STYLE DAMPERS** - Butterfly style dampers are to be supplied to the same materials of construction and quality assurance parameters as the duct system. Each damper is to ship complete with all the components listed below:

FRP Damper Body
FRP Disc or Blade Assembly
FRP Shaft with thermoplastic bushings
SS Locking Quadrant Hand Mechanism
Flanges - Optional
Actuator - Optional

5.1.1 Certified dimensional drawings shall be provided for approval showing all damper assembly components weights, flange drilling patterns and critical dimensions.

5.2 **BUTTERFLY DAMPER DESIGN:**

5.2.1 **Damper Body** - Flange thicknesses and bolt hole layout shall be the same as for the duct dimensions quoted and shown above in Table 3. Face to face dimensions shall be specified at the time of the system layout and should generally be designed to minimize the number of system flange joints. Standard dimensions are shown on cut sheet drawings fitting style #300.

5.2.2 If automated, the damper body shall be clearly marked to show flow direction. Markings shall be permanent and clearly visible. The damper body shall be designed with a mounting bracket suitable to properly mount the actuator or lock the manual shaft in proper operating position.

5.2.3 **Damper Blade** - Damper blade shall be manufactured from the same material as the duct. The blade should be designed to withstand the design conditions without failure, using a safety factor of 5:1 and a minimum deflection not to exceed 1.0% of the diameter.

5.2.4 **Bushings** - Thermoplastic shoulder bushings are supplied as standard. Viton O-rings are available (and are standard on Dual Guard 2000 duct systems). Optional or outboard bearings shall be mounted in a packing gland outside of the damper body and shall be readily accessible for lubrication and/ or removal.

5.2.5 **Deformation or Creep** - The equipment shall be suitable for all operating conditions. Deformation or creep shall not interfere with the damper operation under the most severe combined operating conditions.

5.3 **OPTIONS:**

5.3.1 **Seals** - Blade and/ or shaft seals are available options. Standard design on shaft seals is O-rings. Standard blade seals are rubber (EPDM, Neoprene, or Viton) wiper blades. Teflon seals are generally used where an outside packing gland is ordered.

5.3.2 **Actuator / Coupling** - All electrical components are to be NEMA 4. The design shall insure that thermal growth will not interfere with the damper or actuator operation over the full temperature range - Not provided with base bid.