Design Guide

Dynaform® Fiberglass Structural Shapes

Corrosion Resistant

Fire Retardant

Low Maintenance

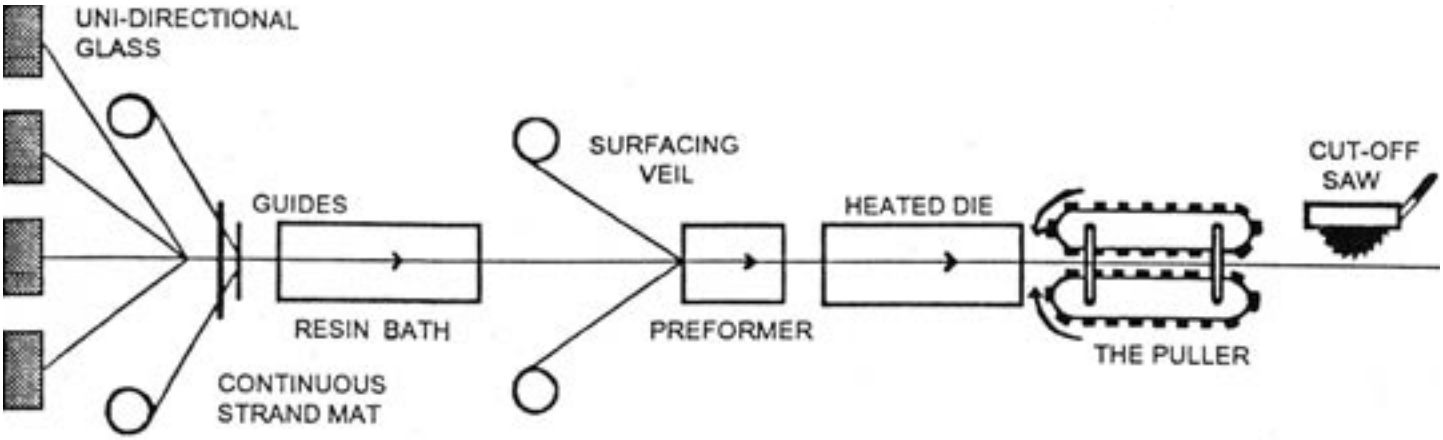
Light Weight

Long Service Life

Fibergrate
Composite Structures

High Performance Composite Solutions

Pultrusion Process



Pultrusion is a continuous process of raw materials, typically resin and reinforcing materials, forming profiles of constant cross section in continuous length.

Pultrusion gets its name from the method by which the profiles are made. Raw materials are literally pulled by what we call "the puller." "The puller" is the machine made-up of pulling pads, which grip the product, and a drive system which keeps the product moving. "The puller" is located just before the final cut-off saw.

The process starts with the reinforcements. Typically, unidirectional glass roving is the fiber that runs along the length of the profile. Second, the fiberglass mat is added in, which is multidirectional reinforcement. Third is the resin, typically polyester or vinylester. The glass is "wet-out" with the liquid resin and pulled into a heated die. Just before all the material enters the die, surface veil may be added which enhances the final product's surface.

Now that all the reinforcements have been "wet-out" and pulled into a heated die, the curing takes place. All the resins used in the pultrusion process have a catalyst or hardener added when the resin is mixed. This catalyst activated at about 200°F. Consequently, as the "wet-out" reinforcement pass through the heated die, the product changes from liquid to a solid profile with all the reinforcement laminated within.

The product exiting the die is pulled by "the puller", which upon exiting can be cut to the desired length.

Standard Resin Systems for Structural Shapes

STANDARD POLYESTER (ISO) RESIN SYSTEM

The STANDARD POLYESTER RESIN SYSTEM refers to a NON FLAME RETARDANT isophthalic polyester resin system. This resin system is manufactured in olive green and incorporates ultraviolet inhibitors. Polyester resins exhibit good corrosion resistance, good electrical properties, low thermal conductivity and excellent mechanical properties.

FLAME RETARDANT POLYESTER (ISOFR) RESIN SYSTEM

This resin system exhibits the same characteristics as the Standard Polyester resin system PLUS a flame spread rating of 25 or less when tested in accordance with ASTM E-84. The FLAME RETARDANT resin system is manufactured in gray and yellow.

FLAME RETARDANT VINYL ESTER (VEFR) RESIN SYSTEM

This resin system is manufactured from vinyl ester resin which exhibits higher strength, improved strength and stiffness retention at elevated temperatures, and improved corrosion resistance. This system also meets a maximum flame spread rating of 25 and is produced in beige and yellow.

ELEVATED TEMPERATURE EFFECTS

The approximate retention of mechanical properties at elevated temperatures are:

	TEMPERATURE	ISO/ISOFR	VEFR
Ultimate Stress	100°F	85%	90%
	125°F	70%	80%
	150°F	50%	80%
	175°F	Not recommended	75%
	200°F	Not recommended	50%
Modulus of Elasticity	100°F	100%	100%
	125°F	90%	95%
	150°F	85%	90%
	175°F	Not recommended	88%
	200°F	Not recommended	85%

Chemical Resistance Guide - Vinyl Ester Threaded Rods

SOLUTION	MAXIMUM RECOMMENDED TEMPERATURE F°/C°
H_2SO_4 - 25 %	210/99
HCl - 20%	210/99
HNO_3 - Gas	100/38
Acetic Acid - 25%	210/99
Phosphoric Acid - 100%	210/99
NaOH - 50%	180/82
Sodium Carbonate - 35%	180/82
NaCl - Saturated	180/82
Ethanol - 10%	120/49
Sodium Hypochlorate - 10%	120/49
All AIK $(SO_4)_2$	210/99
Perochloroethylene - 100%	80/27
n-Heptane - 100%	210/99
Kerosene - 100%	180/82
Toluene - 100%	80/27
H_2O_2 - 30%	150/65
Distilled Water	180/82

NOTE: Threads of threaded rods are cut into specially manufactured pultruded rods. Therefore, after installation of threaded rods and fiberglass nuts in a corrosive environment, the threads are to be sealed with a vinyl ester resin.

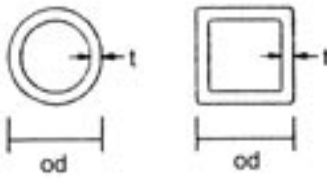
Coupon Properties - Threaded Rods and Nuts

Threaded rod and nuts are manufactured using premium vinyl ester resin containing UV inhibitors. The properties listed below are the result of the ASTM test method indicated.

PROPERTIES	ASTM	UNITS	VALUE Diameter- Threads per Inch (UNC)				
			3/8-16	1/2-13	5/8-11	3/4-10	1-8
Ultimate Transverse Shear (Double Shear)	B-565	lb	4,200	6,800	10,000	13,400	24,000
Longitudinal Compressive Strength	D-695	psi	50,000	50,000	50,000	50,000	50,000
Flexural Strength	D-790	psi	70,000	70,000	70,000	70,000	70,000
Flexural Modulus	D-790	10^6 psi	2.5	2.5	2.5	2.5	2.5 psi
Flammability	D-635		Self-extinguishing for all				
Fire Retardant	E-84		Class 1	Class 1	Class 1	Class 1	Class 1
Water Absorption 24 hr. Immersion	D-570	% max	0.8	0.8	0.8	0.8	0.8
Longitudinal Coefficient of Thermal Expansion	D-696	10^{-6} in/in/°C	6	6	6	6	6
Ultimate Thread Shear using fiberglass nut	----	lb	1,200	2,400	3,600	4,000	8,200
Ultimate Torque Strength fiberglass nut lubricated with SAE 10W30 motor oil	----	ft-lb	12	18	35	75	110
Rod Weight	----	lb/ft	.07	.08	.20	.30	.53
Nut Weight	----	lb	.01	.02	.04	.06	.14
Nut Dimensions	----	in (sq) x in (thick)	.68 x.45	.86 x.56	1.06 x.69	1.24 x.82	1.63 x1.1
Color			Gray	Gray	Gray	Gray	Gray

NOTE: Threads of threaded rods are cut into specifically manufactured pultruded rods. Therefore, after installation of threaded rods and fiberglass nuts in a corrosive environment, the threads are to be sealed with a vinyl ester resin.

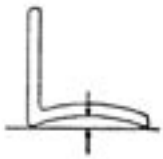
Cross Sectional Tolerances

SHAPE	DIMENSION	OUTSIDE DIMENSION CONDITION	TOLERANCES
ROUND & SQUARE TUBE 	t = thickness	Under 1"	± 20%
		1" and up	± 15 %
	od = outside dimension	Under 2"	± 0.020"
		2" and up	± 0.040"
ROUND ROD & SQUARE BAR 	od = outside dimension	Up to 3"	± 0.010"

FLATNESS

Flatness is measured in the center with the weight of the profile minimizing the deviation by contact with a flat surface.

STRUCTURAL SHAPES RODS, BARS, & SHEET



Allowable deviation from flat	
Width	**All Thicknesses**
Up to 1"	0.008"
Over 1"	0.008"/inch

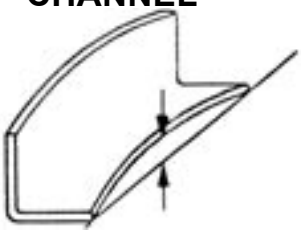
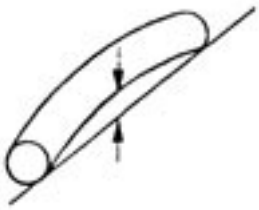
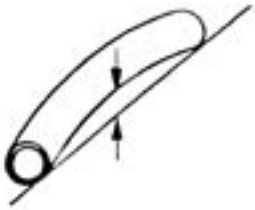
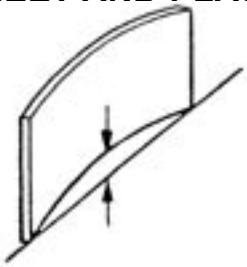
HOLLOW SHAPES

Allowable deviation from flat		
Width	**Thickness 0.125" to 0.188"**	**Thickness 0.189" and over**
Up to 1"	0.012"	0.008"
Over 1"	0.012"/inch	0.008"/inch

Cross Sectional Tolerances

STRAIGHTNESS

Straightness is measured in the center with the weight of the pultrusion minimizing the deviation by contact with a flat surface.

<table>
<tr><td rowspan="2">ANGLE, BEAM AND CHANNEL
  </td><td colspan="2">Allowable deviation from straight</td></tr>
<tr><td>All widths</td><td>0.050"/foot</td></tr>
<tr><td rowspan="4">RODS AND BARS
  </td><td colspan="2">Allowable deviation from straight</td></tr>
<tr><td>Diameter/Depth</td><td>Per Foot</td></tr>
<tr><td>Up to 1"</td><td>0.020"</td></tr>
<tr><td>Over 1"</td><td>0.040"</td></tr>
<tr><td rowspan="4">ROUND, SQUARE, AND RECTANGULAR TUBE
  </td><td colspan="2">Allowable deviation from straight</td></tr>
<tr><td>Diameter/Depth</td><td>Per Foot</td></tr>
<tr><td>Up to 2"</td><td>0.020"</td></tr>
<tr><td>Over 2"</td><td>0.030"</td></tr>
<tr><td rowspan="2">SHEET AND PLATE
  </td><td colspan="2">Allowable deviation from straight</td></tr>
<tr><td>All thicknesses and widths</td><td>0.025"/foot</td></tr>
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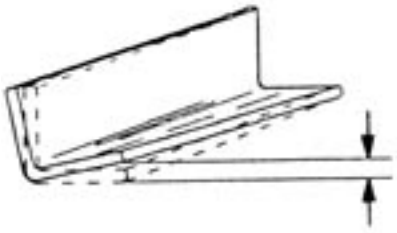
Cross Sectional Tolerances

TWIST

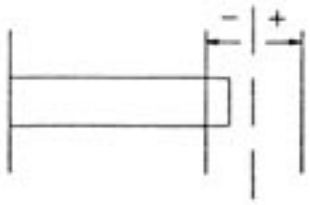
Twist is measured with the weight of the pultrusion minimizing the twist.

ALL PROFILES	Allowable twist		
	**Width/Depth**	**Per Foot**	**Per Piece Max**
	Up to 1.499"	tan 1° x width	tan 7° x width
	1.500" to 2.999"	tan 1/2° x width	tan 5° x width
	3.000" and over	tan 1/3° x width	tan 3° x width

ANGULARITY

ALL PROFILES	Allowable deviation from specific angle	
	thickness up to 3/4"	tan 1 1/2° x width of flange in inches

CUT LENGTHS

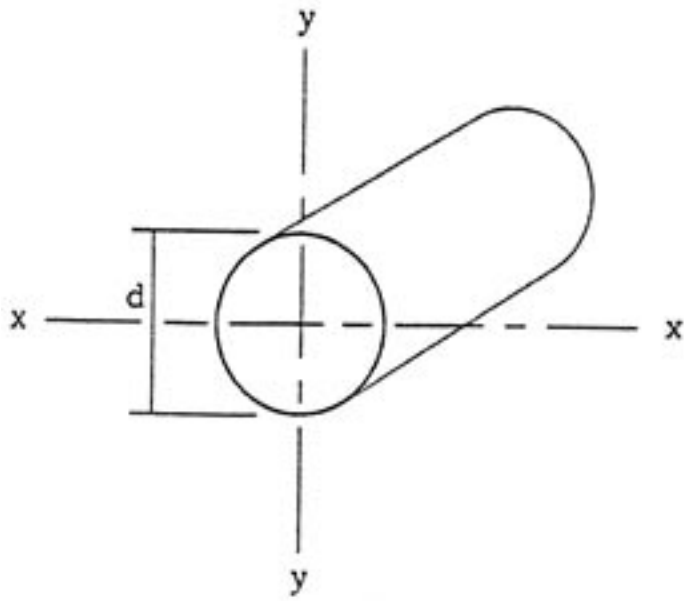
ALL PROFILES	Allowable deviation from specific length	
	Up to 20'	-0", + 1/2"
	Over 20' to 50'	-0", + 1"

SQUARENESS OF ENDCUT

ALL PROFILES	Allowable deviation from square	
	All thicknesses	tan 1° x width in inches

SOLID ROUNDS

SECTION DIMENSIONS			SECTION PROPERTIES		
d	A	Wt.	I	S	r
in.	$in.^2$	lb./ft.	$in.^4$	$in.^3$	in.
0.2500	0.049	0.044	0.0002	0.0016	0.0625
0.3000	0.071	0.062	0.0004	0.0027	0.0750
0.3125	0.077	0.067	0.0005	0.0030	0.0781
0.3500	0.096	0.083	0.0007	0.0042	0.0875
0.3750	0.110	0.095	0.0010	0.0052	0.0938
0.4375	0.150	0.133	0.0018	0.0082	0.1094
0.4720	0.175	0.150	0.0024	0.0103	0.1180
0.4800	0.181	0.160	0.0026	0.0109	0.1200
0.5000	0.196	0.172	0.0031	0.0123	0.1250
0.6250	0.307	0.270	0.0075	0.0240	0.1563
0.7500	0.442	0.397	0.0156	0.0414	0.1875
0.8125	0.518	0.460	0.0214	0.0527	0.2031
0.8750	0.601	0.534	0.0288	0.0658	0.2188
1.0000	0.785	0.697	0.0491	0.0982	0.2500
1.2500	1.227	1.094	0.1198	0.1917	0.3125
1.5000	1.766	1.571	0.2485	0.3313	0.3750



STRUCTURAL CONNECTIONS

BEARING ON FRP

Bolt Allowable for Given FRP Plate Thickness (1)

MATERIAL THICKNESS	BOLT DIAMETER 3/8"	1/2"	5/8"	3/4"	1"
1/8"	469	625	781	938	1250
1/4"	938	1250	1563	1875	2500
3/8"	1406	1875	2344	2813	3750
1/2"	1875	2500	3125	3750	5000
3/4"	2813	3750	4688	5625	7500
1"	3750	5000	6250	7500	10000

(1) BEARING on FRP plate or web controls (Factor of Safety = 3.0; Fp=10,000 psi)
The designer must confirm that no other component of connection controls.

BOLT SHEAR

Bolt Allowable for Given Bolt Diameter (2)

BOLT TYPE & APPLICATION	BOLT DIAMETER 3/8"	1/2"	5/8"	3/4"	1"
316SS- single shear (3)	1408	2503	3912	5633	10014
316SS- double shear	2816	5007	7823	11265	20027
FRP threaded rod (4) single shear	300	600	900	1000	2050
FRP threaded rod - double shear	600	1200	1800	2000	4100

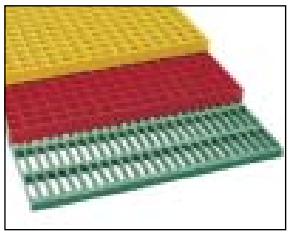
(2) The designer must confirm that no other component of connection controls.
*(3) SHEAR of bolt controls. Fv=0.17*FU = 0.17*75,000 psi = 12,750 psi*
(4) SHEAR of FRP threaded rod controls (Factor of Safety = 4.0).
Ultimate values from Dynaform® Design Guide

RATIO OF EDGE DISTANCE TO FASTENER DIAMETER

	RANGE	RECOMMENDED
Edge Distance - cl* bolt to END	2.0-4.0	3.0
Edge Distance - cl* bolt to SIDE	1.5-3.5	2.5
Bolt Pitch - cl* to cl*	4.0-5.0	5.0

** - "cl" is centerline*

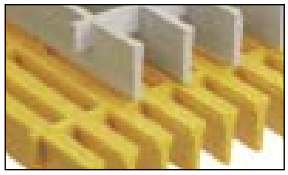
Fibergrate Products & Services



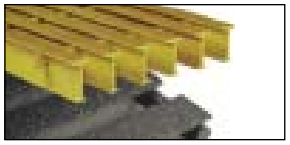
Fibergrate® Molded Grating

Fibergrate molded gratings are designed to provide the ultimate in reliable performance, even in the most demanding conditions. Fibergrate offers the widest selection in the market with more than ten resins including Chemgrate CP-84 and more than twenty grating configurations available in many panel sizes and surfaces.

RIGIDEX® Moltruded® Grating



RIGIDEX Moltruded gratings are the first fiberglass gratings to combine the corrosion resistance of molded grating with the longer span capacity of pultruded grating, all at the low cost of metal gratings.

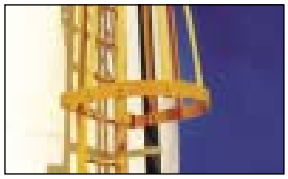


Safe-T-Span® Pultruded Industrial and Pedestrian Gratings

Combining corrosion resistance, long-life and low-maintenance designs, Safe-T-Span provides unidirectional strength for industrial and pedestrian pultruded grating applications.

Dynarail® Handrail

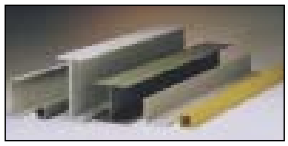
Easily assembled from durable prefabricated components or engineered to your specifications, Dynarail handrail meets or exceeds OSHA and strict building code requirements for safety and design.



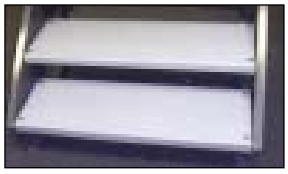
Dynarail® Safety Ladder System

Easily assembled on site, Dynarail safety ladder systems meet or exceed OSHA requirements. Though less costly than prefabricated ladder systems, these safety ladders provide a custom fit to the supporting structure.

Dynaform® Structural Shapes



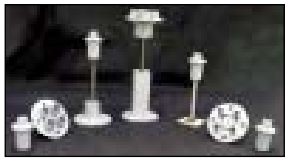
Fibergrate offers a wide range of pultruded structural components for industrial use, including bars, rods, tubes, beams, channels, leg angles and plates.



Stair Solutions

Fibergrate offers a wide range of slip-resistant products to meet your stair safety needs. These durable products which include treads, tread covers and covered stair treads are a long-term, cost-efficient solution for your facility.

Grating Pedestals



Uniquely designed adjustable single and quad head pedestals for square mesh molded grating are manufactured to provide safe and economical support for elevated flooring.

Fabrication Services

Combining engineering expertise with an understanding of fiberglass applications, Fibergrate provides turnkey design and fabrication of fiberglass structures, including platforms, catwalks, stairways and test racks.

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