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BEVATRON VACUUM IMPROVEMENT QUADRANT CRYOLINER - LOW TEMPERATURE BEND OF POLYESTER POLTRUSION

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Engineering & Technical Services Division

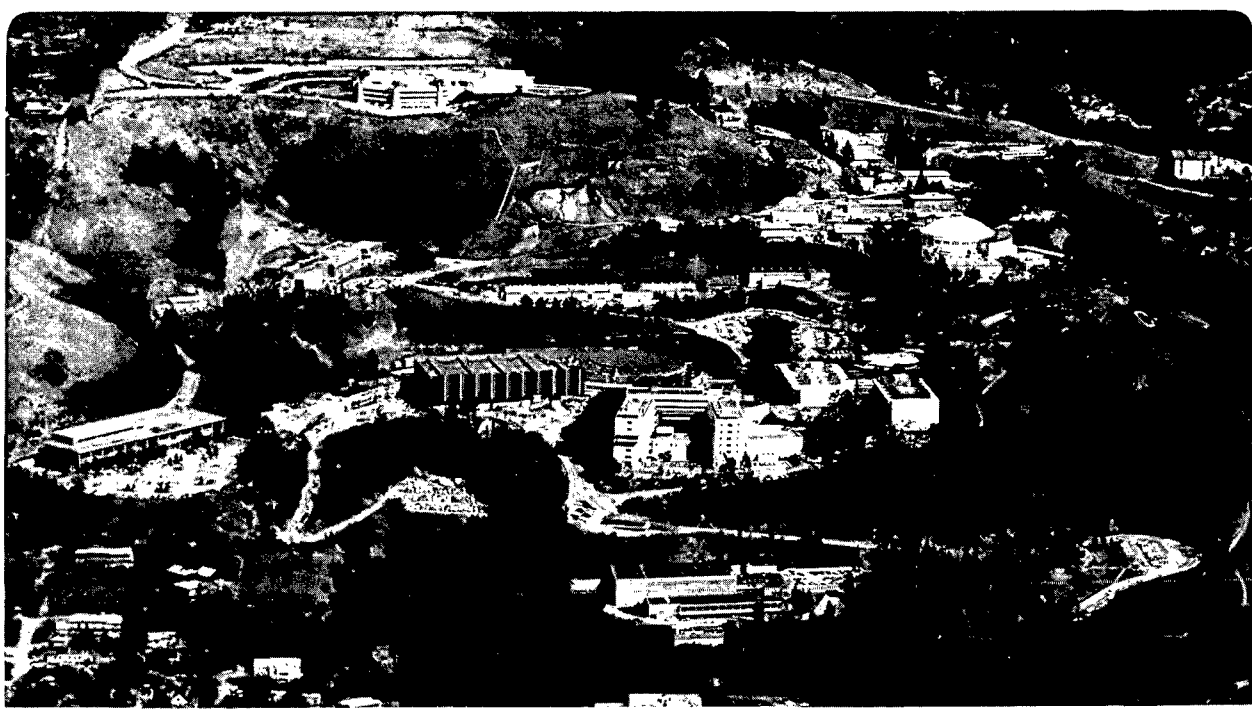
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BEVATRON VACUUM IMPROVEMENT				
QUADRANT CRYOLINER				
TITLE				
LOW TEMPERATURE BEND OF POLYESTER PULTRUSION				

The support beams for the Bevatron cold bore (High-Intensity Uranium Beam Design Report, November 1979) must prevent the 1/8" G-10 panels from sagging during normal operation. However, during an unlikely up-to-air accident the beams must deflect 3.5". G-10 has suitable mechanical properties, both at room temperature and cryogenic temperatures. Large sheets must be machined to make 1/2"-deep by 2"-wide sections of G-10. The residual stress in G-10 sheet warps the 1/2" by 2" sections as they are being sawed. No vender would quote on the 1/2" by 2" sections to the straightness required.

An alternate product with adequate room temperature properties is fiberglass-polyester pultrusion. This product is pulled out of a die that forms the final cross-section without additional machining. Typical properties from a pultrusion manufacturer are shown in Figure 1.

No cryogenic properties could be obtained from the manufacturer, so a simple 77°K bending test was made. A beam 1" wide by 1/2" deep and 4" long was beam loaded in an Instron testing machine at 77°K. The force versus deflection curve is shown in Figure 2. At maximum deflection the strain is equivalent to twice the strain that would occur in the 48" beams of the cold bore where they deflected 3.5".

The maximum strain experienced by the test beams was 0.6%, giving a maximum fiber stress of 15,000 psi and modulus of 2.5 million psi. No permanent set could be observed.

Distribution: B. Avery
T. Henderson
K. Kennedy

/nh

FIGURE I



**MORRISON
MOLDED
FIBER
GLASS
COMPANY**

**P. O. BOX 508,
BRISTOL, VIRGINIA 24201
PHONE: 703-669-1181**

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TYPICAL PROPERTIES OF MMFG EXTREN®

Mechanical (coupon)	Rod & Bar	Flat Sheet	Standard Shapes	
		Series 500 & 525	Rovmat	Series 500 & 525 Improved
Longitudinal Direction				
Ultimate Tensile Strength, psi	100,000	20,000	30,000	30,000
Ultimate Compressive Strength, psi	60,000	20,000	20,000	30,000
Ultimate Flexural Strength, psi	100,000	30,000	30,000	30,000
Tensile Modulus, psi x 10 ⁶	6.0	1.8	2.3	2.5
Compressive Modulus, psi x 10 ⁶	N-T	2.0	2.3	2.5
Flexural Modulus, psi x 10 ⁶	6.0	2.0	1.3	1.6
Ultimate Shear Strength, psi	5,500	4,500	4,500	5,500
	(in torque)			
Ultimate Bearing Stress, psi	N-T	30,000	20,000	30,000
Izod Impact Strength (ASTM-D256) ft-lbs per inch of notch [Sample Thickness — ½" except ¼" for rod]	40	18	18	25
Transverse Direction				
Ultimate Tensile Strength, psi	N/A	10,000	5,000	7,000
Ultimate Compressive Strength, psi	N/A	15,000	10,000	15,000
Ultimate Flexural Strength, psi	N/A	13,000	10,000	10,000
Tensile Modulus, psi x 10 ⁶	N/A	1.2	0.8	0.8
Compressive Modulus, psi x 10 ⁶	N/A	1.3	1.0	1.0
Flexural Modulus, psi x 10 ⁶	N/A	1.2	0.6	0.8
Ultimate Shear Strength, psi	N/A	4,500	4,500	5,500
Ultimate Bearing Stress, psi	N/A	30,000	20,000	30,000
Izod Impact Strength (ASTM-D256) ft-lbs per inch of notch	N/A	9	4	4
Barcol Hardness	50	50	50	50
Full Section in bending				
Modulus of Elasticity, psi x 10 ⁶	6.0	2.0	2.3	2.5
Tensile Strength, psi	100,000	N/A	20,000	20,000
Compressive Strength, psi	N/A	N/A	20,000	20,000
Electrical				
Electric Strength, short term in oil, ½" (ASTM-D149), vpm*	N-T	200	200	200
Electric Strength, short term in oil, KV per inch**	60	25	25	35
Dielectric Constant, 60 Hz. (ASTM-D150)*	6.0	4.5	5.0	.50
Dissipation Factor 60 Hz. (ASTM-D150)*	0.01	0.03	0.03	0.03
Arc Resistance (ASTM-D495), seconds***	130	80	80	80
Thermal				
Thermal Coefficient of Expansion (ASTM-D696) [inches/inch/°F]***	3 x 10 ⁻⁶	5 x 10 ⁻⁶	5 x 10 ⁻⁶	5 x 10 ⁻⁶
Thermal Conductivity, BTU per sq. ft./hr./°F/in.	5	4	4	4
Specific Heat, BTU/Lb/°F	0.24	0.28	0.28	0.28
Other				
Density (ASTM-D792) lbs./in ³				
Solid Shapes	0.072	0.058 (S-500) 0.061 (S-525)	0.059 (S-500) 0.062 (S-525)	0.062 (S-500) 0.065 (S-525)
Hollow Shapes	N/A	N/A	0.061 (S-500) 0.064 (S-525)	NOTE 2
Specify Gravity (ASTM-D792)				
Solid Shapes	2.00	1.61 (S-500) 1.69 (S-525)	1.64 (S-500) 1.72 (S-525)	1.72 (S-500) 1.80 (S-525)
Hollow Shapes	N/A	N/A	1.69 (S-500) 1.78 (S-525)	NOTE 2
Water Absorption [24 hour immersion] (ASTM-D570) Max. % by weight	0.25	0.60	0.75	0.60
Fire Retardant Properties—Series 525				
Flame Resistance [FTMS 406-2023] ign./burn, seconds		83/58		
Intermittent Flame Test [HLT-15], rating		100		
Flammability Test [ASTM-D635]		self. ext.		
Surface Burning Characteristics (ASTM-E84), maximum UL APPROVED (Yellow Component Card)		25		
UL 94 Flammability Classification		SE-0		
Temperature Index (°C)		130		

* Specimen tested perpendicular to laminate face.
** 1" long specimen tested parallel to laminate face using 2" dia. electrodes.
*** Indicates reported value measured in longitudinal direction.
N/A—Not applicable
N-T—Not tested

NOTE 1: Modulus of elasticity shown for full section in bending properties is minimum standard for all shapes. Properties for individual shapes are obtainable from MMFG.

NOTE 2 Lengthwise Izod Impact Strength increases with thickness except strength for ½" Flat Sheet is about 67% of reported value. Tensile Strength of Rod: as determined on a full section piece. Flexural Strength of Rod: as determined in simple bending.

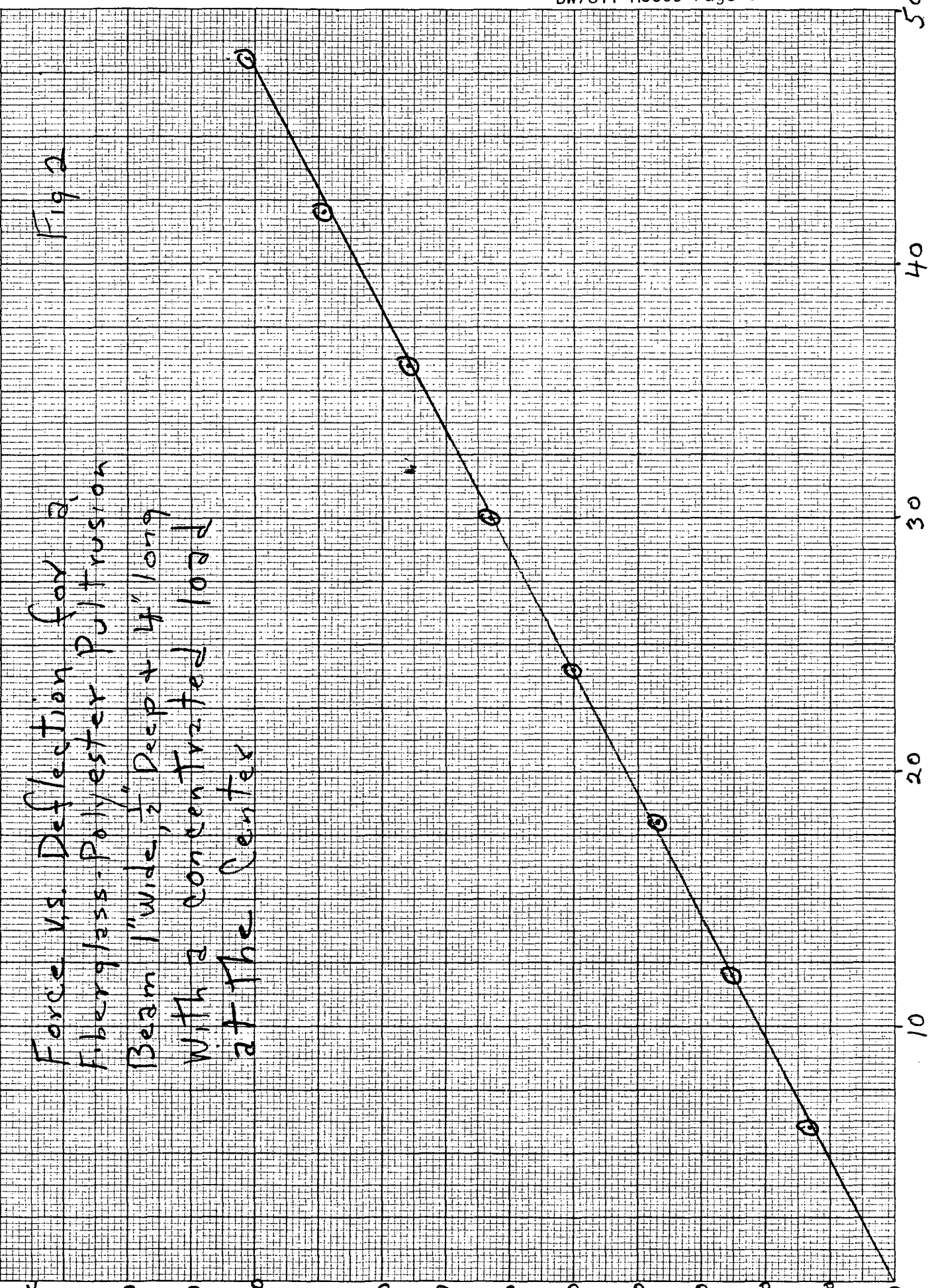
NOTE 3 We have been unable to adapt the improved process to all standard shapes, so some standard shapes are available only in the Rovmat material. Properties of custom products can be tailored to meet the requirements of the customer within above limitations.

CORROSION RESISTANCE GUIDE

Chemicals	75°F	160°F	Chemicals	75°F	160°F	Chemicals	75°F	160°F
Acetic acid, 5%	R	R	Ethylene dichloride	NR	NR	Sodium bicarbonate, 10%	R	R
Acetic acid 25%	R	NR	Ethyl ether	NR	NR	Sodium bisulfate	R	R
Acetone	NR	NR	Ethylene glycol	R	R	Sodium carbonate	R	R
Aluminum sulfate, 5%	R	R	Ferrous sulfate	R	R	Sodium chloride	R	R
Aluminum potassium sulfate, 5%	R	R	Fatty acids, 100%	R	R	Sodium hydroxide, 5%	NR	NR
Ammonium hydroxide, 10%	R	NR	Rauvolic acid, 10%	NR	NR	Sodium hypochlorite, 5%	R	R
Ammonium nitrate	R	R	Hydrochloric acid, 1%	R	R	Sodium nitrate	R	R
Benzene	NR	NR	Hydrochloric acid, 15%	R	NR	Sodium silicate	R	R
Benzenesulfonic acid, 5%	R	R	Hydrochloric acid, 37%	R	NR	Sodium sulfate	R	R
Calcium chloride	R	R	Kerosene	R	R	Sulfuric acid, 1%	R	R
Carbon disulfide	NR	NR	Magnesium chloride	R	R	Sulfuric acid, 5%	R	R
Carbon tetrachloride	NR	NR	Methyl alcohol (methanol)	R	NR	Sulfuric acid, 10%	R	R

Fig 2

Force vs. Deflection for a
Fiberglass-Polyester Pultrusion
Beam 1" wide, $\frac{1}{2}$ " Deep & 4" long
with a concentrated load
at the center



SQUARE 10 X 10 TO THE HALF INCH AS-0013-61
Deflection in mils

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