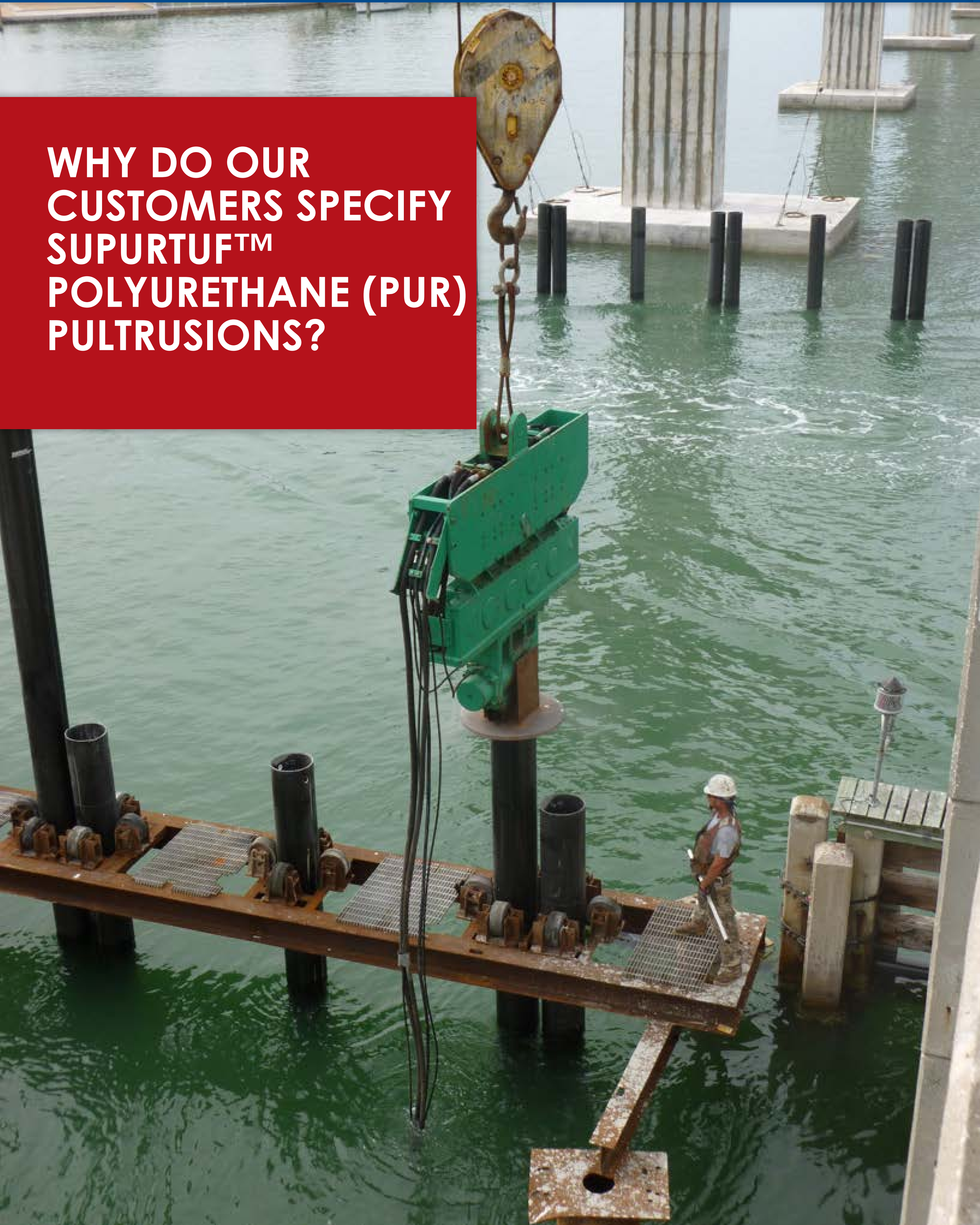
CREATIVE PULTRUSIONS

PRODUCT BROCHURE

SUPURTUF™
POLYURETHANE PULTRUSIONS*

*Available exclusively at Creative Pultrusions, Inc.

WHY DO OUR CUSTOMERS SPECIFY SUPURTUF™ POLYURETHANE (PUR) PULTRUSIONS?



SUPERIOR TOUGHNESS AND IMPACT STRENGTH!

Federal, State, Military and Private Agencies are realizing the cost savings and performance benefits of SUPURTUF™ polyurethane pultrusions over traditional materials of construction.

Transportation Agencies wanted a bridge foundation protection system to protect their bridge piers and foundations from damage due to commercial shipping vessel impact. Creative Pultrusions, Inc. (CPI) developed SUPERPILE to fill that need. SUPERPILE was required to be driven with pile driving equipment, constructed with normal tools and above all, absorb the impact from large shipping vessels.


Fender Rehabilitation, Virginia

SUPURTUF™ polyurethane enabled the birth of the SUPERPILE. A round pipe pile that has the ability to be driven with traditional hammers and to protect docks and bridges from damage do to shipping vessel collisions.

West Virginia University's head of the Constructed Facility Center Hota Gangarao had this to say when he first tested the SUPURTUF™ SUPERPILE.

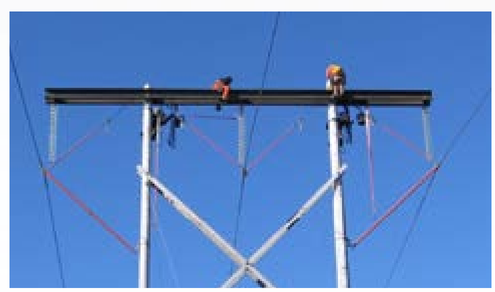
"I have researched, tested and installed composite systems related to civil infrastructure over my entire career. I was astonished at the high strength and modulus values achieved with the polyurethane pipe piles manufactured by Creative Pultrusions, Inc. I expect that the US infrastructure will benefit greatly from this tubular pile technology."

~ Hota GangaRao, PhD, P.E., F. ASCE
West Virginia University


Full Section Pipe Pile Testing
West Virginia University

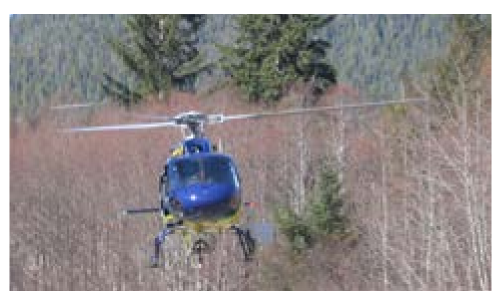
SUPERIOR STRENGTH!

A large utility had a need for a light weight heavy duty transmission arm with superior strength, stiffness and dielectric properties that could hold up in the extreme British Columbia environment. Transmission Innovations approached CPI and asked us to come up with a pultruded solution that met their specification. The application required a pultruded channel with superior long term performance and above all, brute strength to deal with the severe ice and wind loads associated with 287 kV transmission lines.


Polyurethane High Voltage Transmission Arm

"The SUPURTUF™ polyurethane technology allowed FRP Transmission Innovations to provide our customers with a extremely lightweight high strength solutions that met and exceeded all of their specifications and expectations. The high fiber volume fractions associated with the high pressure injection polyurethane manufacturing process permitted us to decrease the wall thickness which resulted in optimized cross sectional shapes, significant weight reduction and cost savings. Our customers can use their lighter more economical and smaller environmental footprint helicopters to fly the arms to the transmission structure installation locations. Overall benefiting clients, service users and the environment."

~ Janos Toth, Principal Engineer, Products and Applications
FRP Transmission Innovations, Inc.


Small Helicopter for Flying in Composite Crossarms.

COST, WEIGHT LABOR SAVINGS!

Contractors wanted a lightweight, corrosion resistant, economical replacement for 316 stainless steel plate that was required to transfer a moment through a bolted connection. The legacy system was heavy, difficult to field drill and grind and was extremely expensive. Upon review of the mechanical, physical and installation requirements the solution called for SUPURTUF™ Polyurethane to make it a reality.

The plate had to perform structurally the same as heavy 316 stainless steel plate. The critical structural properties were in-plane shear, pin bearing and flexural strength. The plate had to have lengthwise and transverse properties that were quasi isotropic.

The end result was a pultruded plate that satisfies all of the structural requirements with the added benefit of being 75% lighter, field drillable and corrosion resistant.

SUPURTUF™ Polyurethane Plate Ready to be Shipped

SUPURTUF™ Polyurethane Testing

WHY SUPURTUF™ RESIN?

Thermoset PUR pultrusions offer superior performance over typical polyester, vinyl ester and epoxy resin systems. The manufacturing process involves high pressure injection of a two part urethane resin system. The high pressure injection process allows for superior fiber "wet out" and reduced void content. The complete fiber wet out combined with the superior resin properties equates to structural performance previously unheard of in the structural composite pultrusion industry.

WHY ARE SUPURTUF™ COMPOSITES BETTER?

- Highest fiber volume fraction.
- PUR resin delivers improved impact and transverse properties.
- Reduced composite defects (i.e., cracks, blisters, voids) (Figure 1 and Figure 2).
- Superior dielectric strength due to improved resin matrix integrity.

BENEFITS

- Lighter and more economical profiles can be manufactured due to the strength advantages.
- Reduced porosity.
- Low water absorption.
- Thermal conductivity is reduced with thinner wall sections.
- No fillers result in excellent RF Transparency properties.
- Reduced composite defects, higher full section strength.
- Superior fastening and fabrication results.
- Higher specific strength and stiffness.
- Available with low Flame, Smoke and Toxicity (FST) performance.

25% Weight Reduction is Typical at Equivalent Strength

SUPURTUF™ PHYSICAL PROPERTIES

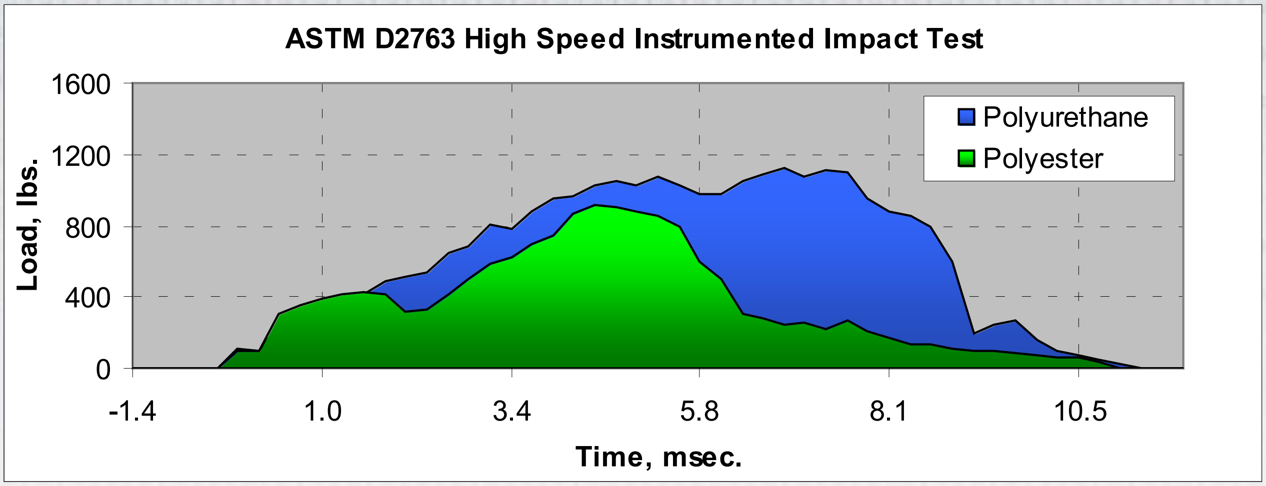


Figure 3.

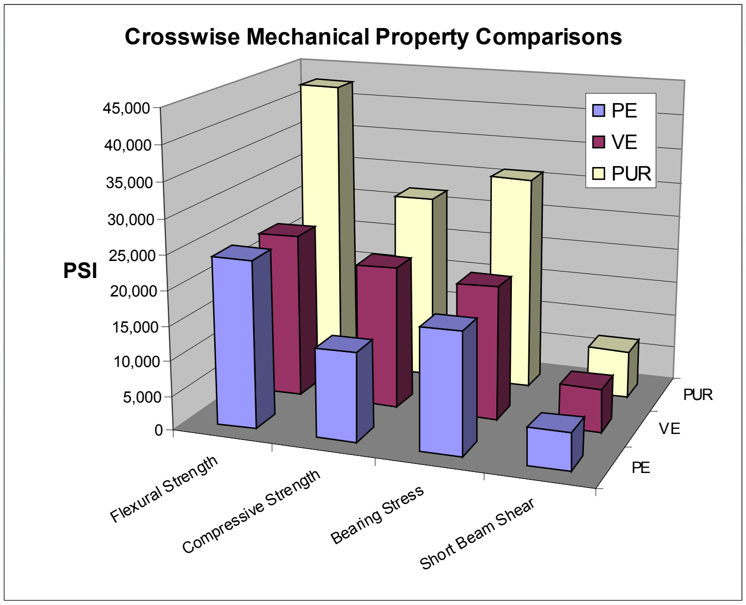
IMPACT AND DAMAGE TOLERANCE

Impact property improvements can best be appreciated from high speed impact test results that show greater impact load capability and total energy absorption as indicated by test curve overlays (Figure 3). The proper combination of tough PUR and engineered fiber architectures yields superior impact performance in both low and high velocity impact events.

IMPROVED TRANSVERSE (CROSSWISE) PROPERTIES

Pultruded products can have a broad range of properties with different fiber compositions. A single table of mechanical coupon properties reflects the strength basis with equivalent fiber compositions, transverse properties highlight the resin contribution to composite strength. As can be seen, PUR is clearly superior in those properties that translate to high full section performance.

The chart depicts the strength enhancements of polyurethane over traditional resins systems. Only the resin was changed, the fiber architecture remained constant.



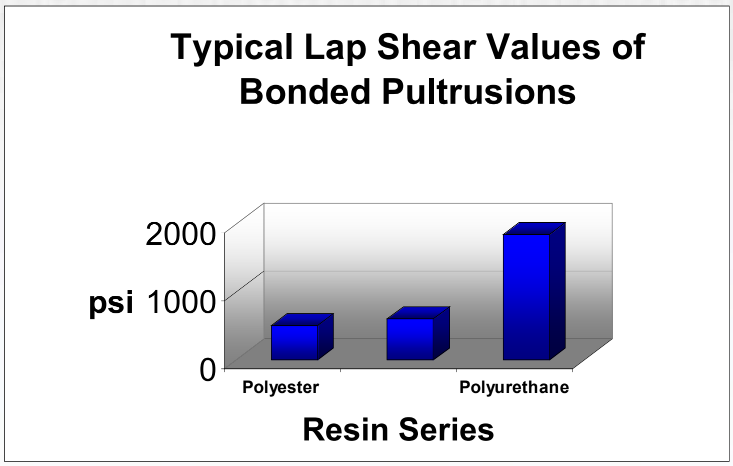
Note: PE = Polyester Resin
VE = Vinyl Ester Resin
PUR = Polyurethane Resin

SUPURTUF™ PHYSICAL PROPERTIES

URETHANE ADHESIVES

- Perfect match for PUR pultrusions.
- No surface preparation required.
- Laboratory adhesive trials, on dust free specimens, demonstrate a 370% increase in bond performance when compared to traditional pultrusions.
- Reduced bonding labor costs!
- Minimal dust, which creates a healthier work environment.
- Superior connection performance.
- Reduced fabrication rework and tooling cost.
- Increased revenues!

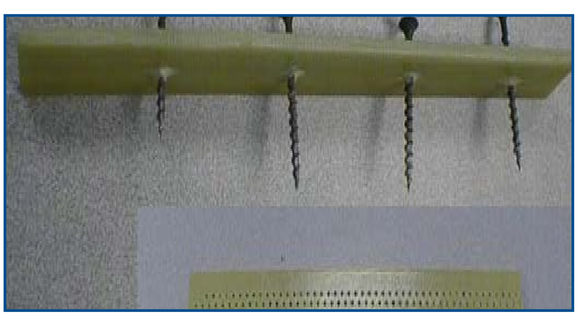
Lap Shear Testing
(Courtesy of Ashland Chemical)

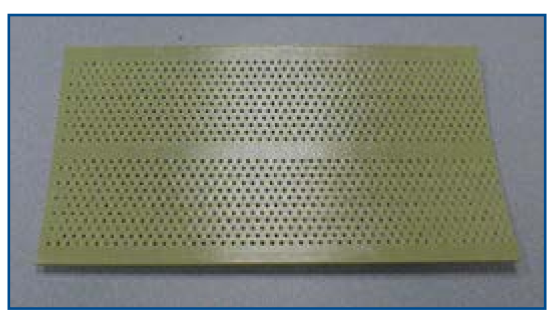


*Note: Adhesive trials performed on the PLIOGRIP 8000 Series.

FABRICATION BENEFITS

Tougher composites means fewer fabrication related defects. Reduced cracking, splitting delamination when drilling, punching and milling make SUPURTUF™ composites a better choice when fabrication is part of final product manufacturing procedures.





All roving parts do not split when fasteners are installed. This gives PUR Superior Machinability.

BOTTOM LINE - COST EFFECTIVE SUPURTUF™ COMPOSITES!

While PUR resin is more expensive than polyester and on par with vinyl ester resins, composite profiles designed with SUPURTUF™ deliver the superior performance of this tough material and can be supplied at equal or marginally higher cost than polyester. A strength optimized cost effective solution can be reached that enables the end user to realize superior performance with total satisfaction.

FIRE PERFORMANCE

The following chart depicts the fire performance of Creative Pultrusions, Inc.'s (CPI) standard PUR (SUPURTUF™) pultrusions.

FIRE REACTION PROPERTIES OF POLYURETHANE COMPOSITES

Fire Safety	Test Description	Units	Polyurethane Triax/Roving	Polyurethane All Roving
Limiting Oxygen Index (LOI)	D2863-97	% O2	36	47
Horizontal Burning	D635	- - -	Self-Extinguishing	Self-Extinguishing
Optical Smoke Density (Flaming)	E662	Ds, 4 min.	20	101
Optical Smoke Density (Flaming)	E662	Dmax	190	342
Optical Smoke Density (Non-Flaming)	E662	Ds, 4 min.	12	1
Optical Smoke Density (Non-Flaming)	E662	Dmax	212	240
Flame Resistance (Ignition)	D229-96	sec	71	64
Flame Resistance (Burning) D229-96	D229-96	sec	372	375

Results based on .250 inch thick samples tested at SGS U.S. Testing Company

PUR composites have also been developed with enhanced low Flame, Smoke and Toxicity (FST) properties for use in transportation applications including train, rail, marine, military and aircraft. High strength and stiffness, with superior damage tolerance and low FST properties delivers the complete package to weight sensitive applications. Heavy char formation during a fire event allows for composite strength retention during fire suppression efforts. Low smoke density and toxicity are achievable due to the low organic resin content and the unique fire barrier package developed for SUPURTUF™ LOW FST grade material.

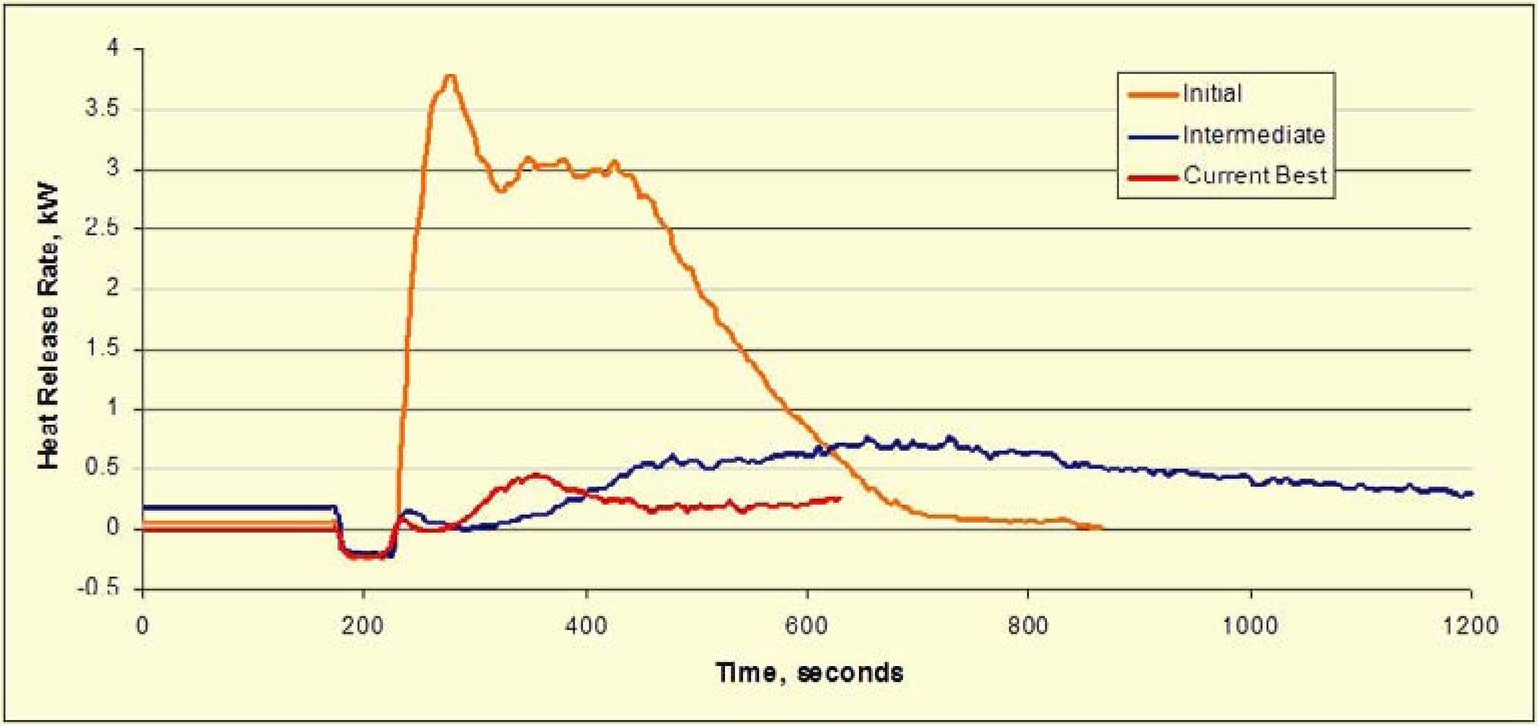
Surface Flammability per IMO Part 5

FIRE PERFORMANCE (CONTINUED)

Heat release curves during the Surface Flammability test show the very low heat release (area under the curve) achieved with the SUPURTUF™ LOW FST grade pultrusion as compared to the popular fire retardant composite alternatives. Given the higher strength, toughness and long term durability of polyurethane, a new option now exists for fire hazard areas in marine and naval applications. Full compliance to International Maritime Organization (IMO) or other standards often may require certification and on-site audit.

Not only does SUPURTUF™ Low FST comfortably pass surface flammability tests, the smoke and toxicity results indicate a substantially reduced smoke and toxicity hazard to allow for degree and fire suppression.

Test Specification for IMO Part 5 Surface Flammability	Bulkhead, Wall & Ceiling Linings	SUPURTUF™ LOW FST
Critical Flux at Ext. (CFE)	≥20.0 kW/m²	33.9
Heat for Sustained Burning (Q_{sb})	≥1.5 MJ/m²	2.60
Total HR (Q_t)	≤0.7 MJ	0.09
Peak HRR (q_p)	≤4.0 kW	0.50
Smoke Generation per ASTM E662		
Specific Optical Density, Flaming Mode	<200	183
Specific Optical Density, Non-Flaming	<200	225
Toxicity Per ASTM E662 via FTIR		
Carbon Monoxide, ppm max.	<1000	342
Hydrogen Cyanide, ppm max.	<30	11
Hydrogen Chloride, ppm max.	<30	0



ENVIRONMENTAL PROPERTIES

ELEVATED TEMPERATURE PERFORMANCE

On par with quality polyesters with a T_g of 105°C, use of SUPURTUF™ should be considered based on load and operating temperatures. As for all composites, strength and stiffness decrease moderately as the T_g is approached. Consult Creative Pultrusions, Inc. Engineering Department for further guidance.

CREEP AND FATIGUE PERFORMANCE

Creep and Fatigue Tests were performed on the PUR pultrusions. The PUR pultrusions were compared to Polyester resin based pultrusions. In both cases the results demonstrated that the PUR and Polyester based pultrusions perform similar.

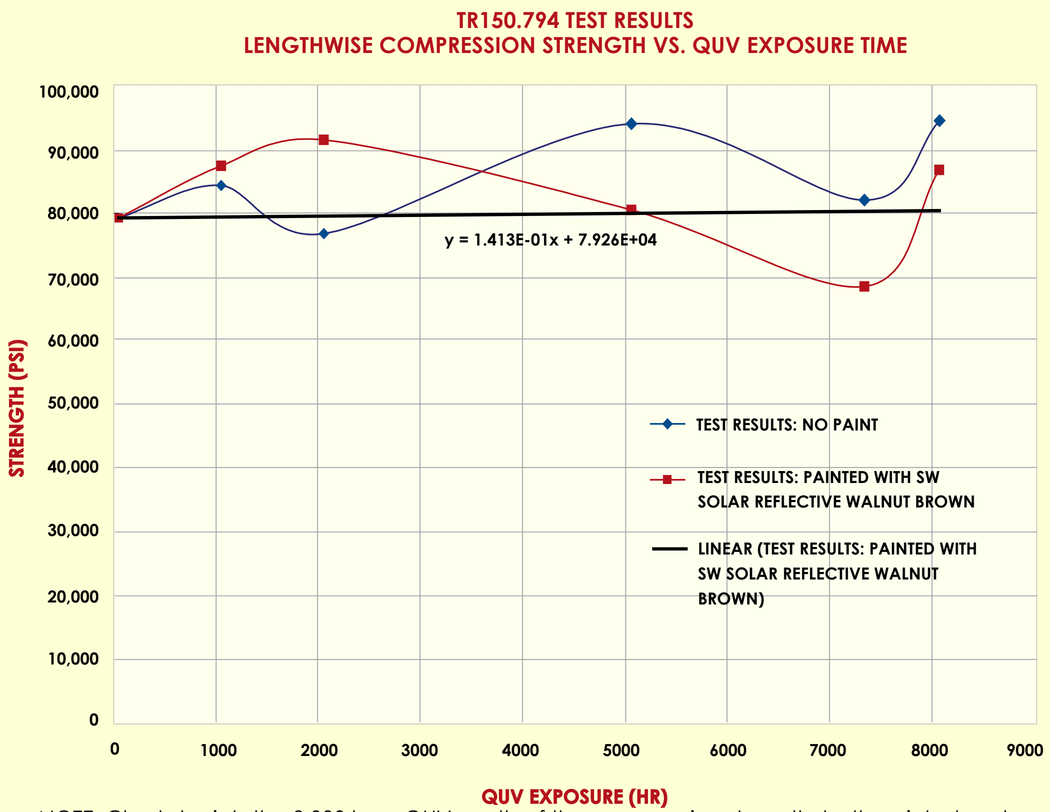
CHEMICAL AND CORROSION RESISTANCE

PUR resins perform very well in acid, alkali and salt spray environments. A Chemical Compatibility Guide for liquid and vapor exposures is available upon request.

WEATHERING

Based on aromatic isocyanate chemistry, PUR resins have a tendency to change color with extended Ultra Violet (UV) exposure. As with polyesters and vinyl esters, some surface resin degradation may occur with exposure time and a protective synthetic veil can be incorporated for protection against glass "fiber bloom". Post weathering tests show little mechanical property degradation due to weathering exposure of PUR samples. For best results in applications where color stability is important, as with polyesters a weathering coating application is recommended.

The QUV exposure graph demonstrates the compression strength vs QUV exposure up to 8,000 hours. The test reveals that although paint improves the long term aesthetics it does not affect the structural integrity over time.



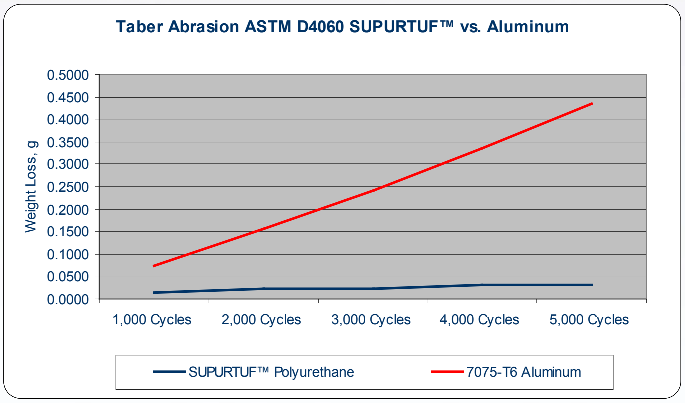
NOTE: Chart depicts the 8,000 hour QUV results of the compression strength, both painted and unpainted. Statistically, no decrease in compression strength was detected after the QUV testing.

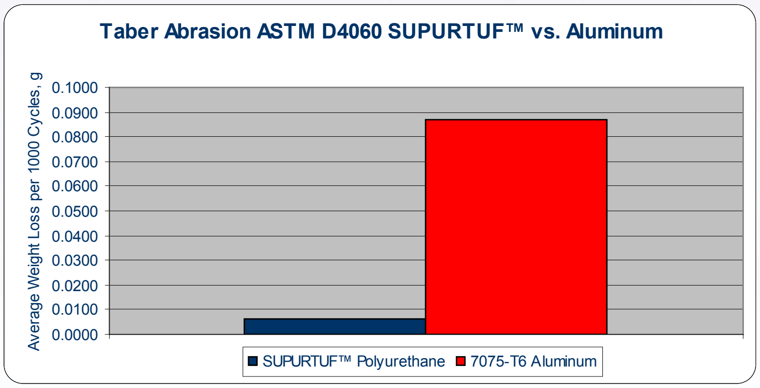
TESTING

TABER ABRASION

Taber abrasion testing has demonstrated that polyurethane is superior to aluminum in terms of abrasion resistance.

Taber Abrasion ASTM D4060	SUPURTUF™ Polyurethane		7075-T6 Aluminum	
	Sample	Weight Loss, g	Sample	Weight Loss, g
Initial wt, g	129.7363		95.4914	
1,000 Cycles Weight, g	129.7219	0.0144	95.4162	0.0752
2,000 Cycles Weight, g	129.7141	0.0222	95.3355	0.1559
3,000 Cycles Weight, g	129.7125	0.0238	95.2488	0.2426
4,000 Cycles Weight, g	129.7059	0.0304	95.1574	0.3340
5,000 Cycles Weight, g	129.7042	0.0321	95.0580	0.4334
Average per 1,000 cycles		0.0064		0.0867





COEFFICIENT OF FRICTION

Coefficient of Friction-Steel ASTM 1894	**Static**	0.276
	Kinetic	0.221
Coefficient of Friction-Itself ASTM 1894	**Static**	0.258
	Kinetic	0.197

MATERIAL PROPERTIES

The following properties are typical of pultruded profiles manufactured in SUPURTUF™ polyurethane resin. Each property chart has been generated based on testing of actual products. The average and standard deviation values have been noted for design purposes. The physical properties demonstrate the various lengthwise and transverse properties that can be achieved with SUPURTUF™. In fact, a quasi isotropic construction is included in the event you desire your product to have lengthwise and transverse properties that are near the same.

MATERIAL PROPERTIES (CONTINUED)

	All Uni-directional Reinforcements FT065.794 Test Specimen .170" (4.32mm) Thick			
Mechanical Properties/Units	ASTM Protocol	Average	Standard Deviation	Three Standard Deviations Minus the Mean
Tensile Strength (LW) psi	D638	125,300	2,105	118,985
Tensile Modulus (LW) psi	D638	8.66E+06	5.03E+05	7,151,000
Tensile Strength (CW) psi	D638	7,745	390.0	6,575
Tensile Modulus (CW) psi	D638	1.96E+06	5.10E+04	1,807,000
Compressive Strength (LW) psi	D6641	119,595	18,744	63,363
Compressive Modulus (LW) psi	D6641	6.60E+06		
Compressive Strength (CW) psi	D6641	21,835	455	20,470
Compressive Modulus (CW) psi	D6641	1.84E+06		
Interlaminar Shear (LW) psi	D2344	11,732	135	11,327
In-Plane Shear (LW) psi	D5379	10,600	181	10,057
Bearing Stress (LW) psi	D953	64,510	7,041	43,387
Bearing Stress (CW) psi	D953	36,350	464	34,958
Density	Calculated	0.075		
Fiber Volume Fraction	Calculated	64.40%		

	Unidirectional/Bias/Transverse Reinforcements CH997 Test Specimen 0.5" (12.7mm) Thick			
Mechanical Properties/Units	ASTM Protocol	Average	Standard Deviation	Three Standard Deviations Minus the Mean
Tensile Strength (LW) psi	D638	78,960	2,443	71,631
Tensile Modulus (LW) psi	D638	5.09E+06	5.62E+05	3,404,000
Tensile Strength (CW) psi	D638	36,093	2802.0	27,687
Tensile Modulus (CW) psi	D638	2.67E+06	3.74E+05	1,548,000
Compressive Strength (LW) psi	D6641	83,224	4,807	68,803
Compressive Modulus (LW) psi	D6641	3.95E+06		
Compressive Strength (CW) psi	D6641	44,456	1,396	40,268
Compressive Modulus (CW) psi	D695	3.37E+06		
Interlaminar Shear (LW) psi	D2344	6,416	343	5,387
In-Plane Shear (LW) psi	D5379	22,665	1,006	19,647
Bearing Stress (LW) psi	D953	77,611	7,041	56,488
Bearing Stress (CW) psi	D953	77,878	464	76,486
Density	Calculated	0.071		
Fiber Volume Fraction	Calculated	55.79%		

MATERIAL PROPERTIES (CONTINUED)

SPLICEPLATE Mechanical Properties	Unidirectional/Bias/Transverse Reinforcements (Near Quasi Isotropic) FT205 Test Specimen 0.75" (19.05mm) Thick					
	Mean (psi)	Mean (Mpa)	Standard Deviation (psi)	Standard Deviation (Mpa)	Minimum Required[2] (psi)	Minimum Required[2] (Mpa)
In-Plane Flexural Strength (LW) ASTM D790	77,101	532	5,407	37	60,880	420
In-Plane Flexural Strength (CW) ASTM D790	65,718	453	2,064	14	59,526	410
Flexural Modulus of Elasticity In-Plane (LW) ASTM D790	2,930,000	20,202	150,000	1,034	2,480,000	17,099
Flexural Modulus of Elasticity In-Plane (CW) ASTM D790	2,770,000	19,098	100,000	689	2,470,000	17,030
Pin Bearing Strength (LW) ASTM D953[1]	60,450	417	1,230	8	56,760	391
Pin Bearing Strength (CW) ASTM D953[1]	62,690	432	1,480	10	58,250	402
In-Plane Shear Strength (LW) ASTM D5379	23,082	159	757	5	20,811	143
In-Plane Shear Strength (CW) ASTM D5379	22,424	155	767	5	20,123	139
Tensile Strength (LW) ASTM D638[3]	61,947	427	3,054	21	52,785	364
Tensile Modulus (LW) ASTM D638[3]	3,270,000	22,546	130,000	896	2,880,000	19,857
Tensile Strength (CW) ASTM D638[3]	47,654	329	1,487	10	43,194	298
Tensile Modulus (CW) ASTM D638[3]	2,180,000	15,031	150,000	1,034	1,730,000	11,928
Compression Strength (LW) ASTM D6641[3]	65,271	450	3,954	27	53,409	368
Compression Modulus (LW) ASTM D6641[3]	2,340,000	16,134	290,000	1,999	1,470,000	10,135
Compression Strength (CW) ASTM D6641[3]	43,065	297	2,887	20	34,404	237
Compression Modulus (CW) ASTM D6641[3]	2,250,000	15,513	390,000	2,689	1,080,000	7,446

214 Industrial Lane, Alum Bank, PA 15521

814.839.4186 • Fax 814.839.4276 • Toll Free 888.CPI.PULL

www.creativepultrusions.com

CREATIVE PULTRUSIONS

PLEASE SCAN WITH PHONE