CRANE Composites

Crane Composites' Tank Cladding- Physical Attribute Comparison

Overview

This document compares our AXSG product with six competing tank cladding products. This document will outline areas of significant importance to tank cladding and provide specific details of comparison.

The comparisons are designed to highlight how our AXSG material fares in comparison to our competitors.

Purpose

The purpose of this document is to showcase results of tests conducted by Crane Composites Research and Development Center. Testing covered the categories of panel properties, impact properties, physical strength, and accelerated UV weathering. ASTM test methods were used where applicable. Specific test methods and results are outlined within this document.

The facts show the benefits of our AXSG product while showcasing the importance of each of the values.

AXSG Description

ArmorTuf-NXT (AXSG) is a high impact-resistant composite panel made with fiberglass reinforcement and specially formulated polyester resin. This product is value engineered for maximum strength with the same benefits of ArmorTuf by utilizing Crane Composites' NexForce Technology. AXSG has a gel-coat surface that is scratch and abrasion resistant that also provides excellent weathering characteristics.

AXSG Application

AXSG offers a durable tank cladding application that is flexible, reduces weight, and increases impact resistance.

AXSG Customers

Daelim

NRS

Eagletainer

Agmark

PANEL PROPERTIES

Product	Description of Physical Properties	Glass Content % of total weight
AXSG	Thermoset resin-impregnated chopped fiberglass with Crane Nex-Force Fiberglass Reinforcement with a gel-coated A-side.	44%
Competitive Material A	Table lay-up translucent thermoset resin-impregnated chopped glass with gel-coated A-side.	34%
Competitive Material B	Thermoset resin-impregnated chopped glass mat with gel-coated A-side.	13%
Competitive Material C	Table lay-up thermoset resin-impregnated chopped glass with gel-coated A-side.	32%
Competitive Material D	Thermoset resin-impregnated chopped glass mat with gel-coated A-side.	25%
Competitive Material E	Table lay-up or spray thermoset resin-impregnated chopped glass on gel-coated A-side.	28%
Competitive Material F	Table lay-up thermoset resin-impregnated chopped glass with gel-coated A-side.	35%

Test Results

	AXSG	Competitive Material A	Competitive Material B	Competitive Material C	Competitive Material D	Competitive Material E	Competitive Material F
Thickness	1.78 mm (0.070")	2.2 mm (0.087")	2.3 mm (0.090")	2.0 mm (0.079")	1.9 mm (0.076")	2.0 mm (0.080")	1.9 mm (0.076")
Weight	2.54 kg/m² (0.520 lb/ft²)	3.03 kg/m² (0.620 lb/ft²)	3.75 kg/m² (0.769 lb/ft²)	2.87 kg/m² (0.588 lb/ft²)	2.69 kg/m² (0.550 lb/ft²)	2.55 kg/m² (0.523 lb/ft²)	2.61 kg/m² (0.535 lb/ft²)

Weight Difference

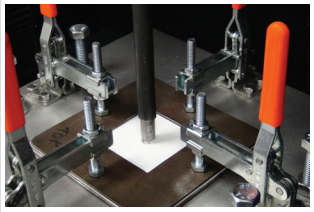
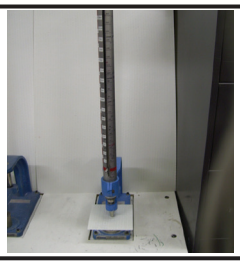
These test results showcase the total weight savings that come along with specifying AXSG vs the competitive material tested. The total weight savings is based on the average coverage of a tank being at 58 m² (625 ft²).

	AXSG	Competitive Material A	Competitive Material B	Competitive Material C	Competitive Material D	Competitive Material E	Competitive Material F
Weight of 58 m² (625 ft²)*	147 kg (325 lbs)	176 kg (388 lbs)	218 kg (481 lbs)	166 kg (368 lbs)	156 kg (344 lbs)	148 kg (327 lbs)	152 kg (334 lbs)
Differential		28 kg (63 lbs)	71 kg (156 lbs)	19 kg (43 lbs)	8 kg (19 lbs)	1 kg (2 lbs)	4 kg (9 lbs)
Differential %		19% More	48% More	13% More	6% More	1% More	3% More
***Size of typical 20' tank container cladding material**							

Conclusion- Panel Properties

The higher the glass content percentage in a material, the greater the strength of a properly formulated composite panel. AXSG is the thinnest and lightest of the materials, while maintaining the highest % of glass. Further testing results will show that its embedded uni-directional reinforcement further enhances strength and impact properties.

PUNCTURE RESISTANCE

Tests Conducted	Test Description	Testing Device
Puncture Resistance Test	This test involves a fixture sample with a 50 mm (2") square surface exposed. A test device applies pressure to a rounded ball point and the point of failure is recorded electronically when the radius point breaks through the test sample. The results are recorded in kg or lb. The puncture resistance test is a Crane Composites in-house test method conducted by the Research and Development center.	
Gardner Fail Test 3.6 kg (8 lb)	This method involves a 3.6 kg (8 lb) weight with a ball tup being dropped from successively higher points until the failure point is reached. The results are recorded in joules (J). This test was conducted by Crane Composites following ASTM D3029.	

Impact on Tank Cladding

These test results reflect the amount of force required to cause significant damage to the tank cladding material.

The best tank cladding material should allow for a greater amount of force before the material is punctured and should be able to withstand greater impact weight before a failure point is reached.

Test Results

	AXSG	Competitive Material A	Competitive Material B	Competitive Material C	Competitive Material D	Competitive Material E	Competitive Material F
Puncture-50 mm (2") base	159 kg (350 lbs)	128 kg (282 lbs)	75 kg (166 lbs)	79 kg (175 lbs)	71 kg (156 lbs)	71 kg (156 lbs)	106 kg (234 lbs)
Differential kg (lbs)		-31 kg (-68 lbs)	-84 kg (-184 lbs)	-80 kg (-175 lbs)	-88 kg (-194 lbs)	-88 kg (-194 lbs)	-53 kg (-116 lbs)
Differential %		20% Less	53% Less	50% Less	55% Less	55% Less	33% Less

	AXSG	Competitive Material A	Competitive Material B	Competitive Material C	Competitive Material D	Competitive Material E	Competitive Material F
3.6 kg (8 lb) Gardner	12.4 J (110 in-lb)	14.0 J (120 in-lb)	8.0 J (70 in-lb)	8.0 J (70 in-lb)	8.0 J (67 in-lb)	7.0 J (65 in-lb)	10.0 J (85 in-lb)
Differential J (in-lb)		1.6 J (10 in-lb)	-4.4 J (-40 in-lb)	-4.4 J (-40 in-lb)	-4.4 J (-43 in-lb)	-5.4 J (-45 in-lb)	-2.4 J (-25 in-lb)
Differential %		13% More	35% Less	35% Less	35% Less	44% Less	19% Less

Conclusion- Puncture Resistance

Crane Composites AXSG has the best puncture resistance of all the materials tested. This attribute comes from the special combination of high glass content, uni-directional glass strands and resin formulation for tank cladding applications.

PENDULUM IZOD IMPACT

Test Conducted	Test Description	Testing Device
Pendulum IZOD Impact Test	IZOD impact testing is an ASTM standard method of determining the impact resistance of materials. An arm held at a specific height (constant potential energy) is released. The arm hits the sample and breaks it. From the energy absorbed by the sample, its impact energy is determined. This test was conducted by Crane Composites following ASTM D256.	

Impact on Tank Cladding

These test values reflect the ability of the tank cladding material to resist impact.

The best tank cladding material should allow for a greater number of pounds per inch to impact the tank cladding material before the material is punctured through.

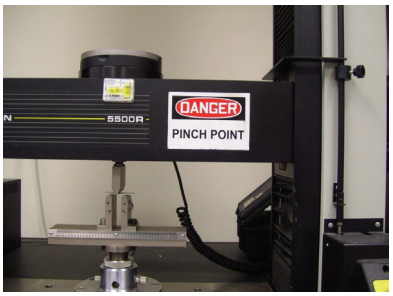
Test Results

	AXSG	Competitive Material A	Competitive Material B	Competitive Material C	Competitive Material D	Competitive Material E	Competitive Material F
IZOD- J/mm (ft-lb/in)	1.5 J/mm (28 ft-lb/in)	1.0 J/mm (19 ft-lb/in)	0.5 J/mm (9 ft-lb/in)	0.6 J/mm (11 ft-lb/in)	0.6 J/mm (11 ft-lb/in)	0.7 J/mm (13 ft-lb/in)	1.0 J/mm (19 ft-lb/in)
Differential J/mm (ft-lb/in)		-0.4 J/mm (-8 ft-lb/in)	-1 J/mm (-19 ft-lb/in)	-0.9 J/mm (-17 ft-lb/in)	-0.9 J/mm (-17 ft-lb/in)	-0.8 J/mm (-14 ft-lb/in)	-0.5 J/mm (-9 ft-lb/in)
Differential %		30% Less	67% Less	59% Less	61% Less	52% Less	32% Less

Conclusion- Pendulum IZOD Impact Test

AXSG resists the greatest amount of weight before breaking of all the sample material tested. The competitive materials ranged from 30% less up to 67% less weight being able to be applied before puncturing.

FLEXURAL STRENGTH

Tests Conducted	Test Description	Testing Device
Flexural Strength Test	This test involves setting up a sample in a test rig that supports the sample on each end. The center span is then subjected to measured pressure between the support points. The stress being applied is electronically measured to the failure point of the sample. This is a 3-point bend method. This test was conducted by Crane Composites following ASTM D790.	

Impact on Tank Cladding

Flexural Strength measures the amount of stress on the fibers on the convex side of the sample and is measured in pounds per square inch.

The best tank cladding material should allow for a greater number of pounds per square inch of force to be applied on the tank cladding material before a failure point is reached.

Test Results

	AXSG	Competitive Material A	Competitive Material B	Competitive Material C	Competitive Material D	Competitive Material E	Competitive Material F
Flex Strength- MPa (lb/in²)	362 MPa (52,000 lb/in²)	170 MPa (24,585 lb/in²)	107 MPa (15,500 lb/in²)	232 MPa (33,653 lb/in²)	161 MPa (23,375 lb/in²)	169 MPa (24,495 lb/in²)	249 MPa (36,125 lb/in²)
Differential MPa (lb/in²)		-192 MPa (-27,415 lb/in²)	-255 MPa (-36,500 lb/in²)	-130 MPa (-18,347 lb/in²)	-201 MPa (-28,625 lb/in²)	-193 MPa (-27,505 lb/in²)	-113 MPa (-15,875 lb/in²)
Differential %		53% Less	70% Less	36% Less	55% Less	53% Less	31% Less

Conclusion- Flexural Strength

AXSG has the greatest flexural strength of all sample materials tested. The superior strength of AXSG will reduce impact damage and reduce resulting repair and M&R costs related to container tank cladding.

COEFFICIENT OF THERMAL EXPANSION

Test Conducted	Test Description	Testing Device
Coefficient of Thermal Expansion	Coefficient of Thermal Expansion testing is the measurement of how much the length of a material will change when the material is heated or cooled. This test involves subjecting each sample to a cycle of temperature changes. The panels are cycled through a freezer (~-12°C - -6°C), ambient room (20°C - 24°C), and oven (~54°C). The panels are each measured as they are moved through the following cycle: oven- room- freezer- room- oven- room- freezer- room.	

Impact on Tank Cladding

These test values reflect the ability of the tank cladding material to resist expansion when exposed to varied temperatures.

The best tank cladding material should remain at its original dimension in order to prevent bumps or ripples in the panel that occur when two panels that are butted together expand or when adequate spacing isn't allowed between panels.

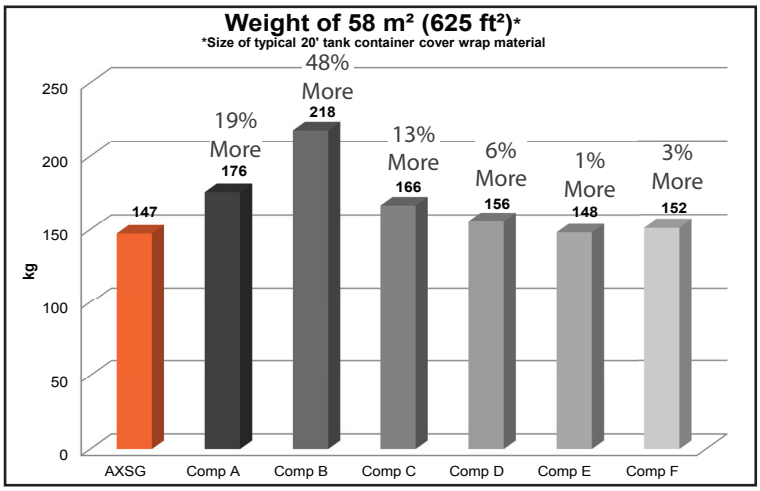
Test Results

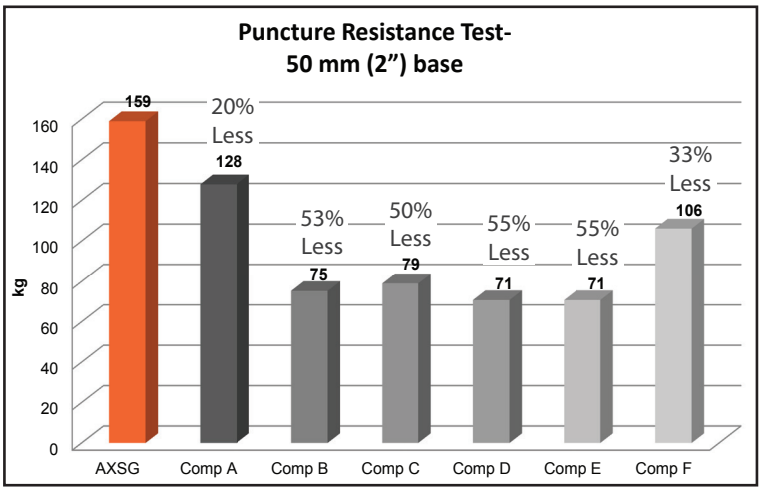
	AXSG	Competitive Material A	Competitive Material B	Competitive Material C	Competitive Material D	Competitive Material E	Competitive Material F
Coefficient of Thermal Expansion- µm/m-°C (in/in-°F)	14.4 µm/m-°C (0.8 x 10^{-5} in/in-°F)	25.2 µm/m-°C (1.4 x 10^{-5} in/in-°F)	23.4 µm/m-°C (1.3 x 10^{-5} in/in-°F)	25.0 µm/m-°C (1.4 x 10^{-5} in/in-°F)	30.6 µm/m-°C (1.7 x 10^{-5} in/in-°F)	23.4 µm/m-°C (1.3 x 10^{-5} in/in-°F)	19.8 µm/m-°C (1.1 x 10^{-5} in/in-°F)
Differential- µm/m-°C (in/in-°F)		10.8 µm/m-°C (0.6 x 10^{-5} in/in-°F)	9.0 µm/m-°C (0.5 x 10^{-5} in/in-°F)	10.6 µm/m-°C (0.6 x 10^{-5} in/in-°F)	16.2 µm/m-°C (0.9 x 10^{-5} in/in-°F)	9.0 µm/m-°C (0.5 x 10^{-5} in/in-°F)	5.4 µm/m-°C (0.3 x 10^{-5} in/in-°F)
Differential %		75% More	63% More	74% More	113% More	63% More	38% More

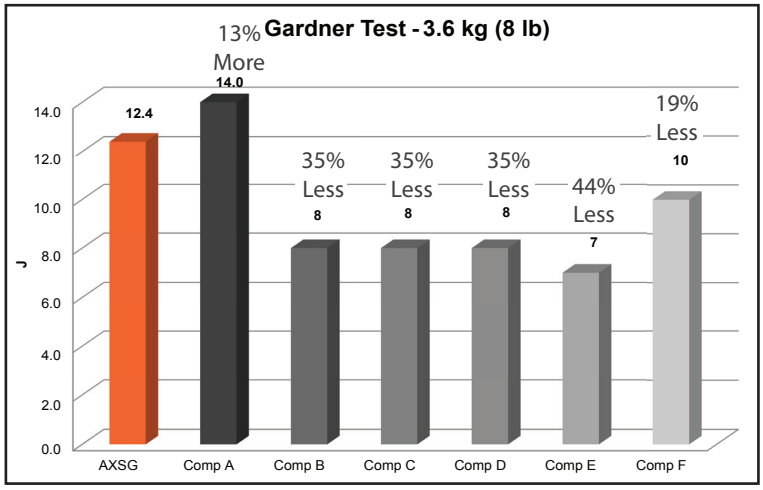
Conclusion- Coefficient of Thermal Expansion Test

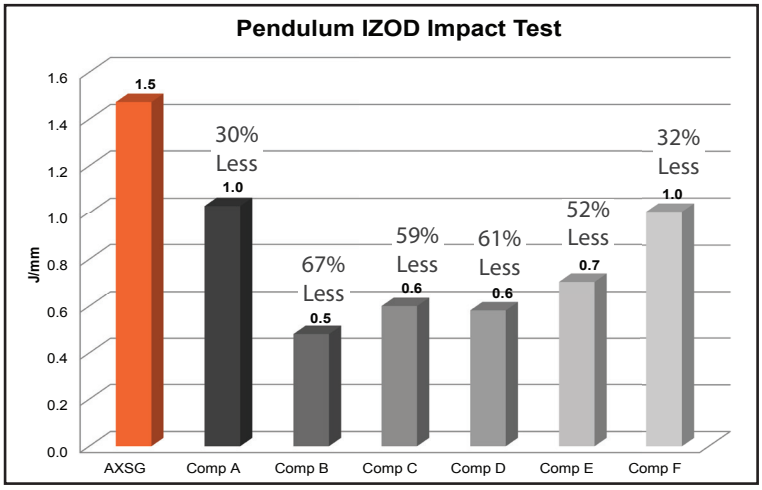
AXSG maintains its original dimension to a greater percentage when compared to all of the sample materials tested. The competitive materials ranged from 38% more up to 113% more expansion.

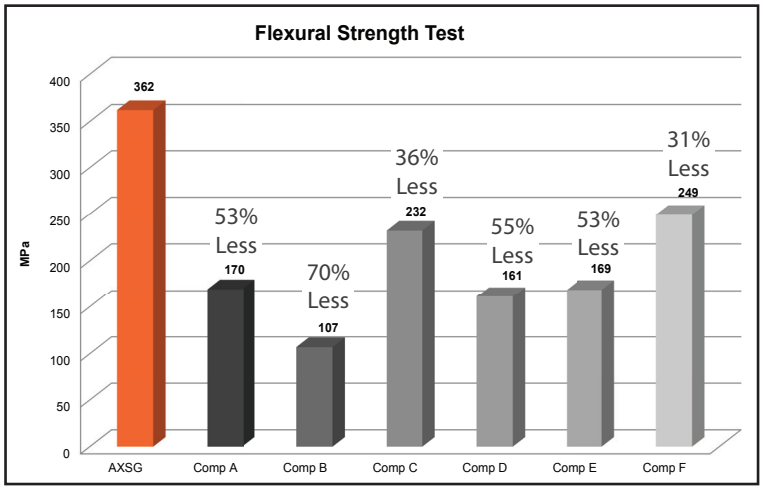
CONCLUSION

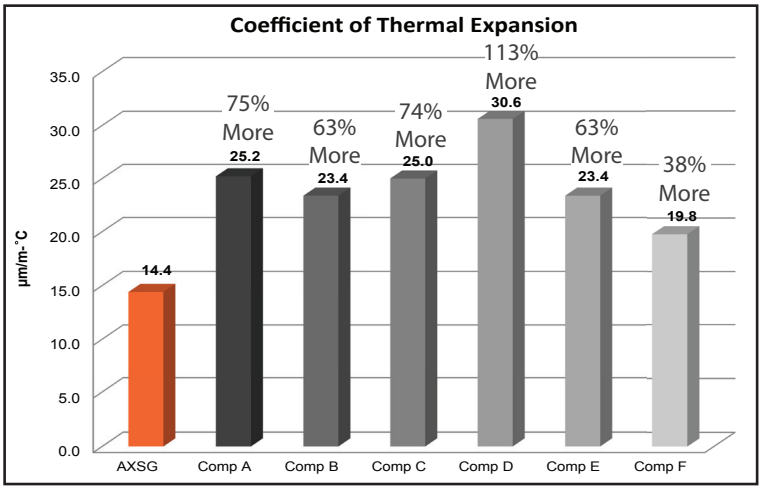

Weight of 58 m² (625 ft²)*
*Size of typical 20' tank container cover wrap material
kg
0
50
100
150
200
250
147
176
19% More
218
48% More
166
13% More
156
6% More
148
1% More
152
3% More
AXSG
Comp A
Comp B
Comp C
Comp D
Comp E
Comp F

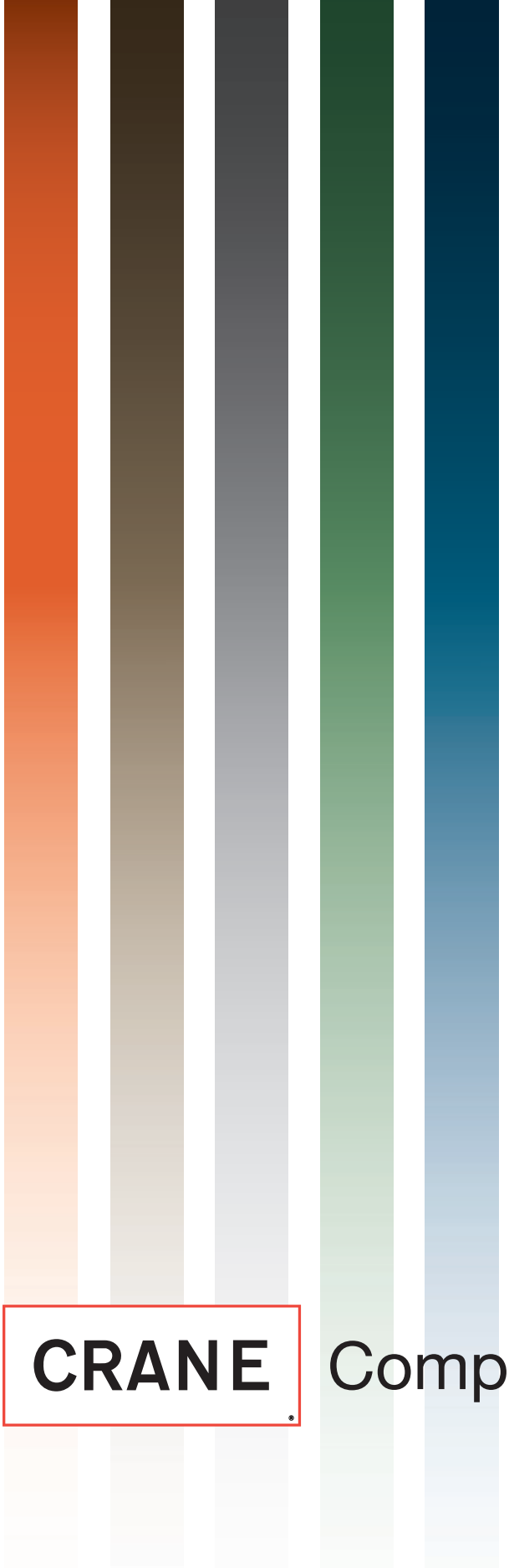

Puncture Resistance Test-
50 mm (2") base
kg
0
20
40
60
80
100
120
140
160
159
128
20% Less
75
53% Less
79
50% Less
71
55% Less
71
55% Less
106
33% Less
AXSG
Comp A
Comp B
Comp C
Comp D
Comp E
Comp F


13% Gardner Test - 3.6 kg (8 lb)
J
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
12.4
14.0
13% More
8
35% Less
8
35% Less
8
35% Less
7
44% Less
10
19% Less
AXSG
Comp A
Comp B
Comp C
Comp D
Comp E
Comp F


Pendulum IZOD Impact Test
J/mm
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.5
1.0
30% Less
0.5
67% Less
0.6
59% Less
0.6
61% Less
0.7
52% Less
1.0
32% Less
AXSG
Comp A
Comp B
Comp C
Comp D
Comp E
Comp F


Flexural Strength Test
MPa
0
50
100
150
200
250
300
350
400
362
170
53% Less
107
70% Less
232
36% Less
161
55% Less
169
53% Less
249
31% Less
AXSG
Comp A
Comp B
Comp C
Comp D
Comp E
Comp F


Coefficient of Thermal Expansion
µm/m- °C
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
14.4
25.2
75% More
23.4
63% More
25.0
74% More
30.6
113% More
23.4
63% More
19.8
38% More
AXSG
Comp A
Comp B
Comp C
Comp D
Comp E
Comp F



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Crane Composites is the manufacturer of ArmorTuf, Kemlite and a variety of other fiberglass reinforced plastic (frp) composite panels. Inspired by the Kemlite tradition, Crane Composites has over 55 years of experience in Transportation Products and is a recognized industry leader in frp applications. ArmorTuf and Kemlite are registered trademarks of Crane Composites, Inc.

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