Vehicle Armor Composite System (VACS)

Composite armor solutions for a wide variety of vehicle systems made with glass fiber manufactured by AGY and processed by proven industry partners. The VACS system has a composite protection solution to meet your needs.

AGY S-2 Glass®/HJ1

Advanced Ballistic Protection with over 25 Years of Proven Performance

The S-2 Glass®/ HJ1 composite armor system is a patented system based on AGY's S-2 Glass reinforcement woven into a plain weave fabric and a phenolic resin system. The combination of materials results in a composite that has superior ballistic protection, excellent durability, and outstanding fire, smoke, and toxicity performance. The system has been tailored for producing large flat panels using a compression molding process. Overall economics are attractive in that a 25 to 40 percent cost savings over comparable performing aramid armor systems is provided.

The S-2 Glass/ HJ1 system was developed in the late 1980s and is now well established in many military applications both in the US and overseas. AGY's 463-AA-250 was the basis for the new MIL-DTL-64154B Class A, Code 1 material. It is the only fiber that meets this specification. Rights to AGY's technology have been licensed to more than a dozen manufacturing companies in the US, Europe, and Asia to provide consistent, competitive and assured availability of this product.

The high tensile and compressive strengths of S-2 Glass fiber reinforced laminates are key factors to both ballistic and structural performance. The fiber's high ultimate elongation (5.7 percent) plays an important role in the dynamic ballistic impact-absorbing mechanism. S-2 Glass fiber reinforced laminates also allow a degree of design flexibility unavailable with other composite materials. Aramids, such as Kevlar*, typically have a weak mechanical bond to resin. S-2 Glass fiber reinforcements form both a mechanical and a chemical bond with the resin matrix through the use of chemical surface treatments applied to the glass during manufacturing. The bonding permits good structural performance in a ballistic performing composite laminate.

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AGY S-2 Glass®/HJ1

AVAILABLE PRODUCTS

Product Identification	Type	Tex	Yards/ Pound
463-AA-750	Assembled Roving	675	735
463-AA-250	Assembled Roving	2033	244

PROPERTIES

Characteristic (in epoxy)	Test Method	Values
Impregnated strand tensile strength	ASTM D-2343	3.4-4.1 GPa (500-600 ksi)
Horizontal shear (short beam)	ASTM D-2344	55-76 MPa (8-11 ksi)
Wet strength retention after 6-hr. water boil — 95%		

GLASS COMPOSITION

"S Glass" (reference: AMS 3832A, ASTM C 162-90, MIL-R-60346C Type IV Class 1, MIL-DTL-64154B Class A, Code 1)

NOMINAL FILAMENT DIAMETER

9 microns or 0.00038 inches

SOLIDS (% LOI*)

0.80 min. 1.00 nom. 1.20 max.
* Loss on ignition after drying

Mechanical Properties – Phenolic System (HJ1)

Property	Standard	Average English	Average Metric
Specific Gravity	ASTM D792	1.96	1.96
Water Absorption	ASTM D570	1% (max)	1% (max)
Loss on Ignition	ASTM D2584	16-23%	16-23%
Tensile Strength Modulus Elongation Poisson Ratio	ASTM D638	70 ksi 3.6 Msi 4% 0.26	485 MPa 25 GPa 4% 0.26
Flexural Strength Modulus	ASTM D790	26 ksi 4.2 Msi	180 MPa 29 GPa
Flexural Strength, Wet Modulus, Wet		18 ksi 3.9 ksi	124 MPa 27 GPa
Short Beam Shear	ASTM D2344	3.6 ksi	24.8 MPa
In-plane Compressive Strength Modulus	ASTM D695	24 ksi 4.4 Msi	165 MPa 30 Gpa
(0°/90°) Compressive Strength Modulus	ASTM D695	109 ksi 0.5 Msi	750 MPa 3.4 Gpa

NOTE: Mechanical properties were determined from specimens of one-half inch thickness rather than thicknesses called out in ASTM standards.

Ballistic performance of the S-2 Glass/ HJ1 system against fragment simulating projectiles (FSP) is superior to metals and similar to aramid reinforced systems at the same areal density. The S-2 Glass/ HJ1 armor system is also thinner than comparable aramid systems at the same areal density. This is an important factor in space limited applications.

The S-2 Glass/ HJ1 composite armor sets the standard for the current generation of armor materials by providing a durable, FST-friendly and lightweight alternative to metals. The system represents a significant cost saving potential over aramid reinforced systems. Other benefits include fabrication ease, low structural deformation after impact and capability for higher ballistic protection in confined spaces. AGY's HJ1 is the only composite armor sytem in the world that meets MIL-DTL-64154B Class A, Code 1.

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