The choice of material is dependent on the concentration of various corrosives present in the application environment and other physical properties necessary to meet the design specifications.

To begin the selection process, one must consider the general atmosphere as well as the corrosive agents which can be present in an application. Defining the corroding agents and determining the concentration can be a complex process. Usually several corrosive elements are present and interactions are not always well documented.

Water (and water states such as ice, snow, mist, fog, vapor) is the most common corrosive and is usually present to some extent in every enclosure application. Each environment is unique and all possible corrosive agents should be identified for the intended enclosure application.

To select the best enclosure material for an application; chemical resistance, physical strength and economic data are presented in several tables beginning on the next page. In Table 1 enclosure materials are rated on a continuum from “Recommended” to “Limited or Unacceptable” in three broad categories of chemicals. Since the chemical resistance categories in the table are extremely broad, some materials may perform well in specific corrosive environments within a general category and it is best to consult the detailed Chemical Resistance Information provided in Table 3.

Besides the enclosure material, the corrosion resistance of windows, gaskets, latches, etc. must also be considered. Table 4 provides corrosion resistance information that can be used to select the commonly used materials for these features.

Much of the chemical resistance information in Table 3 is based on total immersion testing in the chemical for a minimum of 30 days at 72°F. Some fiberglass test specimens were evaluated using procedures outlined in ASTM D 543, Test Method for Resistance of Plastics to Chemical Reagents. The information in these tables is intended as a guide only. Total immersion testing is considered quite severe and **the results may not necessarily reflect the performance under actual field conditions.** The user assumes responsibility for selection of the material based on the characteristics of the application environment.

Specifications for Stahlin Enclosure Back Panel Construction Materials

Fiberglass (FG)
Fiber reinforced polymer made of a plastic matrix reinforced by fine fibers made of glass. The plastic matrix is a thermosetting plastic made of polyester.

Carbon Steel (CS)
A low carbon, rolled steel produced by passing bar stock through a set of rolls. Stahlin CS back panels are powder coated for appearance and protection.

Stainless Steel (SS)
Stainless steel is defined as a steel alloy with a minimum of 11% chromium content by mass. Stainless steel is used where both the properties of steel and resistance to corrosion are required. Stahlin hardware and SS backpanels are fabricated utilizing 3000 series stainless steel.

Aluminum (AL)
A lightweight metal that quickly forms a natural oxide layer to resist corrosion. Stahlin fabricates back panels from Type 3003 H14 Aluminum, the highest strength non-heat treatable aluminum alloy recommended for marine applications.

TABLE 1. BROAD CATEGORIES OF ENCLOSURE MATERIAL CHEMICAL RESISTANCE			
CONTINUUM OF USE	GENERAL CATEGORY OF CHEMICALS		
	Acids	Alkalines	Solvents
Recommended	Stainless Steel Fiberglass	Fiberglass Stainless Steel	Fiberglass Stainless Steel Aluminum Powder Coated Steel
Acceptable	PC PVC Powder Coated Steel	PC Galvanized Steel Powder Coated Steel	Galvanized Steel
Limited or Unacceptable	Aluminum Galvanized Steel	PVC Aluminum	PC PVC

TABLE 2. RELATIVE MATERIAL STRENGTH AND COST COMPARISON OF COMMONLY USED ENCLOSURE MATERIALS

MATERIAL	RELATIVE PHYSICAL STRENGTH	RELATIVE COST	APPLICATION CONDITIONS	TEMPERATURE LIMITATIONS
Aluminum	Average	Average	Indoor and Outdoor, Marine, Solvents, Petrochemical Sulfates, Nitrates and Specific Acids.	None for enclosure applications
Fiberglass	Average	Low-Average	Indoor and Outdoor for continuously damp and highly corrosive environments. Petrochem, Water Treatment, Food Processing, Coating, Salts and Chemicals, Solar.	-40°F(C) to 250°F(121°C) Stahlin -76°F to 274°F (-60°C to 134°C)
Mild Steel: Galvanized Painted	High	Average Low	Indoor and Outdoor where the respective coating provides acceptable protection in a mildly corrosive environment.	None for enclosure applications.
Stainless Steel	High	Average-High	Indoor and Outdoor in highly corrosive applications. Food and Dairy Processing or Marine.	None for enclosure applications.
Acrylic	Average	Low	Enclosure Windows. Weatherable, Scratch Resistant. Good resistance to Solvents.	-31°F(-35°C) to 180°F(82°C)
Poly-carbonate	Average	Low-Average	Enclosure Windows. Not recommended for direct sunlight, exposure to organic solvents and concentrated alkalis.	-31°F(-35°C) to 248°F(120°C)
Nylon	Average	Low	Cord Grip, Hinges, Latches.	-22°F(-30°C) to 212°F(100°C)
Gaskets: Neoprene Silicone Urethane	 Low Low Low	 Low Average Average	 Oil Resistance. Seams may be a problem Oil Resistance Temperature & Chemical Resistance. Water and Oil Resistance, Chemical Resistance.	 -40°F(C) to 225°F(107°C) -40°F(-40°C) to 350°F(175°C) -40°F(C) to 200°F(93°C)

Detailed material strength information is beyond the scope of this catalog and should be obtained from a materials reference; however, Table 2 provides some relative data to help with this selection.

KEY:

S = Superior Resistance/Completely Unaffected under all Conditions
L = Limited Resistance, Some Chemical Attack May Occur Over Time
M = Moderate Resistance, Superficial Effects only, Testing Recommended
U = Unsatisfactory, Severe/Chemical Attack in a relatively short time
– = No Data Available

TABLE 3. CHEMICAL RESISTANCE OF FIBERGLASS MATERIALS AND ENCLOSURE ACCESSORIES

			Steel			Stainless Steel			
CHEMICAL	Aluminum	Fiber Glass Polyester	Polyester Powder	Urethane Enamel	Gal-vanized	Type 304	Type 316	PC	PVC
Acetyldehyde	S	U	—	—	—	S	S	U	U
Acetic Acid (10%)	L	S	U	U	U	S	U	S	U
Acetone	S	L	L	U	L	S	S	U	U
Aluminum Chloride (10%)	U	S	U	U	U	U	M	S	S
Aluminum Sulfate (10%)	L	S	U	U	U	U	S	S	S
Ammonia Gas	L	S	—	—	—	S	S	—	—
Ammonium Chloride	U	S	U	U	U	S	S	S	S
Ammonium Hydroxide (10%)	S	L	U	U	U	S	S	U	S
Ammonium Nitrate (10%)	M	S	U	U	U	S	S	U	S
Ammonium Phosphate (10%)	L	M	S	L	U	S	M	S	—
Ammonium Sulfate	S	S	—	—	—	S	S	S	S
Aniline	L	U	—	—	—	S	S	U	L
ASTM #1 Oil	S	S	S	S	S	S	S	L	—
ASTM #3 Oil	S	S	S	S	S	S	S	L	—
Axle Grease	S	S	S	S	S	S	S	L	—
Benzene	S	S	—	—	S	S	S	U	L
Boric Acid (10%)	M	S	U	U	U	S	S	S	L
Bromine	U	L	U	U	U	U	U	U	U
Butyl Acetate	M	L	—	—	—	S	S	U	U
Butyric Acid	U	S	—	—	—	S	S	U	U
Calcium Chloride (10%)	L	S	U	U	U	L	S	S	L
Calcium Hydroxide (10%)	U	S	U	U	U	S	S	S	L

TABLE 3. Continued									
		Fiber	Steel			Stainless Steel			
CHEMICAL	Aluminum	Glass Polyester	Polyester Powder	Urethane Enamel	Gal-vanized	Type 304	Type 316	PC	PVC
Calcium Hypochlorite (10%)	L	M	U	U	U	U	M	L	L
Calcium Sulfate	M	S	U	U	U	S	S	S	L
Carbolic Acid (25%)	M	L	U	U	U	S	S	U	
Carbon Disulfide	S	L	—	—	—	S	S	U	U
Carbon Tetrachloride	S	M	U	S	S	U	S	U	
Chlorine (dry)	S	S	—	—	—	S	S	U	U
Chlorine (water) 5-10 ppm	M	L	S	U	U	U	—	S	S
Chlorobenzene	S	S	—	—	S	S	S	U	
Chloroform	L	U	—	—	—	S	S	U	U
Chrome Plating Solution	U	L	U	U	U	L	L	S	—
Chromic Acid	S	S	—	—	—	U	U	U	U
Citric Acid (10%)	U	M	U	U	U	S	S	S	L
Copper Sulfate	U	S	—	—	—	S	S	S	S
Creosote	L	L	—	—	—	S	S	U	—
Cutting Fluid (5 Star) 10%	S	S	U	U	U	S	S	L	—
Cutting Fluid (Castrol 980 H)	S	S	S	U	U	S	S	L	—
Cutting Fluid (Norton 205)	U	S	U	U	U	S	S	S	—
Cutting Fluid (Rustlick) 10%	M	S	U	U	U	S	S	S	—
Cutting Oil (Dark)	S	S	S	S	S	S	S	S	—
Diethyl Ether	S	S	—	—	—	S	S	U	U
Ethyl Alcohol	S	S	M	U	S	S	S	M	S
Ethylene Dichloride	S	L	—	—	—	—	—	U	U
Ethylene Glycol	S	S	S	S	U	S	S	S	S
Ferric Chloride	U	S	U	U	U	S	U	S	S
Ferric Nitrate	—	S	—	—	—	S	S	S	S
Ferric Sulfate	M	S	—	—	—	S	S	S	S
Fluorine	S	U	—	—	—	M	—	L	U
Formaldehyde	S	S	—	—	—	L	S	S	L
Formic Acid	U	S	U	U	U	M	S	S	—
Fuel Oil (#2)	S	S	M	S	S	S	M	L	S
Gasoline	S	M	—	—	—	S	S	U	S
Glycerine	S	S	—	—	S	S	S	S	S
Hydraulic Brake Fluid	S	S	U	U	S	S	S	U	—
Hydraulic Oil	S	S	S	S	S	S	S	L	S

Technical Information

TABLE 3. Continued

CHEMICAL	Aluminum	Fiber Glass Polyester	Steel			Stainless Steel		PC	PVC
			Polyester Powder	Urethane Enamel	Gal-vanized	Type 304	Type 316		
Hydrochloric Acid (10%)	U	M	U	U	U	U	U	S	S
Hydrocyanic Acid	S	U	—	—	—	S	S	L	L
Hydrofluoric Acid (20%)	U	U	U	U	U	U	U	L	L
Hydrogen Peroxide	S	M	—	—	—	L	S	S	S
Hydrogen Sulfide	M	S	—	—	—	L	S	L	L
Hypochlorus Acid	U	S	—	—	—	—	—	—	—
Isopropyl Alcohol	S	S	M	U	S	S	S	S	—
Kerosene	S	S	S	S	S	S	S	L	S
Lacquer Thinner	S	S	L	U	S	S	S	U	U
Lactic Acid	M	S	—	—	—	L	S	L	L
Lime	M	M	—	—	—	—	—	—	L
Liquid Dish Soap (10%)	M	S	U	U	U	S	M	S	S
Lubricating Oils	S	S	—	—	—	S	S	S	—
Magnesium Chloride (10%)	L	S	U	U	U	S	S	S	L
Magnesium Hydroxide (10%)	L	S	U	U	U	S	S	S	S
Mercuric Chloride (10%)	U	M	U	U	U	S	U	S	L
Methyl Ethyl Ketone	S	L	—	—	—	S	S	U	U
Methylene Chloride	S	S	U	U	M	S	S	U	U
Milk	S	S	—	—	—	S	S	S	S
Mineral Oil	S	S	—	—	—	S	S	S	S
Mineral Spirits	S	S	S	S	S	S	S	L	S
Motor Oil (10 weight)	S	S	S	S	S	S	S	S	L
Nickel Salts	L	S	—	—	—	L	S	S	S
Nitric Acid (10%)	U	M	U	U	U	S	S	L	S
Nitrobenzene	S	L	—	—	—	S	S	U	U
Oleic Acid	S	S	—	—	—	L	S	S	L
Perchlorethylene	S	S	S	U	S	S	S	U	L
Phosphoric Acid (25%)	U	L	U	U	U	S	S	S	S
Phosphoric Acid (50%)	U	U	U	U	U	S	S	S	S
Pickling Solution	U	M	U	U	U	S	M	S	—
Potassium Carbonate (10%)	U	S	S	S	L	S	S	S	L
Potassium Chloride (25%)	L	S	U	U	U	S	S	S	S
Potassium Hydroxide (25%)	U	U	U	U	U	M	M	U	S
Potassium Nitrate (10%)	U	S	U	U	U	S	S	S	S

TABLE 3. Continued									
CHEMICAL	Aluminum	Fiber Glass Polyester	Steel			Stainless Steel		PC	PVC
			Polyester Powder	Urethane Enamel	Gal-vanized	Type 304	Type 316		
Potassium Sulfate (10%)	L	S	U	U	U	S	S	S	L
Soap (Igepal) 10%	L	S	S	U	U	S	S	S	S
Sodium Bicarbonate (10%)	L	S	S	S	U	S	S	S	S
Sodium Bisulfate (10%)	U	L	U	U	U	S	S	S	S
Sodium Chloride (25%)	L	S	U	U	U	S	S	S	S
Sodium Hydroxide	U	U	U	U	U	M	M	U	S
Sodium Hypochlorite	U	M	U	U	U	S	M	L	S
Sodium Nitrate (10%)	M	S	U	U	U	S	S	S	S
Sodium Phosphate (10%)	L	S	U	U	U	S	S	S	S
Sulfuric Acid (25%)	U	S	U	U	U	S	S	S	S
Sulfurus Acid (10%)	U	U	U	U	U	S	S	S	S
Tannic Acid ((10%)	L	S	U	U	U	M	M	S	S
Tetrahydrofuran	M	L	U	U	U	S	S	U	U
Toluene	S	S	L	U	S	S	S	U	U
Trichloroethylene	S	U	—	—	—	L	S	U	U
Trisodium Phosphate	L	M	—	—	—	—	—	S	S
Turpentine	S	M	M	U	L	S	S	S	U
Vegetable Oils	S	S	—	—	—	S	S	S	S
Vinegar	M	S	—	—	—	S	S	S	L
Water, Industrial	L	S	L	L	L	S	S	S	S
Water, Rain	L	S	S	L	L	S	S	S	—
Water, Sea	L	S	U	U	U	S	S	S	S
Water, Tap	L	S	S	L	L	S	S	S	S
Xylene	S	S	L	U	S	S	S	U	U
Zinc Acetate	S	S	—	—	—	S	S	—	—
Zinc Chloride	L	S	S	U	U	M	S	M	L
Zinc Sulfate	S	S	—	—	—	M	S	S	S

Sources: Robroy Industries Reagent Testing Lab, Corrosion Resistant Materials Handbook, 4th Edition, Noyes Data Corp., Raw Material Vendors

Technical Information

TABLE 4. SPECIFIC CHEMICAL RESISTANCE INFORMATION OTHER MATERIALS USED FOR ENCLOSURE FEATURES

			Gaskets			Windows	
CHEMICAL	**Rigid PVC**	**Glass Nylon**	**Neoprene Rubber**	**Silicone Rubber**	**Urethane**	**Acrylic**	**Poly-carbonate**
Acetyldehyde	U	—	S	S	—	—	—
Acetic Acid (10%)	L	U	U	M	L	S	S
Acetone	U	S	U	S	U	U	U
Aluminum Chloride (10%)	S	U	S	S	S	S	S
Aluminum Sulfate (10%)	S	L	U	S	S	S	S
Ammonia Gas	—	S	S	S	—	S	—
Ammonium Chloride	S	U	S	S	S	S	S
Ammonium Hydroxide (10%)	S	—	L	L	S	S	U
Ammonium Nitrate (10%)	S	U	U	S	S	S	U
Ammonium Phosphate (10%)	—	L	U	S	S	S	S
Ammonium Sulfate	S	U	S	S	—	—	—
Aniline	S	L	U	U	—	S	—
ASTM #1 Oil	—	—	M	S	S	S	M
ASTM #3 Oil	—	—	U	L	S	S	M
Axle Grease	—	—	L	S	S	S	M
Benzene	U	S	U	U	—	U	—
Boric Acid (10%)	L	S	S	S	S	S	S
Bromine	U	U	U	U	U	L	U
Butyl Acetate	U	S	U	U	—	U	—
Butyric Acid	U	U	U	—	—	—	—
Calcium Chloride (10%)	S	U	S	S	S	S	S
Calcium Hydroxide (10%)	S	—	U	S	L	S	S
Calcium Hypochlorite (10%)	S	U	U	S	U	M	S
Calcium Sulfate	S	U	S	S	S	S	S
Carbolic Acid (25%)	—	—	U	U	U	U	U
Carbon Disulfide	U	—	U	—	—	S	—
Carbon Tetrachloride	L	S	U	U	U	S	U
Chlorine (dry)	L	—	—	—	—	—	—
Chlorine (water) 5-10 ppm	L	—	L	S	S	S	S
Chlorobenzene	U	S	U	U	—	L	—
Chloroform	U	U	U	U	—	U	—
Chrome Plating Solution	—	—	U	U	U	S	S
Chromic Acid	L	U	U	M	—	U	—
Citric Acid (10%)	S	L	U	S	U	S	S

TABLE 4. Continued

CHEMICAL	Rigid PVC	Glass Nylon	Gaskets			Windows	
			Neoprene Rubber	Silicone Rubber	Urethane	Acrylic	Poly-carbonate
Copper Sulfate	S	L	S	S	—	U	—
Creosote	—	U	U	U	—	—	—
Cutting Fluid (5 Star) 10%	—	—	U	S	S	S	M
Cutting Fluid (Castrol 980 H)	—	—	L	S	S	S	L
Cutting Fluid (Norton 205)	—	—	S	S	S	S	S
Cutting Fluid (Rustlick) 10%	—	—	S	S	S	S	S
Cutting Oil (Dark)	—	—	U	S	S	S	S
Diethyl Ether	U	—	—	U	—	U	—
Ethyl Alcohol	S	—	L	S	S	U	M
Ethylene Dichloride	U	—	U	U	—	U	—
Ethylene Glycol	S	—	S	S	S	S	S
Ferric Chloride	S	U	L	S	L	S	S
Ferric Nitrate	S	U	S	M	—	—	—
Ferric Sulfate	S	U	S	M	—	—	—
Fluorine	L	—	—	U	—	—	—
Formaldehyde	L	U	U	M	—	S	—
Formic Acid	L	S	U	L	L	U	S
Fuel Oil (#2)	S	—	U	U	U	S	S
Gasoline	S	S	U	L	—	S	—
Glycerine	S	S	S	S	—	S	—
Hydraulic Brake Fluid	—	—	U	S	U	U	U
Hydraulic Oil	—	—	U	S	S	S	M
Hydrochloric Acid (10%)	S	U	L	L	U	S	S
Hydrocyanic Acid	S	—	S	M	M	—	—
Hydrofluoric Acid (20%)	L	U	U	U	—	S	M
Hydrogen Peroxide	S	U	U	M	—	S	—
Hydrogen Sulfide	S	—	U	M	—	—	—
Hypochlorus Acid	—	—	—	—	—	—	—
Isopropyl Alcohol	—	—	S	S	S	S	S
Kerosene	S	—	U	U	S	S	M
Lacquer Thinner	—	S	U	S	L	U	U
Lactic Acid	S	L	L	—	—	L	—

Technical Information

TABLE 4. Continued							
			Gaskets			Windows	
CHEMICAL	Rigid PVC	Glass Nylon	Neoprene Rubber	Silicone Rubber	Urethane	Acrylic	Poly-carbonate
Lime	—	—	S	M	—	—	—
Liquid Dish Soap (10%)	S	—	L	S	S	S	S
Lubricating Oils	—	—	U	U	—	S	—
Magnesium Chloride (10%)	S	S	S	S	S	S	S
Magnesium Hydroxide (10%)	S	—	S	S	S	S	S
Mercuric Chloride (10%)	L	—	U	L	U	S	S
Methyl Ethyl Ketone	U	S	S	U	—	L	—
Methylene Chloride	—	U	U	S	U	U	U
Milk	S	—	S	S	—	S	—
Mineral Oil	S	—	L	M	—	S	—
Mineral Spirits	—	—	U	U	S	S	M
Motor Oil (10 weight)	—	—	U	U	S	S	S
Nickel Salts	S	—	U	S	—	—	—
Nitric Acid (10%)	S	U	U	U	U	S	L
Nitrobenzene	U	S	U	—	—	—	—
Oleic Acid	S	U	—	U	—	—	—
Perchlorethylene	—	—	U	S	U	U	U
Phosphoric Acid (25%)	S	U	S	S	U	S	S
Phosphoric Acid (50%)	S	U	S	S	U	S	S
Pickling Solution	—	—	L	M	M	S	S
Potassium Carbonate (10%)	L	S	S	S	S	S	S
Potassium Chloride (25%)	S	L	S	S	S	S	S
Potassium Hydroxide (25%)	S	S	U	L	M	U	U
Potassium Nitrate (10%)	S	L	S	S	S	S	S
Potassium Sulfate (10%)	SL	S	S	S	S	S	S
Soap (Igepal) 10%	S	—	U	S	S	S	S
Sodium Bicarbonate (10%)	S	S	S	S	S	S	S
Sodium Bisulfate (10%)	S	L	S	S	L	S	S
Sodium Chloride (25%)	S	S	S	S	S	S	S
Sodium Hydroxide	S	S	U	U	M	S	U
Sodium Hypochlorite	S	U	U	S	U	S	S
Sodium Nitrate (10%)	S	S	S	S	S	S	S

TABLE 4. Continued							
			Gaskets			Windows	
CHEMICAL	Rigid PVC	Glass Nylon	Neoprene Rubber	Silicone Rubber	Urethane	Acrylic	Poly-carbonate
Sodium Phosphate (10%)	S	—	U	S	S	S	S
Sulfuric Acid (25%)	S	U	S	S	U	S	S
Sulfurus Acid (10%)	S	—	U	U	L	S	S
Tannic Acid ((10%)	S	U	U	L	U	S	S
Tetrahydrofuran	—	S	U	U	U	U	U
Toluene	U	S	U	U	U	U	U
Trichloroethylene	U	U	U	U	—	U	—
Trisodium Phosphate	S	—	—	—	—	—	—
Turpentine	—	S	U	L	U	S	S
Vegetable Oils	S	—	L	S	—	S	—
Vinegar	—	S	L	S	—	S	—
Water, Industrial	S	—	S	S	S	S	S
Water, Rain	S	—	S	S	S	S	S
Water, Sea	S	—	S	S	S	S	S
Water, Tap	S	—	S	S	S	S	S
Xylene	—	S	U	M	U	S	U
Zinc Acetate	—	—	—	U	—	—	—
Zinc Chloride	S	U	M	S	U	S	M
Zinc Sulfate	S	L	S	S	—	—	—

Sources: Robroy Industries Reagent Testing Lab, Corrosion Resistant Materials Handbook, 4th Edition, Noyes Data Corp., Raw Material Vendors

TECHNICAL INFORMATION

SPECIFICATION: PHYSICAL PROPERTIES OF NON-METALLIC MATERIALS

Table 7 provides technical data for assistance in evaluating non-metallic enclosures and commonly used accessory materials.

TABLE 7. PHYSICAL PROPERTIES OF NON-METALLIC MATERIALS

Materials Typical Properties	Test Method ASTM	Polyester Fiberglass (SMC)	Polyester Fiberglass Hand Lay-up	Polyester Fiberglass Pultrusion	Acrylic Sheet for Windows	Dispensed Silicone Gaskets	Foamed Urethane Gaskets	Extruded Silicone Gaskets	Neoprene Gaskets	Poly-carbonate	PVC
Flexural Strength (psi)	D 790	17K	30K	45K	16K	N/A	N/A	N/A	N/A	15k	12.8k
Notched Izod (ft - lb/in @ 1/8")	D 256	7-22	5-30	25	0.3-0.4	N/A	N/A	N/A	N/A	13	1.3
Impact Resistance (lb-in)	UL 746C	≥216	—	—	—	N/A	N/A	N/A	N/A	—	—
Compressive Strength (psi)	D 695	20K	35K	26K	18K	N/A	N/A	N/A	N/A	12k	10.8k
Tensile Strength (psi)	D 638	8K	17.5K	40K	10.5K	200	60	100	50	9.5k	7.5k
Specific Gravity	D 792	1.71	1.5-2.1	1.7	1.17-1.20	1.32	0.3	0.55	1.24	1.20	1.41
Flammability	UL 94	V-0 5V	—	V-0	94HB	—	—	—	—	H-B, V0	V0
Heat Deflection (°F at 264 psi)	D 648	375-500	>400	<400	205	N/A	N/A	N/A	N/A	270	176
Service Temperature Range (°F)		-76°F to +274°F	-76°F to +274°F	-40°F to +250°F	-31°F +180°F	-40°F to +350°F	-40°F to +200°F	-100°F to +500°F	-40°F to +225°F	-20˚ to +240°F	-4°F to +140°F
K Factor, Thermal Conductivity (BTU/hr/ft²/°F/in)		1.68	1.68	1.68	1.3	1.3	1.0	1.3	1.45	1.3	0.90
Dielectric Strength (VPM)	D 149	380	380	200	500	400	330	400	400	390	544
Arc Resistance (sec)	D 570	200+	200+	80	No Track	N/A	N/A	N/A	N/A	117	—
Water Absorption (% in 24 hr)	D 570	0.10-0.25	0.05-0.5	0.05-0.5	<0.4	0.12-0.15	<2	5	—	0.12	<0.07
Hardness (Barcol-Rockwell M-Shore A)		50-70 Barcol	60-80 Barcol	50 Barcol	105 Rockwell	18 Shore	8 Shore	—	15-95 Shore	M70/R118	R115
Shrinkage in/in Minimum		.005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.006	—
Elongation (%)		N/A	N/A	N/A	N/A	850	100	400	100-800	N/A	50-150
Compression Set 24 hr @ 50%, 72°F		N/A	N/A	N/A	N/A	<5%	<2%	<5%	15-60	N/A	—

-- no test data available
K = 1000
N/A not applicable

Stahlin offers no guarantee or warranty as to the applicability of this chart on a particular situation as the actual conditions of use on our enclosures are beyond our control.

Enclosure Weight Load Capacity

Large control enclosures 20" x 16" and above can support 200 lbs. of equipment on the back panel. Smaller-junction enclosures 18" x 16" and below should be limited to 75 lbs. Listed values assume the enclosure is vertically mounted against a reasonably flat surface and are based on a **minimum safety factor of two.**

Sunlight (UV) Resistance

In time sunlight may roughen the fiberglass enclosure surface, but its **electrical and mechanical properties remain unaffected.** Surface roughening caused by UV exposure is a common phenomenon encountered with virtually all fiberglass products, but it only affects surface appearance. Tests have confirmed the effect on polyester fiberglass is only 40 to 80 microns (0.0015"-.003") in depth. If appearance is a concern, an outdoor acrylic paint (clear or pigmented) will provide protection for many years. Most acrylic paints in ordinary spray cans work well.

Stahlin fiberglass enclosures are molded using a patented material formulation (SolarGuard®) which can provide up to 60% more UV resistance.

Flammability Test Methods

UL94-HB

Test is run with bars 1/2 of an inch wide and five inches long. These are held horizontally and exposed to a flame 3/4 of an inch high. Ignition is forced until one inch of sample has burned, the flame removed and the burning rate is measured. To pass UL94-HB a sample over 1/8 of an inch thick must burn slower than 1-1/2 inches per minute, and a sample 1/8 of an inch thick or less must not burn faster than 3 inches per minute.

UL94-V0

Test is run with bars 1/2 of an inch wide and five inches long, held vertically with a flame size of 3/4 of an inch high. Each sample is ignited for ten seconds, the flame allowed to go out and ignited for a second time of ten seconds. To pass UL94-V0 the flame must be out in ten seconds or less, no glow beyond thirty seconds and no burning material can fall.

UL94-5V

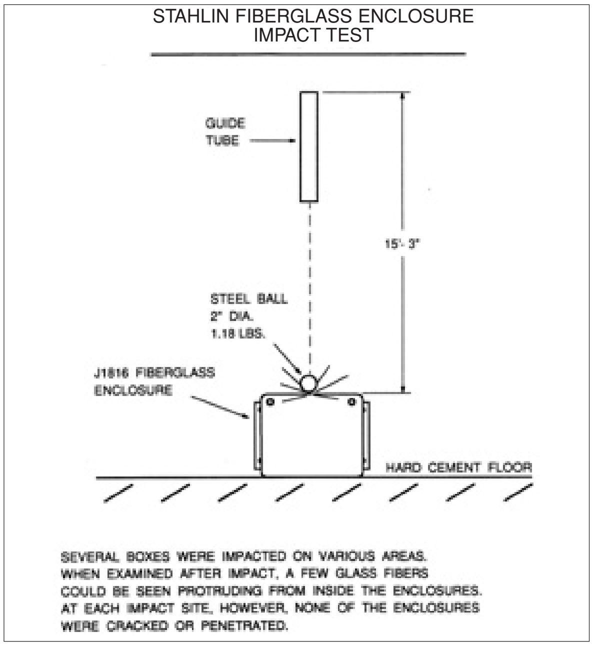
This is a newer and tougher version of UL94 V test. The sample size remains the same, but the flame size increases to five inches from 3/4 of an inch and number of ignitions increases from two to five, but the duration is decreased from ten to five seconds. To pass UL94-5VA the flame must be out in sixty seconds or less, no burning material can fall and the flame cannot penetrate through the test sample.

Drilling, Sawing, Cutting and Punching

Installers find fiberglass easy to cut or drill. Ordinary drills, hacksaws, hole saws and punches cut through fiberglass with little effort. In large installations requiring many holes, glass abrasion may cause tools to become dull over time. Carbide tip tools work best for such applications.

Impact Resistance

Stahlin fiberglass enclosures are quite resistant to damage caused by falling tools or flying debris. When tested in accordance with UL Standard 746C, Section 24, these fiberglass enclosures withstood an impact in excess of 216 pound-inches. The test was performed by dropping a 2" diameter solid steel ball on various areas of the enclosure from a height of 15 ft. The impact force from such a test is comparable to dropping a large wrench from 3 or 4 ft. The durability results from randomly oriented glass reinforcing fibers incorporated in all designs.



Integrity of the enclosure was not compromised

Technical Information
Enclosure Security

Safety

Enclosures may contain the controls or elements of a control system which are crucial to the safety of many people. Control enclosures in large chemical plants, electrical generating facilities, airports, mass transit systems or hospitals can house equipment critical to the well being of numerous individuals. In these and many other applications, rigorous security requirements are designed to protect the public and prevent unauthorized or accidental operation of control equipment.

Location

If the enclosure will be installed in a fenced area, within a building or in other secure areas, the security requirements will be affected. The selection of latches and hinges can be influenced by the location of adjacent equipment or other enclosures.

Appearance

Enclosure appearance can be influenced by both hinges and latches. Some enclosures are designed with hidden hinges and quarter turn latches to make these features less prominent.

Hinges & Latches

Access frequency – daily or annually can be an important factor in specifying the type of latches. Will the location or any specifications require a tool for opening, will it require a padlock are other considerations for latches. In many cases when the enclosure is selected the hinge type is automatically selected because the hinge is an integral part of the enclosure. For some enclosures it is possible to select the hinge or hinge less options available.

Monetary Loss

In some applications the monetary value of the equipment in an enclosure may be sufficient to justify additional security costs. In most applications, the economic consequences of unauthorized or accidental operation of a control system will be more significant than the value of the equipment.

Myth: It is much easier for vandals to get into a non-metallic enclosure vs. a metal enclosure.

Truth: An individual can simply break the lock, NOT the box, no matter the material. Various hinge and latch combinations are available to secure the contents of an enclosure. Although the security requirements will be unique for each application, the selection process should include at least the following considerations.

Overview

Electrical and electronic components are continually being reduced in size allowing designers to place more equipment in a smaller space. This concentration of equipment generates higher internal temperatures and makes heat dissipation very important. Overheating causes electrical insulation to deteriorate and shortens the life of electrical and electronic components. As a rule of thumb, for every 18°F (10°C) above room temperature (72°F or 22°C) an electronic device operates, its life expectancy is reduced by 50%

Enclosure Materials

The following information applies to gasketed and unventilated enclosures. Exterior surface finishes significantly influence temperature rise. Fiberglass and painted steel enclosures dissipate heat better than unfinished aluminum or stainless steel enclosures because the fiberglass and painted steel surfaces are more efficient thermal radiators than the unfinished surfaces. In outdoor applications light colored enclosures such as white have a high reflectance which minimizes solar heat gain compared to dark colored enclosures.

Enclosure Surface Area

The total surface area of the enclosure directly influences heat dissipation. The larger the total surface area the lower the temperature rise will be.
To calculate the total internal surface area in sqft use the following equation:

Surface Area = 2[(AxB)+(A*C)+(BxC)] / 144 where the specific enclosure inside dimensions are A x B x C.

This equation uses all six (6) sides of an enclosure. If any particular side is not available for transferring heat (example the back is mounted against a cement wall) that surface area should be subtracted from the total surface area available.
Also note, enclosure volume cannot be substituted for enclosure area.

Enclosure Heat Input

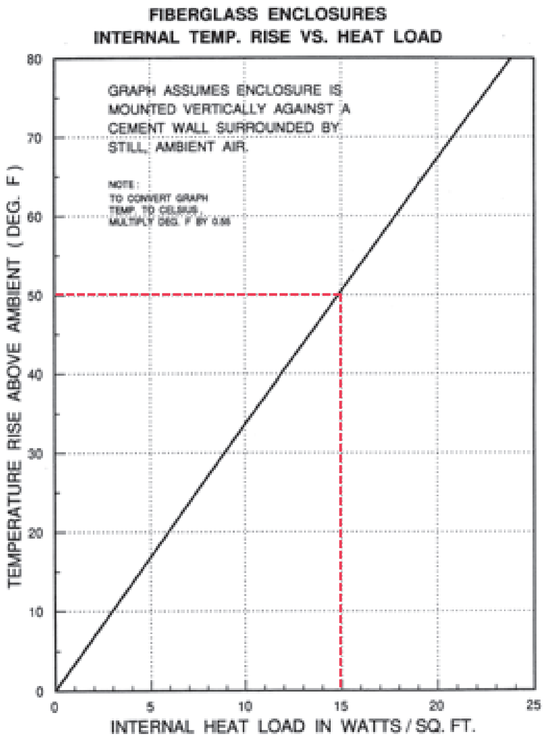
The heat generated in an enclosure varies and depends on the equipment mounted in the enclosure and the application. In order to calculate Temperature Rise, this heat input or power input must be known. This information can be obtained from the component manufacturers of components to be installed in the the enclosure.

Enclosure Temperature Rise (ΔT)

Enclosure temperature rise is the temperature difference between the air inside a non-ventilated or cooled enclosure and the ambient air outside the enclosure. The enclosure temperature rise is independent of the ambient temperature; it is dependent on the heat generated within the enclosure and the actions taken to dissipate that heat. To establish the maximum service temperature, the temperature rise value from the graph in Figure 1, must be added to the maximum ambient temperature surrounding the enclosure.

Example:
Max ambient T = 130°F
Internal Heat Load = 15 watts/sqft or 50°F estimated from Figure 1
Calculated Maximum Service Temperature =
(130°F + 50°F) = 180°F

Figure 1. Internal Temperature Rise vs. Heat Load



The temperature graph was developed through empirical testing using several enclosures of various sizes. The temperatures represent an average of one temperature measurement near the bottom of the enclosure and a second measurement near the top. Electric heaters mounted equidistant from the internal surfaces of the enclosure were used as the heat source. Because hot air rises, a significant temperature gradient occurred from top to bottom. Typical of an actual installation, the top was much hotter than the bottom.

Technical Information

Table 1. Approximate Enclosure Internal Surface Areas for Popular Enclosure Sizes

Fiberglass Enclosures					
Cat. No.	**Internal Area Sq. Ft.**	**Cat. No.**	**Internal Area Sq. Ft.**	**Cat. No.**	**Internal Area Sq. Ft.**
N16107	5.37	N30247	17.08	J1407	3.27
N20166	7.98	N302410	19.53	J1412	4.24
N20168	8.98	N302412	20.95	J1614	5.36
N201610	9.97	N302414	22.50	J1816	7.77
N201612	10.98	N302416	24.06	J2016	9.39
N201616	12.82	N36308	24.82	CL707	1.51
N24126	8.04	N363012	28.60	CL907	1.81
N241210	10.09	N363016	32.41	CL1109	2.82
N242410	15.72	N483612	39.87	CL1311	3.89
N30208	14.78	N483616	44.57	CL1513	5.11
N302010	16.17	J606	1.16	C2016	8.98
N302012	17.56	J806	1.45	C2412	10.09
N302014	18.95	J1008	2.01	C2424	15.72
		J1210	3.09	C3024	19.53
				C3630	26.71

Influences of Heat Transfer

Convection and thermal radiation are used most often to dissipate heat from enclosures. Because fiberglass is used as a thermal insulator, a common misconception exists that fiberglass enclosures operate at significantly higher temperatures than metal enclosures. To the contrary, performance data reflect that enclosure material has little influence on the operating temperature and confirm that non-metallic and painted metallic enclosure function at nearly the same temperature with the same internal heat load. Based on these observations material thermal conductivity is not a major factor in determining heat transfer for an enclosure.

Even though the thermal conductivity of the composite plastic is much less than aluminum or steel, the heat transfer characteristic of fiberglass and metal enclosures are similar. Other factors such as the high thermal insulation of air contained within the enclosure along with the finish, color and total surface area of the enclosure have more influence on heat transfer than thermal conductivity. In general the finish and color of an enclosure most affect the heat transfer capability, In-door and in out-door applications.

Thermal conductivity is commonly measured in BTU/hr/ft²/°F/in, the K Value. K units represent the quantity of heat, which can pass through one square foot of material in one hour for every °F in temperature difference across one inch of material thickness. Larger K values indicate better heat conductivity. The K value for fiberglass is 1.68; the K value for steel is 334; and the K value for aluminum is 1050.

The heat transfer factor (Q) is measured in BTU/hr/ft2/°F or watts/ft²/°F. For the analysis in this section the Q value used for steel enclosures is 1.25 BTU/hr/ ft²/°F (0.37 watts/ft²/°F); for fiberglass enclosures the Q value is 0.62 BTU/hr/ft²/°F (0.2 watts/ft²/°F). The Q value for sheet metal enclosures will vary between 1 BTU/hr/ft²/°F (0.29 watts/ft²/°F) and 5 BTU/hr/ft²/°F (1.46 watts/ft²/°F), depending on the amount of enclosure insulation.

Air as an Insulator

If metals have much better thermal conductivity, why does equipment in a fiberglass enclosure operate at nearly the same temperature as in metal enclosures? The air confined within the enclosure has a K value of 0.017, almost 100 times less than fiberglass. The thermal resistance of the air and the enclosure wall material are in series and must be added. Because air is a superior thermal insulator compared to either fiberglass or steel, it is a predominant factor in establishing heat dissipation. This helps explain why equipment operates at the same temperature regardless of which enclosure material is used and also why environmental control systems heat or cool the air to control the internal temperature.

Surface Area as a Factor

Another factor, which directly influences heat dissipation, is surface area. If the enclosure surface area is doubled with a given internal heating load, the temperature rise will only be half as great. It is important to remember that surface area is not necessarily related to enclosure volume, i.e., an enclosure having twice the surface area does not always have twice the volume.

Other Related Issues

Certain applications may require the walls of an enclosure to act as a heat sink. For example, it is not uncommon to locate a high power semiconductor on the wall of a metal enclosure to dissipate heat. Fiberglass will not perform this function efficiently because the compression-molded walls have negligible thermal conductivity. In this application conduction is used to dissipate the heat and a fiberglass enclosure will not function the same as a metal enclosure.

Calculating Temperature Rise

Enclosure temperature rise can be approximated using the following steps and calclulations:

1. Calculate the internal surface area
   a. (some common enclosure sizes and areas are already calculated and can be found in Table 1.
   b. Using the Enclosure Surface Area formula on page 173
2. Determine the Input Power by dividing the expected heat load by the internal surface area
3. Then using Figure 1, estimate the temperature rise by finding where the Internal Heat Load value intersects the line and reading the approximate temperature rise on the left vertical axis of the graph.
   Note these are approximations, safety factors should be considered to minimize uncertainties.

Example

A J1816 enclosure contains a device that generates 120 watts, calculate the internal temperature rise.

Solution

1. Surface Area = 7.77sqft from Table 1 (alternate method for any size use calculation on page 357 for Internal Surface Area)
2. Internal Heat Load = 120 watts / 7.77 sqft = 15.44 Watts/sqft
3. Using Figure 1, Input Power of 15.44 intersects the diagonal line corresponds to a temperature rise of 51`F above ambient.

Additional Cooling Methods

When it has been determined that the heat load is too large for an enclosure to dissipate by radiation and convection, the following supplemental cooling methods are available:

Breather Vents and Louver Vents

Breather Vents and Louver Vents are designed to remove heat from the enclosure by allowing natural air circulation around the heat source and ex-hausting the hot air through slots or louvers. This method is relatively inexpensive and has no operating cost; however, it can only be used to dissipate a limited amount of heat and it is difficult to predict the temperature drop produced by a vent utilizing natural convection.

Circulating Fans

In larger sealed enclosures a fan can be used to circulate the air and reduce localized heat concentrations; however, the applications are limited because a closed system fan only redistributes heat, it does not dissipate the heat generated by the hot spot.

Where an enclosure does not need to be sealed from the outside environment, fans can be used to circulate air through an enclosure and dissipate the heat generated by power supplies, transformers and other heat producing equipment. Fans can provide as much as 10 times the heat transfer rate of natural convection a radiation. Once the heat input in watts/ft2 is determined and temperature rise is established from Figure 1, the following equation can be used to calculate the fan flow rate:

Fan Flow Rate (CFM) = 3.17 x Internal Heat Load (watts)/Temperature Rise

Example
Equipment in an N363012 enclosure generates sufficient heat to require a fan, which will dissipate 300 watts. The maximum ambient temperature in the application environment is 115°F. If the temperature of the other contents in the enclosure cannot exceed 125°F, what size is required?
The allowable temperature rise is 125°F - 115°F = 10°F.
The application requires dissipation of 300 watts.

Solution
To determine the cubic feet per minute (CFM) required in a standard application, use the following equation (if the air density is significantly more that 0.075 lb. per cubic foot, a non-standard application exists and this equation should not be used):

Fan Flow Rate (CFM) = 3.17 x 300 watts/10°F
Fan Flow Rate (CFM) = 95 CFM

This calculation is exact, but adding an additional 25% capacity to the CFM level is standard to provide a safety factor.

1.25 x Fan Flow Rate (CFM) = 1.25 x 95 CFM = 119 CFM

If the air density is non-standard (significantly more than 1.075 lb. per cubic foot), the following equation can be used to calculate the fan capacity:

Fan Flow Rate (CFM) x 0.075 lb. per cubic foot / Non-standard Air Density (lb. per cubic foot)

Fans can be used to draw air through an enclosure insert, exhaust hot air from an enclosure or to draw cool air into an enclosure. An inlet fan offers the following advantages:

- Raises the internal pressure, which helps keep dust and dirt out of an unsealed or frequently open enclosure.
- More turbulent airflow improves heat transfer.
- Longer fan life with cooler incoming air.

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The following considerations are important in locating a fan:

- Avoid placing transformers, power supplies or other heat generating devices in front of the fan. Although this cools the device, it increases the heat load on other devices within the enclosure. It is best to place these devices near the exhaust outlet.
- To achieve maximum cooling, the inlet and outlet should be separated by the maximum distance. If the outlet and inlet are adjacent to each other, the hot outlet air will be drawn into the inlet and cooling efficiency will be reduced. In general the inlet should be at the bottom of the enclosure and the outlet at the top.
- Fans should not be used or located in areas where the airflow is restricted. A plenum is recommended to accelerate air velocity and improve fan performance. A plenum is particularly helpful when a filter is used where airborne contaminants are a problem.
- The air outlet area should at least equal the inlet area. For best results the exhaust opening should be 1.5 times the area of the fan opening.
- Air is less dense at high altitudes. For this reason airflow should be increased in high altitude applications.
- All fans used in parallel should be identical.

Heat Exchangers - Cooling

Heat exchangers are a good option when precise control of heat and humidity are not required and the heat transfer requirements are significant. The required heat exchanger capacity can be calculated using the formula,

Heat Exchanger Capacity (watts/°F)	=	Internal Heat Load/ΔT + 0.22 x Enclosure Surface Area, Where ΔT = Temperature Rise.

Example

If the internal heat load is 1000 watts in an N603616 Fiberglass enclosure, what is the minimum cooling capacity for the heat exchanger unit? The Maximum ambient temperature is 130°F and the internal equipment will malfunction if the internal enclosure temperature exceeds 105°F.

Solution

Internal Heat Load = 1000 watts
Maximum Temperature Differential = T_i - T_o =105°F-130°F = -25°F = [25°F], use Absolute Value.
Enclosure Surface Area = 53.49 ft^2

Heat Exchanger Capacity =
1000 watts/(25°F) - 0.22 x 53.49 ft^2 = 28.23 watts/°F

In this example the surface area acts to cool the enclosure and is subtracted, the Absolute Temperature Value is used because this is a temperature difference.

Air Conditioning-Cooling

Air conditioning will be required in high ambient temperature locations where precise temperature control and humidity reductions are required in a sealed enclosure. Air conditioning can also be required where neither convection, thermal radiation, louvers, slots nor a circulating fan system provide adequate cooling. Because air conditioners remove moisture from the enclosure, a condensate drain is generally required.

The four-step process to size and select the air conditioner is influenced by the internal heat load, enclosure size and the application environment. The following information is required:

Step 1. Determine the Internal Heat Load

Heat generated by all sources within the enclosure shall be added together to establish the internal heat load in watts. The heat load in watts may be multiplied by 3.413 to convert to BTU/hr.

Internal Heat Load =________________ watts X 3.413 =_______________ BTU/hr.

Step 2. Calculate the Surface Area of the Enclosure

For an enclosure size not shown in Table 1, the surface area can be calculated by using this formula.

SURFACE AREA = [2(AxB)+2(AxC)+2(BxC)]/144 IN² = AREA IN SQUARE FEET

If the enclosure is mounted on a wall or against another enclosure, the surface area calculation may be modified as identified in
Table 2.

Step 3. Establish the Temperature Differential

The temperature differential (ΔT) is calculated by subtracting the maximum allowable temperature inside the enclosure (T_i) from the maximum ambient temperature outside the enclosure (T_o).

$T_o - T_i = \Delta T =$ _______°F

Step 4. Calculating the Required Air Conditioning Capacity

The values determined in the first three steps are used to calculate the required capacity of the air conditioner according to the following formula,

Cooling Capacity (BTU/hr) = Surface Area x ΔT x Q + Internal Heat Load, where Q = 0.62 BTU/hr/ft²/°F (0.2 watts/hr/ft²/°F) for fiberglass enclosures.

Example
If the internal heat load is 500 watts in an N20168 fiberglass enclosure, which is wall mounted, what is the cooling capacity required for the air conditioning unit? The maximum ambient temperature is 125°F and the internal equipment will malfunction if the internal enclosure temperature exceeds 110°F.

Step 1: Internal Heat Load = 500 watts = 3.413 x 500 watts
= 1707 BTU/hr

Step 2: From Table 1, Total Surface Area = 8.98 ft°

Step 3: Temperature Difference:
$T = T_o - T_i$ = 125°F - 110°F = 15°F

Step 4: Air Conditioner Capacity
8.98 ft² x 15°F x 0.62 BTU/hr/fr²/°F + 1707 BTU/hr
= 1790.5 BTU/hr

8.98 ft² x 15°F x 0.2 watts/ft² +500 watts
= 526.9 watts

Air Conditioning - Heating

Some enclosure systems have minimum as well as maximum operating temperature limitations. When the equipment in an enclosure must be maintained above a minimum temperature at low ambience, these same equations can be modified and used to calculate the supplemental heat required to select and size the heaters. The only differences are that the internal heat load will help heat the enclosure and the temperature difference, ΔT, is calculated by subtracting the minimum ambient temperature (T_o) outside the enclosure from the required temperature (T_i) inside the enclosure. The minimum supplementary heat can be calculated according to one of the following equations:

$\Delta T = T_o - T_i$

Supplementary Heat = [Surface Area x (ΔT - 1)] /4.1
or = Surface Area x ΔT x Q
where Q = 0.2 watts/ft² °F

<u>Example</u>

If the internal heat load in 100 watts in an N20168 Fiberglass enclosure, which is wall mounted, what is the minimum heating capacity for the heating elements? The minimum ambient temperature is 0°F and the internal equipment will malfunction if the internal enclosure temperature drops below 40°F.

$\Delta T = T_o - T_i = 40°F - 0°F = 40°F$

Supplementary

Heat = [8.98 ft^2 x (40°F -1)] /4.1 = 85.4 watts

- or -

8.98 ft^2 x 40°F x 0.2 watts/ft^2 °F = 71.84 watts

Two Commonly used, but different, equations shown above have been used to show the effect of using different heat transfer values.

In addition to heating, supplementary heaters are often used in enclosures to keep the internal enclosure ambient temperature a few degrees above the ambient temperature to prevent condensation on internal equipment.

TABLE 2. CALCULATION OF ENCLOSURE SURFACE AREA DEPENDING ON LOCATION

Enclosure Configuration	Position	Formula for Surface Area	Surface Area of N20168
Single Enclosure, Free Standing	■	[2(AxB) + 2(AxC) + 2(BxC)]/144	8.98 ft^2
Single Enclosure, Free Standing*	■	[1.8(AxB) + 1.8(AxC) + 1.4(BxC)]/144	7.66 ft^2
Single Enclosure, Against a Wall	//////// ■	[1.4(BxA) + 1.4(BxC) + 1.8(CxA)]/144	6.78 ft^2
Side by Side Enclosures; First or Last Enclosure in Bank of Enclosures	■ □ □	[1.4(CxA) + 1.4(BxC) + 1.8(BxA)]/144	7.16 ft^2
Side by Side Enclosures; First or Last Enclosure in Bank of Enclosures Against Wall	//////// ■ □ □	[1.4(AxB) + 1.4(AxC) + 1.4(BxC)]/144	6.28 ft^2
Side by Side Enclosures Not at the End of Enclosure Bank	□ ■ □	[1.8(AxB) + 1.4(BxC) + (AxC)]/144	6.65 ft^2
Side by Side Enclosures within an Enclosure Bank, Bank Against a Wall	//////// □ ■ □	[1.4(AxB) + 1.4(BxC) + (AxC)]/144	5.77 ft^2
Side by Side Enclosures within an Enclosure Bank, Bank Against a Wall & Roof Above	//////// □ ■ □ □	[1.4(BxA) + 0.7(BxC) + (CxA)]/144	5.05 ft^2

*Depending on the enclosure design, the complete surface area may not be exposed for cooling. This formula and the remaining ones are conservative and account for such differences.

The requirements and standards for enclosure electromagnetic compatibility are continually increasing with the proliferation of electronics for industrial process control, information processing, and communication equipment. In the United States the Federal Communications Commission establishes the requirements and regulates the amount of electromagnetic interference, (EMI). Since January 1, 1996 the European Union (EU) has enforced legislation, Electromagnetic Compatibility (EMC) Directive 89/336/EEC, which regulates the amount of EMI and Radio Frequency Interference (RFI) that products can emit or must repel to function acceptably.

While the enclosure itself is not covered by these requirements, once the electronic equipment is installed within the enclosure, the package must comply with applicable EMI/RFI directives. Shielding and electromagnetic compatibility are highly specialized with their own terminology. The following definitions will help to specify EMI/RFI compatibility and select enclosures if the acronyms and technology are unfamiliar:

Attenuation A measure of the ability to contain or repel EMI/RFI energy. It can also be called shielding effectiveness and is usually expressed in decibels (dB).

Decibel (dB) Unit to express the effectiveness of a material or system in reducing electromagnetic interference. If a shielded enclosure reduces the EMI by 30 dB, the power of the interfering wave will be reduced by a factor of 1000 in passing through the enclosure. If the EMI reduction is 40 dB, the power is reduced by a factor of 10,000. The equation for calculating attenuation in decibels is $dB = 10 \log_{10} (P1/P2)$ where P1 = power of the interference wave before it passes through the enclosure, P2 = power of the wave after it has been reduced (attenuated) by the enclosure.

Electromagnetic Emission Electrical energy radiated into the environment intentionally by an antenna or incidentally by an electronic component or power equipment during a switching operation.

Electromagnetic Field Invisible fields which surround energized conductors such as wires and antennas. A field has both electric and magnetic components.

Electromagnetic Immunity The capability of an electronic component or electrical equipment to perform its intended function in the presence of external electromagnetic fields.

EMI (ElectroMagnetic Interference) Randomly radiated electrical energy which can emanate from high voltage equipment or power lines, welding equipment, switches, relays, spark plugs, or any device that generates an electric spark or corona. The random voltages or currents generated by these sources are coupled to electronic systems with undesirable results. EMI waves are not well ordered, vary widely in intensity, and cause interference over a wide frequency range. The sun is a natural generator of EMI.

EMC (ElectroMagnetic Compatibility) The ability of electronic equipment to perform its intended function in the presence of EMI and RFI disturbances without affecting proper operation.

EMP (ElectroMagnetic Pulse) Interference caused by a large and sudden electrical discharge such as lightning. EMP is short in duration but can radiate intense power. Like EMI, EMP is not well ordered and causes interference over a wide range of frequencies.

Ohms per Square A measurement unit for electrical continuity of the metal coating applied internally to fiberglass enclosures for EMI/RFI shielding. Although the coating thickness influences shielding to some extent, the electrical continuity is much more important. The conductive coating on Stahlin Enclosures typically measures less than 2 ohms per square. The surface resistance (or conductivity) measurement is without units because the surface area does not influence the reading, i.e., measurements taken on a large sheet of conductive material will yield the same result over 1sq in, 1 sq. ft, 1 sq. yd., or 1 sq. meter.

RFI (Radio Frequency Interference) Interference caused by radio waves which emanate from commercial radio and television stations, amateur radio broadcasts, radar, microwave ovens, etc. Radio waves are usually well defined in terms of amplitude and frequency.

Military specification, MIL-STD-285, is used to test the shielding effectiveness of Stahlin Enclosures. The procedure involves placing a transmitting antenna within the enclosure and a receiving antenna outside the enclosure. Measurements are then made alternately with the enclosure door/cover open and closed. The difference between the open and closed measurements expressed in dB is the shielding effectiveness. Measurements are usually made at 10 frequency points ranging from 0.01 to 1000 MHz.

Depending on the enclosure design and frequency of the EMI/RFI, the attenuation of a standard Stahlin non-metallic enclosure without modification will vary between 0 and 20 dB.

Fiberglass enclosures interior surfaces can be coated with a highly conductive nickel coating that provides excellent EMI/RFI shielding. The coating has been tested by an independent test laboratory and provides an average attenuation of 60 dB over the frequency range from 0.01 to 10000 MHz.

The fiberglass coating description and properties are provided in the following table:

COATING DESCRIPTION AND PROPERTIES	
Shielding Material	Nickel
Binder	Acrylic
Pencil Hardness	> 9 H
Sheet Resistance	< 2.5 Ohm/Square
Attenuation	60 - 65 dB

What is Torque?

Torque is the tendency of a force to rotate an object about an axis. Just as a force is a push or pull, a torque can be thought of as a twist. Loosely speaking, torque is a measure of the turning force on an object such as a bolt. The unit of measure is generally expressed in foot pounds or inch pounds

The formula for torque is:
$\tau = r \times F$
where:
τ is the torque
r = the length of the lever arm
F = the force

Properly fastened threaded products achieve their holding power from the tension (or torque) that is derived from the mating of the external and internal threads subject to the elastic limit of the material.

What torque to apply is a generally asked question, but the answer depends on the variables of material, threads' class of fit, method of thread manufacture, and thread lubrication - if any.

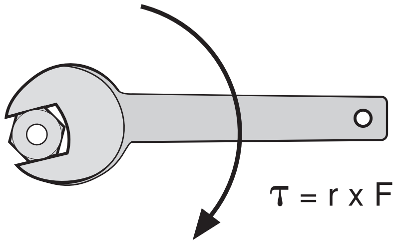
Table 3 is offered as the suggested maximum torque values for threaded products. The table is only a guide. Actual tests were conducted on dry, or near dry, products. Mating parts were wiped clean.

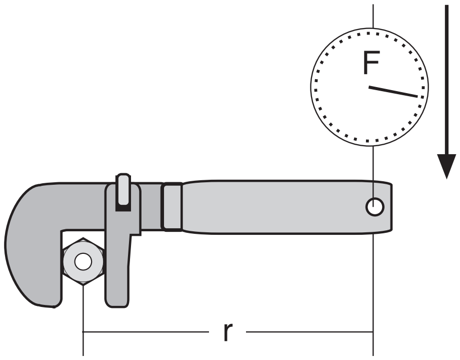
Table 3 – Strength Characteristics

Bolt Size	18-8 SS	Brass	Silicon Bronze	Aluminum 2024-T4	316 SS	Monel	Nylon*
	In. Lbs.	In. Lbs.	In. Lbs.	In. Lbs.	In. Lbs.	In. Lbs.	In. Lbs.
2-56	2.5	2.0	2.3	1.4	2.6	2.5	.44
2-64	3.0	2.5	8.0	1.7	3.2	3.1	
3-48	3.9	3.2	3.6	2.1	4.0	4.0	
3-56	4.4	3.6	4.1	2.4	4.6	4.5	
4-40	5.2	4.3	4.8	2.9	5.5	5.3	1.19
4-48	6.6	5.4	6.1	3.6	6.9	6.7	
5-40	7.7	6.3	7.1	4.2	8.1	7.8	
5-44	9.4	7.7	8.7	5.1	9.8	9.6	
6-32	9.6	7.9	8.9	5.3	10.1	9.8	2.14
6-40	12.1	9.9	11.2	6.6	12.7	12.3	
8-32	19.8	16.2	18.4	10.8	20.7	20.2	4.3
8-36	22.0	18.0	20.4	12.0	23.0	22.4	
10-24	22.8	18.6	21.2	13.8	23.8	25.9	6.61
10-32	31.7	25.9	29.3	19.2	33.1	34.9	8.2
1/4"-20	75.2	61.5	68.8	45.6	78.8	85.3	16.0
1/4"-28	94.0	77.0	87.0	57.0	99.0	106.0	20.8
5/16"-18	132	107	123	80	138	149	34.9
5/16"-24	142	116	131	86	147	160	
3/8"-16	236	192	219	143	247	266	
3/8"-24	259	212	240	157	271	294	
7/16"-14	376	317	349	228	393	427	
7/16"-20	400	327	371	242	418	451	
1/2"-13	517	422	480	313	542	584	
1/2"-20	541	443	502	328	565	613	
9/16"-12	682	558	632	413	713	774	
9/16"-18	752	615	397	456	787	855	
5/8"-11	1110	907	1030	715	1160	1330	
5/8"-18	1244	1016	1154	798	1301	1482	
3/4"-10	1530	1249	1416	980	1582	1832	
3/4"-16	1490	1220	1382	958	1558	1790	
7/8"-9	2328	1905	2140	1495	2430	2775	
7/8"-14	2318	1895	2130	1490	2420	2755	
1"-8	3440	2815	3185	2205	3595	4130	
1"-14	3110	2545	2885	1995	3250	3730	
	Ft. -Lbs.	Ft. -Lbs.	Ft. -Lbs.	Ft. -Lbs.	Ft. -Lbs.	Ft. -Lbs.	
1-1/8"-7	413	337	383	265	432	499	
1-1/8"-12	390	318	361	251	408	470	
1-1/4"-7	523	428	485	336	546	627	
1-1/4"-12	480	394	447	308	504	575	
1-1/2"-6	888	727	822	570	930	1064	
1-1/2"-12	703	575	651	450	732	840	

*Nylon figures are breading torque, all others represent safe working torque.
The 3/8" diameter and under metal products were roll-threaded and, where size range permitted, were made on automatic bolt making equipment.

Torque Formula Illustrations

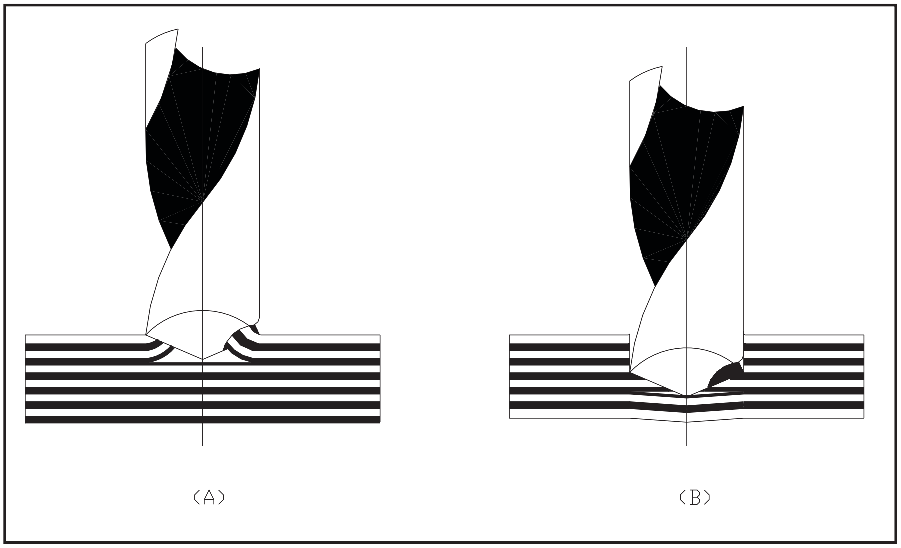




Methods For Making Holes And Cutouts In Non-Metallic Enclosures

Drilling of composite fiberglass material has been difficult and, for some, a mystery. The ability to accurately drill holes in composite fiberglass material has been the subject matter of numerous articles and how to demonstrations. There are several types of machining operations that can be performed on composites such as turning, drilling, routing, trimming, sanding, and milling. Most of these operations are similar to metal removal techniques but there are some differences that need to be addressed in order to make clean, high quality holes and cutouts in composites.

Delaminating of the outer surface and glass fibers directly below the surface are the main failure modes noticed when holes or cutouts are drilled or cutout improperly. Most times excessive edge chipping around the perimeter of the cutout or hole is due to improper tools used and methods applied. Other times excessive fiber pulls or attached fibers not sheared off during the cutting or turning process can also cause delamination failure from the tearing action during material removal. Improper tools used and/or methods are also a culprit of this failure mode. All these can lead to downstream assembly problems, functionality problems, and become aesthetically unappealing if taken to the extreme.



The most common source of failure mode when making holes in an enclosure is a dull cutting tool. Dull tools tend to rip or tear the material rather than cutting or shearing the material and glass fibers. The main culprit for tools becoming dull is glass fibers embedded in the material. These glass fibers are very abrasive and can cause a tool to become dull very quickly. A little planning and understanding of the proper methods to machining composites up front can make all the difference in the final outcome of the operation.
Figure A shows delamination of the surface of the part at the drill entrance.
Figure B shows similar delamination just prior to drill exit.

(Continued on the following pages)

1. Hole Saw. The easiest and least complex method to provide an opening in a composite enclosure is to use a fine-toothed hole saw. You must first layout the size and location of the cutout, pre-drill a small hole in the center within the cutout area for the hole saw to start, and then carefully cut out the area to be removed. This is more time consuming and the least accurate method but can be accomplished in almost any environment. Keeping the saw perpendicular to the cutting surface, maintaining a consistent sawing action, and using a diamond/carbide impregnated saw or fine toothed saw will provide the highest quality cutout with minimal edge chipping.

2. Drilling, Boring. Putting round holes in enclosure walls or thru the enclosure door is the most common type of cutout. A recommended tool would be a carbide tipped or PCD diamond tipped hole saw or twist drill bit that will maintain a sharp cutting edge. HSS tools will also work but they will become dull very quickly resulting in excessive edge chipping and a poor looking hole. We also recommend using high RPM's and low feed rates when using drills. This reduces the chipping around the cutout. The single most important factor though is keeping a very sharp tool.

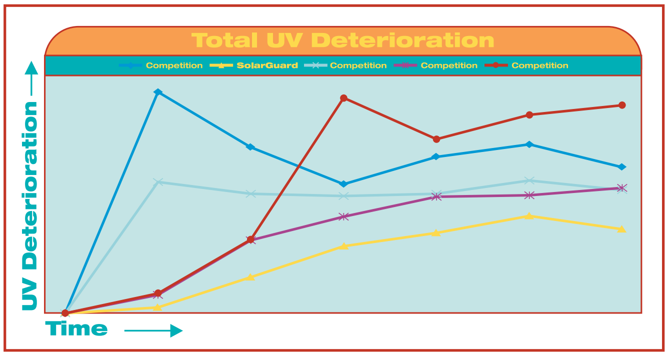
Using a drill with a positive rake angle and thin points or split points can help reduce cutting pressure and thus delamination at both entrance and exit. Feed rates must also be constant and may even be reduced upon exiting from a hole to reduce flexing of the part when the drill exits. Using a solid back surface to support the part when drilling can also aid in reducing delamination and chipping.

3. Routing. A third method is to use a router bit and router. This method produces very clean holes and cutouts but also requires the holes and cutouts to be manually laid out beforehand and a steady hand to stay within the layout lines. The use of a jig or fixture to help guide the handheld router or the use of CNC machining centers is helpful to keep straight edges and clean cutouts. The use of diamond impregnated router bits is preferred for longevity but carbide bits will work just as well.

4. Punching. A fourth method is to use a standard hole punch similar to what you would use with metal boxes. This produces a good clean hole but can leave chipped edges if the punch is dull. Again maintaining sharp tools is essential to producing clean cutouts. A pilot hole is required before using a standard hole punch. Manual or hydraulic punch actuators can both be used with composite materials.

A non-haloginated fiberglass system that beats the effects of outdoor exposure plus provides the chemical and flame resistance you've come to expect from Stahlin Fiberglass Enclosures!

SolarGuard™, in extensive comparison testing, outperformed other available SMC formulations by as much as 60% in its ability to retain gloss and color after exposure to concentrated UV light.



SolarGuard™ maintained stability in thickness proving that its physical properties remain very much intact despite EMMAQUA testing that concentrates natural sunlight using 10 highly reflective mirrors to create an intensity level of approximately 8 suns!

SolarGuard™ meets a NFPA No. 101 Class A flame spread index. Fire retardancy, achieved through use of alumina trihydrate fillers, meets UL 94 5V standards.

SolarGuard™ is a non-halogenated system...meaning that it contains no bromine and no antimony, thereby reducing the risk of smoke-borne toxicity.

SolarGuard™ requires less maintenance than paint, wax or gel-coat alternatives used to prolong the life of electrical enclosures in outdoor environments.

How Does SolarGuard™ Do What It Does?

SolarGuard's™ patented double-protection formula was developed in Stahlin's FormRight lab.

Due to its chemical composition and other additives, SolarGuard™ is able to reduce the effects of UV degradation such as surface roughening and fiber blooming.

How does SolarGuard™ achieve this level of performance?

SolarGuard™ features proprietary double-protection formulation technology that significantly enhances the molecular bond strength and crosslinking that occurs during the curing process in thermosetting polyester sheet molding compounds (SMC). Stahlin's SolarGuard™ system fights polymer degradation by making it much more difficult for UV light to attack molecular bonds of both primary chains and crosslinks.

A special UV Absorber is added to the SolarGuard™ formulation which acts to absorb UV energy, then to release it without damaging the polymer chain. The neo-pentyl glycol (NPG) isopthalic based resin system of SolarGuard™ ensures UL 94 5V fire retardancy, but provides a much stronger bond of the polymer chain resulting in significantly improved weathering resistance.

As the standard SMC formulation for all Stahlin fiberglass electrical products, SolarGuard™ provides an unsurpassed level of UV resistance, fire retardancy, chemical resistance and safe, durable performance...all without adding cost to Stahlin's world class electrical enclosures.

How SolarGuard™ Benefits You!
AT A GLANCE: DOUBLE PROTECTION THAT WORKS!

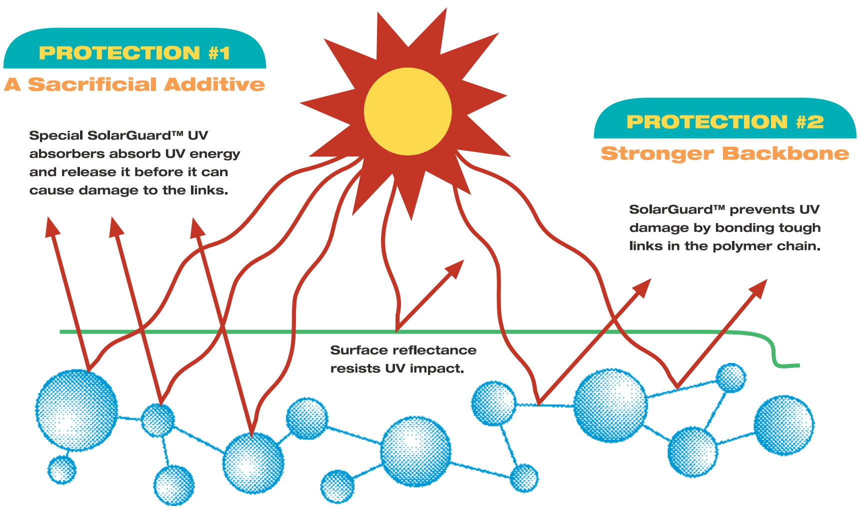
1.) THE SOLARGUARD™ WAY

The SolarGuard™ formulation is a neo-pentyl glycol (NPG) isopthalic based resin system that contains no bromine. Therefore, there are no weak links in the polymer chain making the UV energy required to break these links significantly greater. The result? SolarGuard™ SMC material provides much better UV weathering characteristics. Fire retardancy requirements are still achieved and maintained via fillers that meet UL 94 5V standards.

2.) THE SOLARGUARD™ WAY

The special UV absorber is also added into SolarGuard™ and works to absorb UV energy and release it without damaging the polymer chain. This is achieved by absorbing UV energy and emitting the light at a different wavelength and frequency than that of the electrons in the carbon-carbon bonds. This prevents the polymer bonds from breaking apart. This material will also absorb UV energy more readily than the links of the polymer chain thus providing increased protection of the polyester material and increased resistance to the damaging effects of UV radiation.

SOLARGUARD™ DOUBLE PROTECTION



THE SOLARGUARD™ DIFFERENCE

- Between a 32-and-60 % improvement, compared to other SMC formulations, in its ability to retain gloss and color after exposure to concentrated UV light.
- Material thickness remains very stable, demonstrating that the physical properties of SolarGuard™ are still very much intact after rigorous testing.
- Excellent chemical resistance in both exposed vapor and total submersion applications.
- ASTM flame spread testing meets a NFPA No. 101 Class A (I) Flame Spread Index.
- Potential toxic emissions have been eliminated or substantially reduced from elimination of materials such as bromine, tin and antimony. Other acid gasses have been reduced or eliminated along with significant reductions of black smoke when burned. This formulation is considered to be non-haloginated.

A unique SMC system for maximizing polymer chain and crosslink bonding.
Up to 60% more UV-resistant compared with other available formulations.
Meets UL 94 5V Fire-Retardancy Standards plus NFPA No. 101 Class A Flame Spread Index.
Eliminates toxic bromine and antimony.
Available to you at NO additional finished-product cost.

Proof Through Performance

Physical Properties of SolarGuard™

MATERIALS TYPICAL PROPERTIES	TEST METHOD ASTM	SOLARGUARD POLYESTER FIBERGLASS (SMC)
Flexural Strength (psi)	D 790	17K
Notched Izod (ft-lb/in @ 1/8")	D256	11
Impact Resistance (lb-in)	UL 746C	≥216
Compressive Strength (psi)	D 695	20K
Tensile Strength (psi)	D 638	8K
Specific Gravity	D 792	1.71
Flammability	UL 94	V-0 & V-5
Heat Deflection (°F at 264 psi)	D 648	375-500
Service Temperature Range (°F)		-76°F to 274°F (-60°C to 134°C)
K Factor, Thermal Conductivity (BTU/hr/ft/°F²/in)		1.68
Dielectric Strength (VPM)	D 149	380
Arc Resistance (sec)	D 495	190
Water Absorption (% in 24 hr)	D 570	0.10-0.25
Hardness (Barcol-Rockwell M-Shore A)		50-70 Barcol
Shrinkage in/in Minimum		.005

Note: Product comparison data resulting from independent, third-party accelerated testing can be obtained by contacting Stahlin Non-Metallic Enclosures.

SolarGuard™ Flame Spread Classification Per NFPA No 101 ASTM E162 Surface Flammability Of Materials

CLASS	RANGE	TYPE	SOLARGUARD TEST RESULTS
Class A (I)	0 to 25	Flame Spread	Stahlin SolarGuard flame spread index 20.59
Class B (II)	26 to 75	Flame Spread	
Class C (III)	76 to 100	Flame Spread	

SolarGuard™ optical Density Test Result Summary ASTM E662 Specific Optical Density Of Smoke Generated By Solid Material

	NON-FLAMING	FLAMING
Ds @ 1.5 min. (avg)	0.0	0.3
Ds @ 4.0 min. (avg)	0.0	9.9
Dm (corr) (avg)	10.8	181.9

Testing Procedures Used To Ensure That SolarGuard™ Meets Or Exceeds All Relative Industry Standards

- UL 746 C Polymeric Materials Used In Electrical Equipment Evaluations
- UL 50 Enclosures For Electrical Equipment
- UL 508 Industrial Control Panels.

Additional tests have been performed above and beyond these industry guidelines to aid in providing the end user with a premium product for a broad range of uses. These tests were performed using ASTM standards and other government approved procedures. Test standards and evaluation criteria are:

- Chemical resistance testing (submerged and vapor), 37 various chemicals (acids, bases)
- ASTM E162 Flame Spread
- ASTM E662 Smoke Density
- Particulate dust weight (NIOSH 05000), Acid gases HBr, HCl, HNO3, HPO4, H2SO4 (NIOSH 7903), Cyanide (NIOSH 7904), Metals (NIOSH 7300), VOC's with TIC's (EPA TO-14/TO-15), PAH (NIOSH 5506), Carbon Monoxide, Carbon Dioxide, Visual Fiberglass (NIOSH 7400), Ammonia, NO, NO2, HS2.

Additional UV testing has been performed under the following guidelines and evaluation criteria. Exposure testing is performed in Arizona in accordance with ASTM G90-98, Spray Cycle 1 (EMMAQUA, day spray with nighttime wetting).

- ASTM G 147-96 Standard Practice for Conditioning and Handling of Non-Metallic Materials for Natural and Artificial Weathering Test
- ASTM G 90-98 Standard Practice for Performing Accelerated Outdoor Weathering of Non-Metallic Materials Using Concentrated Natural Sunlight
- ASTM D 660-93 Method for Evaluating Degree Checking of Exterior Paints
- ASTM D 2244-93 Test Method for Calculation of Color Difference from Instrumentally Measured Color Coordinates
- ASTM E 308-96 Standard Practice for Computing the Colors of Objects by Using the CIE System
- ASTM D1729-96 Practice for Visual Appraisal of Color and Color Difference of Diffusely-Illuminated Opaque Materials
- ASTM D 661-93 Method for Evaluating Degree of Cracking of Exterior Paints
- SFTS-1 (Wash)) 92-03-30 Method of Cleaning Exposed Specimens Prior to Inspection, Method A, Washed With Deionized Water and Soft Sponge
- ASTM D 523-89 (1999) Test Method for Specular Gloss
- ASTM D 4214-89 Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films, Method D, Transparent Tape Method

UV correlation testing has been performed using accelerated artificial weathering devices. Tests were performed using a QUV A Fluorescent Bulb Weatherometer. The test method utilizes a QUV machine, which consists of 2 banks of 4 fluorescent lights each that emit light in the UV-A (340 nm) wavelength. This UV wavelength simulates normal outdoor sunlight. The second part of the test utilizes water vapor to simulate rain/fog. The exposure cycle consist of alternating 4 hours of UV-A at 65 degree C and 4 hours of 100% relative humidity at 50 degree C. Testing is in accordance with ASTM G154 specifications.