

TUFFAK® A

Polycarbonate Sheet



PHYSICAL PROPERTIES



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INTRODUCTION

Tuffak® A polycarbonate sheet is the basic grade of a high-impact polycarbonate plastic sheet produced by Altuglas International.

Virtually unbreakable, Tuffak A sheet is 300-times stronger than single-strength glass, and significantly tougher than other transparent sheet materials of equal thickness. It's unlikely that Tuffak A sheet will break, shatter or chip when bombarded with thrown missiles such as rocks, bricks or bottles. Nor is it likely that this material will break when hammered, twisted or bent.

At the same time, Tuffak A polycarbonate sheet is light in weight, transmits 85% to 89% light in normal window thicknesses, and has good weatherability. UV-stabilized Tuffak A sheet has good resistance to solar exposure for five to seven years in moderate climate. Such exposure over a wide temperature range does not affect its impact strength.

Tuffak A polycarbonate sheet is supplied in colorless transparent sheet and in solar tints for heat and glare control. The material is available in standard sheet sizes ranging from 24" x 48" to 96" x 96" and 72" x 120", and in thicknesses from .060" to .500".

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LIGHT WEIGHT

Tuffak A sheet is half the weight of glass and 43% lighter than aluminum. Table 2 shows the weight of Tuffak A sheet in various thicknesses.

SAFETY

Amazing strength, light weight and ease of installation make Tuffak A sheet the material of choice for window glazing when vandalism is expected. Tuffak A sheet in normal thicknesses of .093" and greater complies with the requirements of the ANSI Z97.1 Safety Glazing Standard. This material also meets the requirements of Underwriters Laboratories for a burglary-resisting material in .125" (3 mm) or thicker sheet. Tuffak A sheet can be used for safety guards and other industrial plant applications that must meet OSHA requirements.

THERMAL VALUES

Tuffak A polycarbonate sheet has good insulating qualities, which can save heating costs in winter and air conditioning costs in summer. Table 3 gives the U-values for vertical windows glazed with Tuffak A sheet.

THERMAL EXPANSION AND CONTRACTION

Tuffak A sheet is subject to greater dimensional change due to thermal expansion and contraction than other materials with which it is used in construction. Table 4 compares the coefficients of thermal expansion of Tuffak A sheet with other building materials.

DESIGN STRESS LIMIT

Design limits for continuously imposed loads on Tuffak A sheet should not exceed 2,000 psi; for shorter duration, intermittent stresses can be higher. These recommendations are based on normal ambient temperature exposure. Higher temperatures, 125°F and above, require lower working stress values. Tests under use conditions are recommended, if a problem is anticipated.

Tuffak A sheet can be cold formed and secured in a frame. The minimum radius of curvature is $100t$ where t = sheet thickness.

SERVICE TEMPERATURE

The allowable continuous service temperature for Tuffak A polycarbonate sheet is 250°F-270°F in dry air and 140°F in water or 100% RH air.

RIGIDITY

Tuffak A sheet is not as rigid as many other materials used in buildings, although it is more rigid than most other transparent plastic sheet materials. The modulus of elasticity of Tuffak A sheet is 340,000 psi. The material will deflect under high wind loads and foreshorten as a result of the deflection.

CHEMICAL RESISTANCE

Tuffak A polycarbonate sheet has successfully been used in many different environments. Although each application should be investigated separately (because temperature, stress, concentration, time and other agents will affect the results), Tables 6 and 7 will be of use to the designer in selecting applications for Tuffak A polycarbonate sheet.

Various food contact uses for plastics are regulated by the Food and Drug Administration. Consult your Altuglas representative for the status of Tuffak materials for food contact applications.

Tuffak A sheet must be used with an appreciation for the fact that it is a combustible material. It will burn when exposed to flame. The flame/fire precautions that are observed in connection with the handling and use of any ordinary combustible material should be observed when handling, storing or using Tuffak A sheet.

The high impact resistance of Tuffak A sheet requires the use of access panels for evacuation and venting by fire-fighting personnel of rooms glazed with Tuffak A sheet. Consult local fire officials for their requirements.

The fire hazard of uses of Tuffak A sheet can be kept at an acceptable level by complying with building codes and applicable standards, and by observing established principles of fire safety.



TABLE 1: Typical Physical Properties of TUFFAK A Polycarbonate Sheet⁽¹⁾

Property	ASTM method	Units	All grades
Specific Gravity	D-792	-	1.2
Optical			
Refractive Index	D-542	-	1.586
Light Transmittance	D-1003	%	85-91
Haze	D-1003	%	0.5-2.0
Mechanical			
Tensile Strength	D-638	-	-
Ultimate	D-638	psi	9,500
Yield	D-638	psi	8,400
Elongation	D-638	%	100
Tensile Modulus	D-638	psi	340,000
Flexural Strength	D-790	psi	13,500
Flexural Modulus	D-790	psi	340,000
Compressive Strength (0.05"/minute)	D-695	psi	12,500
Impact Strength			
Izod (1/8", notched)	D-256	ft-lbs/ inch of notch	16
Charpy Impact	D-256	ft-lbs/1/2" x 1" section	NB
Rockwell Hardness	D-785	-	R118 M70-78
Shear Strength	D-732	psi	5,800
Thermal			
Heat Deflection Temperature			
Under Load, 264 psi	D-648	°F	275
66 psi	D-648	°F	285
Coefficient of Thermal Expansion	D-696	in/in/°F	3.8 x 10 ⁻⁵
Coefficient of Thermal Conductivity	C-177	BTU/hr/sq ft/ °F/in	1.35
Specific Heat		BTU/lb/°F	0.30
Water Absorption (24 hrs at 73°F)*	D-570	%	0.15
Equilibrium at 73°F (Long term)			0.35
Equilibrium at 212°F (Long term)			0.58
Electrical			
Dielectric Constant	D-149	volts/mil	380 @ 25°C
Test at .125" thick			450 @ 100°C
Dielectric Constant	D-150		
60 Hz			2.9
1,000,000 Hz			2.9
Volume Resistivity at 23°C	D-257	ohm/cm	10 ¹⁶
Miscellaneous			
Flammability	D-635	cm/min	Average Time of Burning: 32 sec Average Extent of Burning: 0.7"
Flammability Classification @ 0.054" minimum ⁽²⁾	UL94		94 HB ⁽³⁾

*Test performed on .125"-thick specimens; all other test specimens were .250" thick.

NOTE: NB = No break.

(1) Values reported are averages and should not be used for specification purposes.

(2) TUFFAK S qualifies @ 0.058" minimum.

(3) For grades XL and CM-2, see applicable bulletins for their classification.

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TABLE 2: Weight of TUFFAK A Sheet

Thickness	Weight/sq ft	Thickness	Weight/sq ft
.118"	0.74 lbs	.375"	2.34 lbs
.177"	1.11 lbs	.500"	3.12 lbs
.236"	1.47 lbs		

TABLE 3: U-Values for Vertical Windows, BTU/Hr/Sq Ft/°F

TUFFAK A Sheet	Winter heat loss ⁽¹⁾				Summer heat gain ⁽²⁾			
Thickness, inches	.118"	.177"	.236"	.375"	.118"	.177"	.236"	.375"
Single-glazed	1.06	1.01	0.96	0.88	0.98	0.93	0.89	0.82

(1) 15 MPH wind velocity.

(2) 7.5 MPH wind velocity.

TABLE 4: Comparison of Coefficient of Thermal Expansion, TUFFAK A Sheet vs. Other Building Materials

Product	In/In/ °F x 10 ⁻⁵
Tuffak A Polycarbonate Sheet	3.80
Aluminum	1.29
Steel	0.63
Plate Glass	0.50

In Table 8 we list the fire response characteristics of Tuffak A sheet in one column and the recommended practices for design, engineering, and fire protection of Tuffak A sheet installations in an adjacent column.

HEALTH AND SAFETY PRECAUTIONS

Heating Tuffak A sheet or any other thermoplastic may result in the release of vapors or gases.

Machining Tuffak A sheet will cause localized heat and may generate some polymer dust.

Processing Tuffak A sheet in areas with adequate ventilation,* in accordance with techniques, processing conditions, and temperatures recommended herein, should not result in harmful concentrations of gases

or vapors. It is always good practice to provide local exhaust ventilation as close to the point of possible generation of vapors as practical.

Any dust produced by the machining of Tuffak A sheet is considered nuisance dust. The American Conference of Governmental Industrial Hygienists' recommended TWA for nuisance dust is 10 mg/m³ — total dust, and 5 mg/m³ — respirable dust.

Worker exposure to dust can be controlled with adequate ventilation, vacuum dust removal at the point of generation or by suitable protective breathing devices.

Solvents, adhesives, sealants and paints often contain volatile components which may be harmful if inhaled for extended periods of time or swallowed. It is recommended that you ventilate to control exposure to the limits in Table 5.

Employees should protect themselves from direct skin or eye contact with the liquids by use of protective equipment such as gloves, aprons and goggles suitable to each material where splashes are possible.

Care must be taken when mixing multicomponent (polymerizable) cements so that the proper order and proportion of each component is used. Deviation from the manufacturer's recommendations may result in a reaction causing an explosion or fire.

Many of the chemicals recommended in this manual are flammable. Most release noxious fumes during heating and must be kept from flames or sources of high heat. There should be no smoking in any area

*Suggestions for design of exhaust ventilation are provided in *Industrial Ventilation — A Manual of Recommended Practice*, published by the American Conference Governmental Industrial Hygienists (1988); and American National Standards Institute, *Fundamentals Governing the Design and Operation of Local Exhaust Systems*, Z9.2-1979.



TABLE 5: Recommended Exposure Limits

Cement & solvents	ACGIH ⁽¹⁾ TWA	Atoglas TWA
Tetrahydrofuran ⁽²⁾	200 ppm	200 ppm
Methylene chloride	50 ppm	50 ppm
Methyl methacrylate (from PS-30)	100 ppm	50 ppm
Isopropyl alcohol	400 ppm	400 ppm

(1) American Conference of Governmental Industrial Hygienists.

(2) On prolonged storage, THF may react to form highly flammable and possibly explosive peroxides.

**TABLE 6: Materials Compatible with
TUFFAK A Polycarbonate Sheet at Room Temperature**

Aluminum chloride	Glazier's putty	Potassium bromide
Aluminum sulphate	Glycerin	Potassium chloride
Ammonium chloride	Glycol	Potassium nitrate
Ammonium nitrate	Grapefruit juice	Potassium perchlorate
Ammonium sulphate	Grapefruit peel	Potassium permanganate
Antimony trichloride	Hydrochloric acid (20%)	Potassium persulphate
Arsenic acid (20%)	Hydrogen peroxide (30%)	Potassium sulphate
Beer	Ink	2-Propanol (isopropanol alcohol)
Borax	Iron chloride	Propargyl alcohol
Butyl alcohol	Iron sulphate	Propionic acid (20%)
Calcium chloride	Isoamyl alcohol	Propyl alcohol
Calcium nitrate	Lactic acid (20%)	Rum
Castor oil	Linseed oil	Salad oil
Cement	Liqueur	Salt solution (10%)
Chlorinated lime paste	Magnesium chloride	Silicone oil
Chlorinated lime solution (2%)	Magnesium sulphate	Silver nitrate
Chocolate	Manganese sulphate	Soap (soft and hard)
Chrome alum	Mercuric chloride	Sodium bicarbonate
Chromic acid (20%)	Milk	Sodium bisulphate
Cinnamon	Mineral heating oil	Sodium bisulphite
Citric acid (40%)	Mineral water	Sodium carbonate
Cocoa	Mustard	Sodium chlorate
Cod liver oil	Nickel sulphate	Sodium chloride
Coffee	Oleic acid	Sodium hypochloride
Cognac	Olive oil	Sodium sulphate
Copper chloride	Onions	Stannous chloride
Copper sulphate	Orange juice	Sulphur
Cuprus chloride	Orange peel	Sulphuric acid (50%)
Decahydronaphthalene	Paraffin oil	Table vinegar
Detergents (nonionic & anionic)	Pentane	Tartaric acid (30%)
Ethyl alcohol (96%)	Pepper	Tincture of iodine (5%)
Fish oil	Petroleum ether	Tomato concentrate
Floor polish	Phosphoric acid (concentrated)	Tomato juice
Formalin (30%)	Potassium aluminum alum	Trichloroacetic acid (20%)
Formic acid (10%)	Potassium bichromate	Vodka
Fruit syrup	Potassium bromate	

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(Continued from Page 3)

in which the solvents, adhesives or paints are stored or used. In case of fire, only dry powder or chemical fog fire extinguishers should be used.

Before using any chemical suggested in this manual (e.g., solvent, paint remover, adhesive, paint, sealant, cleaner, etc.), the user should become familiar with the properties of the product to be used and the precautions necessary for its safe usage. Material Safety Data Sheets should be obtained from the suppliers of these materials.

Copies of the approvals of Tuffak A sheet under various codes will be made available on request.

In addition, reports on the status of Tuffak A sheet under federal government regulations will be provided promptly. Altuglas International code consultants and engineers offer assistance in interpreting the codes for installation of Tuffak A sheet that constitutes justifiable exceptions to existing restrictions. Tuffak A sheet may be classified as a CC-1 light-transmitting thermoplastic under the model building code.

TABLE 7: Materials NOT Recommended for Use with TUFFAK A Polycarbonate Sheet

Acetaldehyde	Cyclohexanone	Methyl salicylate
Acetic acid	Cyclohexene	Nitric acid
Acetic anhydride	Cresol	Nitrobenzene
Acetone	Cutex #510 Nail Polish Remover	Nitrocellulose lacquer
Acrylonitrile	Delco Electrolite	Oakite #117 Cleaner
Ammonia	Dimethyl formamide	Ozone
Ammonium carbonate	Ethane tetrachloride	Phenol
Ammonium fluoride	Ethyl acetate	Phosphorous hydroxy chloride
Ammonium sulphide	Ethylamine	Phosphorous trichloride
Benzene	Ethylene chlorohydrin	Propionic acid
Benzoin acid	Ethylene dichloride	Skydrol
Benzyl alcohol	Ethyl ether	Sodium hydroxide
Bromo benzene	Formic acid (concentrated)	Sodium nitrate
Butyric acid	Freon	Sodium sulphide
Carbolic acid	Freon refrigeration oil	Styrene
Carbon bisulphite	Gasoline	Sulphuric acid (concentrate)
Carbon disulphide	GM Heavy-Duty Brake Fluid	Sulphuryle chloride
Carbon tetrachloride	Hydrazine	Tetrahydronaphthalene
Caustic potash solution	Hydrochloric acid (25%)	Thiophene
Caustic soda solution	Kester Flux #1544	Toluene
Chlorobenzene	Lacquer thinner	Turpentine
Chloroform	Lindane (20%)	Wagner Brake Fluid
Chlorothene	Methyl alcohol	Xylene
Chrysler Brake Fluid	Methylene chloride	



TABLE 8: TUFFAK A Sheet and Fire

Fire response characteristics	Recommended practices
As is inherent in all polycarbonate materials, the ignition temperature of Tuffak A sheet is higher than that of most woods, but it will ignite. When involved in fire, Tuffak products will burn and generate heat and smoke rapidly.	Install Tuffak A sheet away from sources of intense heat or flame. Enclose edges of components made with this material. Observe building code stipulations and restrictions. Do not use a greater quantity of Tuffak sheet than required to perform the functions required of it. Employ fire protection systems — such as sprinklers, fire detectors, and automatic vents — as fire hazard analysis indicates.
Tuffak A sheet softens when heated above 275°F, which is below its self-ignition temperature of 1090°F.	Do not use Tuffak A sheet as supporting elements or in any location where resistance to fire penetration is required.
When burning, Tuffak A sheet will drip.	In overhead lighting, mount Tuffak A sheet in free channel mountings to assure fallout prior to ignition. Extinguish burning Tuffak A sheet with water or fire extinguisher.
When installed as a wall laminated to a substrate, Tuffak A sheet provides a surface over which flame may spread and release heat and gases, contributing to flashover.	Do not install Tuffak A sheet as applied wall or ceiling finish or as a substrate surfacing material for large interior surface areas in building applications unless the areas are protected by an automatic sprinkler system.
Large-area installations of Tuffak A sheet (such as transparent enclosures) are not provided for in building code regulations, because they do not conform to area limitations. Therefore, these installations require special permits based on an analysis of all relevant fire-safety considerations.	Relevant considerations are use of the structure (occupancy), location (exposure), height and area, nature of interior arrangements (decorations, finishes and furnishings), availability and construction of fire exits, need for special fire protection systems such as sprinklers, automatic heat and smoke vents, early warning devices and deluge systems or water curtains.
Burning Tuffak A sheet produces smoke. The concentration of carbon monoxide and/or carbon dioxide released by burning Tuffak A sheet is a factor of the quantity of the Tuffak A sheet involved and the conditions of burning.	The use of Tuffak A sheet may be restricted or prohibited in some locations because of high smoke generation. The use of Tuffak A sheet is not restricted because of the toxicity of its products of decomposition.
Impact resistance of Tuffak A sheet may create entry and venting problems for firemen, as is the case for any polycarbonate sheet.	When possible, install Tuffak A sheet in operable windows. Fire departments and building occupants should be informed of the location of fixed Tuffak A glazing in order to provide for alternative evacuation and venting facilities.

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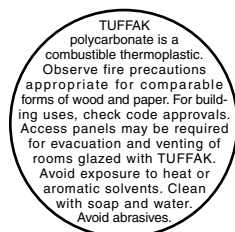
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