# TUFFAK® CM-2

## Abrasion-Resistant Polycarbonate Sheet


# TECHNICAL MANUAL

ALTUGLAS INTERNATIONAL
ARKEMA GROUP


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## INTRODUCTION

*Tuffak® CM-2 is the Altuglas International designation for Tuffak polycarbonate sheet with a durable, clear coating that significantly increases the abrasion resistance of Tuffak sheet in typical exposures such as washing operations, airborne dust and dirt, and non-abusive public contact. In addition, the abrasion-resistant coating significantly increases the weatherability and chemical resistance of Tuffak sheet and has essentially the same physical properties of the Tuffak polycarbonate substrate. The effectiveness of Tuffak CM-2 polycarbonate sheet has been established by laboratory tests and outdoor weathering.*

*Tuffak CM-2 sheets are coated on one or both sides and shipped with a protective masking on both sides. The sheets are supplied in a wide range of standard sizes and thicknesses in both clear and transparent tints.*

*Tuffak CM-2 sheet finds wide use in glazing applications requiring abrasion resistance and weatherability combined with high impact resistance. Typical applications include architectural glazing, glazing for buses, trains and other mass transit vehicles, glazing for off-highway vehicles, and glazing for showcases protecting valuable displays and artifacts.*

# TUFFAK® CM-2 Abrasion-Resistant Polycarbonate Sheet

## PHYSICAL PROPERTIES

### ABRASION RESISTANCE

Tuffak CM-2 sheet meets the abrasion resistance requirements of AS4 and AS5 of Federal Motor Vehicle Safety Standard #205 for glazing. Table 1 shows the results of various abrasion tests. This table illustrates the ability of Tuffak CM-2 polycarbonate sheet to withstand abrasion from typical architectural and rotary brush washing methods.

This coated sheet will not withstand intentional gouging with sharp objects such as keys, screwdrivers or knives, although no delamination of the coating will occur beyond the point of penetration. Once scratched or deeply gouged, the coating cannot be repaired.

### IMPACT STRENGTH

Tuffak CM-2 sheet has the same impact strength as uncoated Tuffak sheet. Normally, Tuffak CM-2 sheet will not break or shatter when struck by thrown missiles such as rocks, bricks, or bottles. Tuffak CM-2 sheet meets the impact strength requirements of ANSI Z97.1 at 0.080" and above, and the CPSC Architectural Glazing Material Safety Standard (16 CFR 1201). In nominal .125" thickness, Tuffak CM-2 polycarbonate sheet meets the requirements for a burglary-resistant glazing material when tested in accordance with Underwriters' Laboratories Standard UL 972. In addition, Tuffak CM-2 sheet can be used for safety guards and other industrial plant applications that must meet OSHA requirements.

### CHEMICAL RESISTANCE

Tuffak CM-2 sheet meets the chemical resistance requirements of Items AS4 and AS5 of Federal Motor Vehicle Safety Standard #205 for glazing. It resists attack from gasoline, kerosene, motor oil, liquid or felt-tip markers, spray paint and many other agents, as illustrated in Table 2. Contact with strong mineral acids, ketones, chlorinated hydrocarbons and aromatics should be avoided, especially along the edges of the sheet or abraded surface areas.

### WEATHERABILITY

Tuffak CM-2 sheet now adds unsurpassed weatherability to the proven breakage resistance of polycarbonate plastic sheet. The weatherability of Tuffak CM-2 sheet has been confirmed by more than 4,000 hours of accelerated weathering tests and many years of actual outdoor weathering in transit glazing applications. Tuffak CM-2 polycarbonate sheet meets the weathering requirements of AS4 and AS5 of Federal Motor Vehicle Safety Standard #205 for glazing and ANSI Z97.1.

### OPTICAL CLARITY

Tuffak CM-2 sheet has the same slightly higher transmittance and similar haze characteristics compared to uncoated Tuffak sheet. Both have adequate optical properties for window glazing applications.

### MECHANICAL/THERMAL

Tuffak CM-2 sheet has the same mechanical and thermal properties as uncoated Tuffak sheet. These properties are given in Table 6.

## CLEANING AND MAINTENANCE

### NORMAL CLEANING

To wash Tuffak CM-2 sheet by hand, use a water solution of mild soap, household liquid detergent or ammonia, or a recommended industrial cleaner from Table 3. Apply with a soft clean cloth, sponge or chamois; rinse well and dry with a soft clean cloth or soft rubber squeegee.

### CLEANING TOUGH DEPOSITS AND GRAFFITI

To remove such deposits as glazing compound, masking paper adhesives, dried egg, paint, ink, and miscellaneous graffiti, follow the recommendations in Table 4. Cleaning with these agents should be followed immediately with a second cleaning using a solution of soap or detergent and water, and rinsing well.

Cleaning agents listed in Table 4 with numbers higher than 6 will attack the polycarbonate substrate through any scratches in the coating; however, they may be used momentarily on a surface with intact coating.


### TABLE 1: Abrasion Resistance

| Property | Typical Values[3] | | |
|---|---|---|---|
| | Test method | TUFFAK CM-2 (coated) sheet | TUFFAK A (uncoated) sheet |
| Eraser Abrasion Rating | (1) | 0 | 5 |
| Taber Abrasion | ASTM D-1044 | | |
| (CS10F Wheel, 500 gms each wheel) | ANSI Z26.1 | | |
| | Test #17 | | |
| Initial, % haze | | <1.0 | 1.0 |
| 100 rev., % haze | | <3.0 | 40.0 |
| Steel Wool Rub Resistance | (2) | | |
| 0000 (superfine) | | None | Heavy |
| 00 (very fine) | | Trace | Heavy |
| 1 (medium) | | Light | Heavy |
| 3 (coarse) | | Moderate | Heavy |

[1] Visual ratings based on a scale of 0 to 5; 0=high abrasion resistance; and 5=poor abrasion resistance, i.e., uncoated polycarbonate abrasion resistance.
[2] Ratings based on visual observation after 5 seconds of vigorous hand rubbing with each grade of steel wool. Ratings: none, trace, very light, light, moderate, heavy.
[3] Not for specification purposes.

Many of the solvents in Table 4 are flammable. They should be used in small quantities with good ventilation. There should be no smoking in areas where the solvents are stored or used. Employees should be protected from direct skin or eye contact with the liquids by use of protective equipment, such as impervious gloves, aprons and goggles where splashes are possible.

## REMOVING GLAZING COMPOUND AND MASKING PAPER ADHESIVE

Glazing compound and masking paper adhesive can be easily removed from Tuffak CM-2 sheet with a soft cloth wet with VM&P naphtha or kerosene, followed by a thorough cleaning with soap and water. Do not scrape with a putty knife or other sharp instrument.

### *Do Not Use:*

Do not use cleaners containing strong mineral acids or organic solvents such as ketones, chlorinated hydrocarbons and aromatics. The use of razor blades, putty knives or other sharp instruments should also be avoided, as they may scratch the material and, once scratched, the abrasion-resistant coating cannot be repaired.

# FABRICATION PROCEDURES

## MACHINING

Tuffak CM-2 sheet can be sawed, drilled and routed using the same tools and techniques recommended for uncoated Tuffak sheet. Tools must be sharp. Dull tools can cause chipping of the Tuffak sheet.

The sheet should remain masked during machining operation and the work surfaces should be kept clean and free from chips that could gouge the material. See the Tuffak Forming and Fabrication Manual (ADV980496) for complete fabrication information.

## TABLE 2: Chemical Resistance Test Method ASTM D-1308

| Chemical | Time to Visual Attack | |
|---|---|---|
| | TUFFAK CM-2 (coated) sheet | TUFFAK A (uncoated) sheet |
| Methylene Chloride (MDC) | 4 hrs. (W,C) | 1 min. (D,W) |
| Toluene | 4 hrs. (W,C) | 1 min. (D,W) |
| Solvesso™* 100 | 1 week | 4 hrs. (W) |
| Kerosene | 1 week | 1 week |
| Acetone | 48 hrs. (C) | 1 min. (D,W) |
| Oxalic Acid | 1 week | 1 week |
| Hydrochloric Acid (conc.) | 1 week | 1 week (S,W) |
| Nitric Acid (conc.) | 1 week (Y,C) | 1 week (Y) |
| Sodium Hydroxide (sat.) | 1 week (S,W) | 48 hrs. (W) |
| Ammonium Hydroxide (conc.) | 1 week | 1 week |

**Note**: Teflon washer placed on surface, filled with chemical indicated and covered with a watch glass. Samples checked within 1 minute, 4 hours, 8 hours,16 hours and then every 24 hours thereafter, for a total of 1 week.
Code: S=slightly, W=whitened, C=crazed, Y=yellowed, D=dissolved.

*SOLVESSO 100 - expired trademark of Standard Oil Company.

## CEMENTING

Tuffak CM-2 sheet cannot be cemented readily to itself or to other materials. To cement the sheet, remove by sanding or grinding the coating from the area to be cemented. After the coating is removed, the cements used for uncoated Tuffak sheet may be used. See the Tuffak Forming and Fabrication Manual for cementing instructions.

## COLD FORMING

Tuffak CM-2 sheet can be cold formed, that is, bent while cold, to a smooth, moderate contour and held to that contour by springing the material into a curved channel support. The radius of curvature should be greater than that recommended for Tuffak A. Tight radii curves may cause crazing of the material.

## CODES AND REGULATIONS

Tuffak CM-2 sheet installations should be used in conformance with applicable code requirements and regulations. These may include building and fire safety codes, safety glazing regulations, motor vehicle codes, industrial safety codes (including OSHA), and other applicable codes and regulations. Tuffak CM-2 sheet will meet most codes and regulations that set requirements for glazing materials. (See page 4 for fire considerations.)

Tuffak CM-2 polycarbonate sheet meets the requirements of a Class CC-1 light-transmitting plastic material under the model building code authorities: BOCA, ICBO and SBCCI. Tuffak CM-2 polycarbonate sheet meets the requirements of FRA Type I and Type II railroad glazing materials as defined in 49 CFR 223, Appendix A, as follows:

- Single glazing — nominal .460" thickness
- Double glazing — nominal .236" thickness with a .125" or .250" air space.

Check with Atoglas on applications where a standard is involved.


## TABLE 3: Recommended Cleaners for TUFFAK CM-2 Polycarbonate Sheet

| Mass Transit | |
|---|---|
| **Cleaner** | **Supplier** |
| C-1102 | DuBois Chemicals |
| F.O. 479 Safe-Klean | Hexcel/Fine Organics |
| Key-Chem® 552 | Key Chemical |
| Subway Soil Solvent Part I | Neleco |
| Subway Soil Solvent Part II | Neleco |
| Oakite® Fleetline® 205 | Oakite Products |
| Magnus® NZL | Magnus Chemical/ Economic Lab |
| **Architectural Cleaner** | |
| Ammonium Hydroxide Concentrate (100%) | |
| Ammonium Hydroxide Concentrate (50% in water) | |
| Ammonium Hydroxide Concentrate (25% in water) | |
| Windex® | |
| Glass Wax® | |
| Glass Plus® | |

**Note**: Since these cleaners are not manufactured or sold by Atoglas, the performance tests that we may run are necessarily limited to establishing only that a product has the potential to provide a necessary function. We cannot warrant that it will consistently maintain the required performance characteristics. We recommend that you contact the suppliers directly and have them verify that their product is safe for use with Tuffak CM-2 polycarbonate sheet.

## TUFFAK CM-2 AND FIRE

Tuffak CM-2 sheet must be used with an appreciation for the fact that it is a combustible material. Tuffak CM-2 sheet will burn when exposed to flame. The same 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 CM-2 sheet.

## TABLE 4: Graffiti Removal

**Cleaning Agents**
*(listed in order from least to most harsh)*

| | |
|---|---|
| 1. Rub with **moistened** flannel only | *6. Methanol |
| 2. VM&P Naphtha | 7. Toluene |
| 3. Kerosene | 8. Acetone |
| 4. Soap or Detergent | 9. Methyl Ethyl Ketone |
| 5. Isopropanol | 10. Methylene Chloride |

*Cleaning agents with numbers higher than 6 will attack the polycarbonate substrate through any scratches in the coating; however, they may be used momentarily on a surface with intact coating.

| Type of Stain | Cleaning Agent Required To Remove Stain |
|---|---|
| Glazing Compound and Masking Paper Adhesive | VM&P Naphtha or Kerosene |
| **Felt Markers** | |
| Blaisdell Liquid Tip 1100, Black | Kerosene |
| Blaisdell Liquid Tip 1100, Red | Kerosene |
| Marsh 88 Marker, Black | Kerosene |
| Perm Color, Esterbrook®, Red | Kerosene |
| Sanford's® Marker Deluxe #69, Black | Isopropanol |
| Sanford's® Impact Marker #39, Blue | Kerosene |
| Sanford's® MR Sketch, Black | Water |
| Major Accent® #49, Orange | Water |
| **Spray Paint** | |
| Krylon® #1601, Glossy Black | Methanol |

**Note:** In all cases, graffiti was applied at room temperature and allowed to dry 24 hours before removal. Stain was removed by rubbing with a flannel cloth saturated with the cleaning agent listed, starting with the least harsh.

## TABLE 5: TUFFAK CM-2 Sheet and Fire

| Fire Response Characteristics | Recommended Practices |
|---|---|
| As is inherent in all polycarbonate materials, the ignition temperature of Tuffak CM-2 sheet is higher than that of most woods, but it will ignite. When involved in fire, Tuffak CM-2 sheet will burn and generate heat and smoke rapidly. | Install Tuffak CM-2 polycarbonate sheet away from sources of intense heat or flame. Enclose edges of Tuffak CM-2 sheet components. Observe building code stipulations and restrictions. Do not use more Tuffak CM-2 sheet than required to perform the function required of it. Employ fire protection systems—such as sprinklers, fire detectors, and automatic vents—as fire hazard analysis indicates. |
| Tuffak CM-2 polycarbonate sheet softens when heated above 275°F, which is below its self-ignition temperature of 1090°F. | Do not use Tuffak CM-2 sheet as a supporting element or in any location where resistance to fire penetration is required. |
| When burning, Tuffak CM-2 sheet will drip. | In overhead lighting, mount Tuffak CM-2 polycarbonate sheet in free channel mountings to ensure fallout prior to ignition. Extinguish burning Tuffak CM-2 with water or fire extinguishers. |
| When installed as a wall or ceiling finish or when laminated to a substrate, Tuffak CM-2 sheet provides a surface over which flame may spread and release heat and gases contributing to flashover. | Do not install Tuffak CM-2 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 CM-2 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 analysis of all relevant fire-safety considerations. | Relevant considerations are use of the structure (occupancy); location (exposure); height and area; nature of interior arrangement (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 CM-2 sheet produces smoke. The concentration of carbon monoxide and/or carbon dioxide released by burning Tuffak CM-2 sheet is a factor of the quantity of Tuffak CM-2 involved and the conditions of burning. | The use of Tuffak CM-2 sheet may be restricted or prohibited in some locations because of high smoke generation. The use of Tuffak CM-2 is not restricted because of the toxicity of its products of decomposition. |
| Impact resistance of Tuffak CM-2 sheet may create entry and venting problems for firemen, as is the case for any polycarbonate sheet. | When possible, install Tuffak CM-2 sheet in operable windows. Fire departments and building occupants should be informed of the location of fixed Tuffak CM-2 sheet glazing in order to provide for alternative evacuation and venting facilities. |

Building codes and standards define good practice in the use of Tuffak CM-2 sheet for light transmission and control on a design and engineering basis that takes into account the combustibility and fire characteristics of the material.

The fire hazard of uses of Tuffak CM-2 sheet can be kept at an acceptable level by complying with building codes and applicable standards, and observing established principles of fire safety. Listed in Table 5 are the fire response characteristics of Tuffak CM-2 sheet and recommended practices for design, engineering, and fire protection of Tuffak CM-2 sheet installations.

The high impact resistance of Tuffak CM-2 polycarbonate sheet may require the use of access panels by fire-fighting personnel for the evacuation and venting of rooms glazed with Tuffak CM-2 sheet in the event of fire. Consult local fire officials for their requirements.

Copies of the approvals of Tuffak CM-2 polycarbonate sheet under various codes will be made available on request. In addition, reports on the status of Tuffak CM-2 sheet under federal government regulations will be provided. Assistance will also be provided by Atoglas code consultants and engineers in interpreting the codes for installations of Tuffak CM-2 sheet that constitute justifiable exceptions to existing restrictions. A considerable amount of information is available to support such applications.

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