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Transportation Safety Division

Substrates and Preparations for Retroreflective Sign Sheeting Applications

Information Folder 1.7
April 2022

Replaces Information Folder 1.7 Dated August 2013

1 Introduction

The use of proper substrates and preparation methods, as outlined in this documents, are essential for achieving successful applications of 3M retroreflective sheeting products. Always consult the appropriate 3M product bulletin and information folder prior to sheeting application. If additional information is needed, contact 3M Application Engineering at 1-800-553-1380 or contact your 3M representative.

Many clean, smooth, non-porous, flat, rigid, weather resistant surfaces are suitable for proper application of 3M retroreflective sheeting products. Properly prepared aluminum sheets and extrusions have been found to be the most reliable and durable substrates. Users are urged to carefully evaluate all other substrates prior to use.

2 Substrate Warranty Clarification

A 3M warranty is in effect on properly applied 3M retroreflective sheeting. The 3M warranty applies to all substrates unless functional sign failure is the result of the substrate or its preparation. 3M is only responsible for materials manufactured by 3M and only when those materials are applied according to 3M recommended procedures.

The following is an non-exhaustive list of examples of common substrate failures:

1 Poor sheeting adhesion and visual defects such as wrinkles, bubbles, and rough sheeting texture due to substrate roughness.
2 Poor sheeting adhesion due to inadequate or improper degreasing, etching, or conversion coating of aluminum substrates.
3 Poor sheeting adhesion due to improper substrate surface preparation, including such causes as inadequate cleaning, particulate contamination, low surface energy, and under-cured coating.
4 Sheeting adhesion loss due to substrate degradation, outgassing, or moisture absorption.
5 Loss of functional sheeting performance due to substrate instability, such as dimensional change, warpage, stress fatigue, or flexing.
6 Sheeting distortion due to substrate buckling or extension caused by moisture absorption.

3 Guidelines for Substrate Evaluation

For traffic sign use, the substrates that have been found to be most reliable and durable are properly prepared aluminum sheets and extrusions. **Users are urged to carefully evaluate the adhesion and sign durability properties of all other substrates.** Other substrates that may be suitable for secure and durable applications of 3M retroreflective sheeting products have the following characteristics:

- Clean
- Smooth
- Flat
- Rigid
- Dimensionally stable
- Weather resistant
- Non-porous
- High surface energy (pass water break test)

4 Surface Preparation Methods

4.1 Aluminum Flat Sheets and Extrusions

1 Aluminum flat sheets, street name sign extrusions (dog-bone blanks), and guide sign extrusions must be made from 5052-H38, 6061-T6, or 6063-T6 alloy. Other alloys, such as 3105 may not have sufficient corrosion resistance to satisfy durability expectations.
2 Prior to sheeting application, all aluminum substrates must be free of contaminates and white rust (aluminum oxide), and have a minimum surface energy of 50 dynes/cm.
3 An acid bath utilizing a solution of six to eight percent (6–8%) phosphoric acid has produced reliable surface etching results. Commercially available etching solutions may also be considered.
4 While degreasing and etching are all that is required by 3M for aluminum substrate preparation, agencies may require the use of conversion coating. Follow agency specifications for conversion coating requirements. The conversion coating must not interfere with sheeting adhesion. Substrates that have been conversion coated must pass the tape snap and water break tests. See sections 5.1 and 5.2, respectively, for details.
5 Reclaimed aluminum substrates may be used if they satisfy the surface preparation requirements described above. Mechanically reclaimed (abrasive ground) aluminum must have a surface finish equivalent to a 100 grit abrasive or finer and be completely free of surface contamination prior to sheeting application. Hydro stripping (high pressure water removal) can also be used to produce satisfactory reclaimed aluminum surfaces. Reclaimed aluminum substrates must pass the tape snap and water break tests. See sections 5.1 and 5.2, respectively, for details.

Note: Powder coated substrate surfaces are not recommended for retroreflective sign sheeting applications.

4.2 Plywood and Wood Products

If a plywood product must be used as a permanent sign substrate, the sign fabricator must pay particular attention to the wood substrate choice. Many high density overlay (HDO) plywood products are intended for concrete framing and have release agents applied to them. Plywood products with release agents are not suitable for use as permanent signing substrates. Highway grade HDO is a grade of plywood that is manufactured specifically for use in the production of traffic signage. Signs fabricated using plywood tend to experience more sheeting movement than signs made using aluminum. Sheeting movement can result in a textured or rippled appearance.

The plywood preparation procedures describe below are based on technical information provided by the American Plywood Association. To be used in traffic signs, plywood surfaces must be smooth, impermeable, and weatherproof. This means that all voids must first be filled with wood filler or other suitable sealer, then sanded and completely coated with a quality edge-sealing coating. Edge sealing is very important and can be achieved using multiple coatings of exterior house paint.

Users are urged to carefully evaluate any sheeting applications to plywood and wood product surfaces under actual use conditions to determine suitability and performance life for the intended use.

4.2.1 Highway Grade HDO

1. Clean panel surfaces of all dirt and contaminants.
2. Seal all edges using multiple coatings of exterior house paint.
3. Refer to the plywood manufacturer's recommendations regarding substrate preparation instructions and warranty statement for sign sheeting applications.

4.2.2 Other Plywood Products

Medium Density Overlay (MDO) plywood, exterior grade plywood, hardboard, lumber, and other wood products are generally only suitable for use in construction work zone and temporary signage applications. Due to the variability of these wood products (moisture/glue content, surface roughness, etc.), users must carefully consider their suitability for the intended application. General preparation instructions include:

1. Ensure application surfaces are completely dry, clean, and free of contaminants.
2. Seal all edges using multiple coatings of exterior grade house paint.
3. Prime application surfaces with exterior grade primer. Ensure primer is completely cured prior to sheeting application. Refer to primer manufacturer's instructions for drying time. **House paint is not a suitable surface preparation media as many paints are stain resistant and may repel sheeting adhesive.**
4. Do not use paint as a surface preparation treatment.

4.3 Galvanized Steel

Galvanized steel must be clean and free of oxidation and any loose or flaking coatings. Galvanized steel substrates must pass the water break test. Stainless steel is not a recommended signing substrate.

4.4 Plastic (Polymer) and Low Surface Energy Substrates

Plastics substrates, including polyolefins, fiberglass, recycled plastic sheets, transparent acrylic/polycarbonate panels, etc., vary by composition and manufacturing process. The use of a plastic material as a signing substrate requires cautious consideration. Successful applications have been made to plastic substrates, however, many plastics outgas or contain substances that can migrate to the surface of the substrate and affect sheeting adhesion. Follow the substrate manufacturer's substrate preparation recommendations prior to sheeting application.

Note: Consult with substrate manufacturer regarding warranty policy.

One or more of the following steps are required to obtain maximum sheeting adhesion to plastic or low surface energy substrates.

4.4.1 Solvent Wipe

Adhesion to low energy surfaces may be improved by wiping them with a suitable solvent prior to sheeting application. Suitable solvents are quick drying, leave no residual oily film, and do not damage the substrate. Isopropyl alcohol is often a good choice. Be sure to use appropriate personal protection equipment when using solvents.

4.4.2 Flame Treatment

Many low surface energy plastic substrate materials benefit from flame treatment. Flame treatment is an oxidative process that can increase the surface energy of a plastic substrate to improve adhesion. To achieve a proper flame treatment, the surface must be exposed to an oxygen-rich flame plasma (blue flame) at the proper distance and for the correct duration, typically a distance of one-quarter to two (¼–2) inches and a speed of ≥1 inch/second. Proper flame treatment distance and duration vary and must be determined for any given substrate or device.

The surface to be flame treated must be clean and free of all dirt and oil prior to flame treatment. To achieve an effective flame treatment, the flame should be adjusted to produce a highly oxygenated blue flame. A poorly oxygenated (yellow) flame will not effectively treat the surface. Flame treating is **not** heat treating. Heat is an unwanted by-product of the process and does not improve surface properties. Improper flame treating operations that overheat the plastic can soften or deform the substrate. A properly flame treated surface will not experience a significant rise in temperature.

Hand-held torches may be suitable for small volume flame treatment. For best results, commercially available flame treaters are available from a number of manufacturers. The following substrate materials can benefit from flame treatment.

a. Polyethylene
b. Polypropylene
c. Fiberglass
d. Polyvinyl chloride (PVC)
e. Many recycled plastic substrates

Other unspecified plastic substrates may also benefit from flame treatment. Please contact the substrate supplier for more information.

4.4.3 Applications to Polycarbonate and Acrylics

Internally illuminated signs may require the use of clear polycarbonate or acrylic substrate panels. Such substrates can outgas, which in turn can result in bubbling or delamination of the applied sheeting. To test for outgassing, apply a small piece of vinyl film to a piece of substrate and heat at 150 °F (65 °C) for two hours. If bubbles appear under the film, outgassing is occurring. Follow the substrate manufacturer's preparation recommendations prior to sheeting application.

Note: Sign defects caused by substrate outgassing do not constitute sheeting failures. Review and ensure full comprehension of the substrate warranty policy, as provided by the substrate manufacturer or supplier, prior to sign fabrication.

5 General Surface Testing

Properly treated substrates must be clean at the time of sheeting application. Substrates should be free of any dust, contact grease, oils, and other contaminants before sheeting is applied. The following two tests may be used to help detect surface contamination.

5.1 "Tape Snap" Test

A tape snap test can be used to help detect the presence of particulate contamination (e.g. dirt, dust, white rust) or loose conversion coating.

5.1.1 Procedure

Firmly apply transparent packaging tape to the application surface, then snap the tape up at a right angle, relative to plane of the substrate surface. Any loose material present on the removed tape indicates a contaminated surface or a poorly bonded surface treatment. Substrates that fail a tape snap test are not suitable for sheeting application.

5.2 "Water Break" Test

A water break test may be used to help detect surface contamination by oils, soaps, or unsuitable conversion coating residues. The surface energy of a non-aluminum substrate can also be verified using the water break test.

5.2.1 Procedure

Apply a fine mist of water to the substrate surface using a spray bottle (e.g. window cleaner bottle). The water on the substrate surface should NOT bead up, but instead should flow out to form a uniform film on the surface. Varying levels of water flow out can be expected.

5.3 Dyne Testing

Surface energy levels can also be verified using dyne solution or dyne pens. Dyne testing can be used to verify the effectiveness of a substrate surface preparation and help determine a surface's suitability for sheeting application. At minimum, a surface energy of 50 dynes is required to support predictable sheeting adhesion to aluminum. Follow use instructions supplied with dyne solution or dyne pens.

6 Health and Safety Information

Read all health hazard, precautionary, and first aid statements found in the Safety Data Sheets (SDS), Article Information Sheets, and products labels of any materials for important health, safety, and environmental information prior to handling or use. Also refer to SDSs for information regarding the volatile organic compound (VOC) contents of chemical products. Consult local regulations and authorities for possible restrictions on product VOC contents and/or VOC emissions.To obtain SDSs and Article Information Sheets for 3M products, go to 3M.com/SDS, contact 3M by mail, or for urgent requests call 1-800-364-3577.

7 Other Product Information

Always confirm that you have the most current version of the applicable product bulletin, information folder, or other product information from 3M's Website at http://www.3M.com/roadsafety.

For Information or Assistance
Call: 1-800-553-1380
In Canada Call:
1-800-3M HELPS (1-800-364-3577)

Internet:
http://www.3M.com/roadsafety

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