ION PVC®

FABRICATION GUIDE

GRIMCO®

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MOUNTING

Cold Mounting, substrate not recommended for hot mounting.

Mounting consideration should follow the adhesive manufacturer's instructions. In general, determine the minimum amount of adhesive lay down to attain the desired adhesion level. It is advisable to leave the boards for a period of time to setup. Consult the adhesive manufacturer's instructions to see what specific times are recommended.

Surface Preparation

Surface should be cleaned and free of any surface contaminates (i.e. oils, dust particles, etc.) prior to beginning.

The substrate should be cleaned with isopropyl alcohol, using a non-colored cloth for best results.

Any surface scratches on the substrate will have a tendency to telegraph through the graphic. To remove small scratches or dents, rapidly fan a heat gun over the affected area. Care must be taken not to leave the hot air in one place for too long, as the surface can be deformed.

Considerations

- When using laminate films on only one side of the mounted graphic use care. Moisture pickup will be sealed on one side while the other side in not protected from moisture pickup. Bowing may occur because of moisture imbalance.
- When mounting only one side with spray adhesives. As the mount cures out, tensile forces within the adhesive may cause the substrate to bow. It may be necessary to apply a counter-mount of comparable strength on the backside.
- Use the minimum amount of tension when mounting with film or pressure sensitive adhesives as too much tension will cause the substrate to bow; too little will cause the graphic to wrinkle.

Cold Mounting:

Getting Good Adhesion

- To cold mount pressure-sensitive adhesives, you need sufficient pressure. You also must make sure that proper spacers are used. Because effective mounting depends on equal force exerted across the entire width of the substrate being mounted, the top roll must move down evenly left and right. Even contact between the top and the bottom mounting rolls is essential.
- Adequate pressure helps squeeze out air from between the adhesive, the substrate and the print.
- The mount obtained after 3 hours will generally allow for processing. Maximum mount is usually obtained within 24 hours after mounting.
- To test adhesion, flex the finished mount. It should not come loose in the center.
- Moisture can become trapped between layers of porous material (such as paper) and cause blisters. The level of moisture in the atmosphere should be reduced before press work. Prints may even have to be pre-dried.
- When tacking prints to the substrate, some shops will hang a number of tacked pieces in an upside-down position until they are ready to pass them through. As a precaution, it is advisable not to hold them any longer than 10 minutes or the prints may absorb moisture, change in dimension and cause bubbles and wrinkles.

Getting Good Adhesion Continued

- Please contact the film manufacturer for recommendations concerning the use of their respective laminating material in conjunction with the substrate as film choice is the most important consideration.
- It is advisable to use a film with a high "green tack" strength. When using pressure sensitive films, the substrate should be at room temperature to achieve optimal results.

Demounting Bad Mounts

- Pressure-sensitive adhesives may be demounted if done within 5 minutes after mounting. The print will probably be ruined, but the substrate may be reused.
- Beyond 5 minutes, the adhesive has set and other methods will have to be used, such as a hot air gun or a hair dryer to peel off the laminate. The remaining adhesive may be taken off with isopropyl alcohol or mineral spirits.

Avoiding Wrinkles & Surface Blemishes

- Wrinkles can be caused by misalignment of adhesive roll, too much pressure, or unparallel rolls.
- Small bumps, particularly visible with Cibachrome or glossy prints, are caused by trapped dirt or hardened adhesive. Good housekeeping and an ionizing static eliminator on the press are important to minimize dirt pick-up.
- During mounting, the back of the print should be checked and wiped down before it is processed. If bumps are caused by hardened adhesive (cut open to check), use a fresh roll or sheet of transfer adhesive. To prevent strikethrough, consider using a print made with thicker paper (.007+).
- Pressure roller applicators can compress the leading edge of the mounting substrate. In order to keep the leading edge from rounding as it goes through the roller, use a plastic lead or guide of the same thickness of the mounted substrate.

Clear Overlays

Clear high-gloss overlays enhance color and protect against fading indoors and outdoors. To avoid blistering, do not use overlays, clear coatings, or sprays which contain solvents.

Archival Mounting (Conservation Framing)

The substrate is not suitable for Archival Mounting. Matboards, particularly those in contact with the art, should meet the Library of Congress specifications.

Cold Mounting Procedures:

Cold Mounting by Hand Using Transfer Adhesive

- Take a sheet of transfer adhesive (both sides covered by release paper) and fold back release paper on one side approximately 1/2" from one edge.
- Tack on edge of print to exposed adhesive.
- Lift the print slightly, remove the rest of the release paper and use a roller or squeegee to smooth the print onto the adhesive. The back of the print is now coated with an adhesive which is protected by release paper.

Cold Mounting by Hand Using Transfer Adhesive Continued

- Before mounting to the substrate, remove excess air between print and adhesive. This is done by turning the print over so that the release paper is up and smoothing out from the center with a squeegee.
- Now peel off approximately 1/2"– 1" of release paper from upper edge and fold back.
- Tack on to the substrate, lining up edges.
- Using a hand roller or squeegee, closely follow the removal of the liner to eliminate bubbles caused by air entrapment. Work with a small surface at a time (approximately 12"). Continue this step until the mounting is complete.

Cold Mounting by Hand or Press Using Spray Adhesive

- Select a spray mounting adhesive that is safe to use with polystyrene and the artwork to be mounted; solvent based adhesives should be used with caution.
- Spray adhesive on the back of the piece to be mounted. Spray 6"– 8" away from the surface. A double coat is best, with the second coat applied in a cross direction to the first coat. For mounting most art materials, adhesive need only be applied to one surface, preferably the print. Avoid using excessive bonding adhesive.
- Before mounting, allow adhesive to dry to the touch; the adhesive must be aggressively tacky. If there are blisters due to trapped solvent, allow slightly longer than 4 minutes of drying time.
- Carefully position piece on the substrate and smooth out if possible to eliminate any wrinkles and trapped solvent.
- If using a press, simply turn on the press to complete the mount.
- If mounting is done by hand, place a clean sheet of the substrate over the laminated piece and weigh down for 15 minutes to obtain the maximum bond. Depending upon the type of adhesive, allow 24 hours for maximum cure out before exposing the laminate to sudden temperature or humidity changes.

Cold Mounting by Roller Laminator with an Adhesive-backed Graphic

- Adjust the rollers to slightly compress the substrate to provide adequate pressure for mounting.
- Peel off a 1/2"– 1" section of release paper from the upper edge of the preprinted adhesive backed paper.
- Tack on to the substrate, lining up edges.
- Feed tacked edge into nip of rollers keeping printed piece bent away from the substrate.
- As it passes through the rollers, strip away the release paper. (Make sure there are no wrinkles or trapped dirt.)

Cold Mounting Non-Porous Graphics

For non-porous material such as PVC, other plastics or metal, the following types of contact adhesive with solvent may be used.

- Neoprene, nitrile, polyurethane or other synthetic rubber types.
- Adhesive must be applied to both faces. Parallel beads of adhesive are often preferred because it allows evaporation of solvent providing faster cure.
- For mounting the substrate to flexible PVC sheets, only plasticizer-resistant types of adhesives should be used.

Cold Mounting Porous Graphics

For porous materials such as paper, textiles, fabrics or wood, the following adhesives may be used.

- Contact adhesive with solvent: Same systems as for non-porous materials.
- Construction mastic, structural silicone adhesives.
- Considerations such as expected temperature ranges (expansion/contraction), porous material, and size of substrate should be taken into careful consideration when deciding on a method of attachment.

Cold Mounting with Pressure Sensitive Tapes

Pressure sensitive tapes can be used for:

- Less demanding applications that are stress-free.
- Adhering parts during installation work.
- Holding parts while the primary adhesive is curing.
- It is recommended to trial pressure sensitive tapes prior to use.

Troubleshooting When Using Cold Mounting Presses		
Poor adhesion or bubbles:	a. Insufficient pressure b. Stripping back more than 1" of release paper while tacking on print traps air c. Premature contact between print and adhesive traps air d. The print contains moisture	a. Increase mounting roll pressure if running without spacer shims. If using spacer shims, use next smaller size b. Never strip back more than 1" of release paper c. As it is fed through rolls, the print should be tilted or bent away from adhesive until it enters the nip d. Pre-dry print and/or keep humidity at a low level
Curl (bowing):	Too much web tension	Reduce unwind brake pressure
Wrinkles:	a. Misalignment of adhesive roll, causing web tension b. Top and bottom mounting rolls are not parallel c. Too much pressure d. Substrate material thickness relative to shim thickness is too great (should be no more than 1/32")	a. Shift the material roll on the bar to release tension b. Stripping back more than 1" of release paper while tacking on print traps air c. Reduce roll pressure d. If correctly sized spacer shims are not available, zero the nip

REPOSITIONING VINYL

Repositioning Vinyl

- Identify any misaligned or improperly adhered vinyl graphic.
- Using a sharp edge or razor blade held at a 45-degree angle to the substrate, begin to lift the vinyl, taking care to not scratch the substrate surface.
- After lifting enough of the vinyl surface in order to grab between the fingers, continue to peel back the graphic by hand, proceed with a proper speed so as to not tear or damage the vinyl graphic.
- Once completely removed, lay the vinyl graphic face-down smoothly on transfer paper.
- Reposition the vinyl graphic face-up in the proper location on the substrate and gently rub the transfer paper to re-adhere the vinyl graphic.
- Remove the transfer paper and gently press out any wrinkles or bubbles within the vinyl graphic by hand.

DIGITAL PRINTING

Large format digital printing on flatbed printers has excellent application for the substrate.

Surface Preparation

Surface should be cleaned and free of any surface contaminates (i.e. oils, dust particles, etc.) prior to beginning.

The substrate should be cleaned with isopropyl alcohol, using a non-colored cloth for best results.

Any surface scratches on the substrate will have a tendency to telegraph through the graphic. To remove small scratches or dents, rapidly fan a heat gun over the affected area. Care must be taken not to leave the hot air in one place for too long, as the surface can be deformed.

Ink

The substrate readily accepts all types of inks including:

- Aqueous
- Solvent-Based
- UV-Curable

Elevated UV exposure can affect PVCs printed with UV ink, causing brittleness in the printed areas of the sheet.

SCREEN PRINTING

Large format screen printing has excellent application for the substrate.

Surface Preparation

Surface should be cleaned and free of any surface contaminates (i.e. oils, dust particles, etc.) prior to beginning.

The substrate should be cleaned with 70% isopropyl alcohol, using a non-colored cloth for best results.

Any surface scratches on the substrate will have a tendency to telegraph through the graphic. To remove small scratches or dents, rapidly fan a heat gun over the affected area. Care must be taken not to leave the hot air in one place for too long, as the surface can be deformed.

Ink

The substrate readily accepts all types of inks including:

- Vinyl/Acrylic
- Solvent-Based
- UV-Curable

Screen Printing inks should be tested in a manner which duplicates your printing process before initiating production. It is advised that you contact the equipment and ink supplier to provide you with specific recommendations to achieve maximum results.

Ink Curing

The ink, once applied, must be given proper time and treatment to completely adhere and cure.

Screen printing ink should air dry rather than be heat dried for the substrate as temperature in excess of 150°F may cause warping or bowing of the substrate.

PAINTING

Surface Preparation

Surface should be cleaned and free of any surface contaminates (i.e. oils, dust particles, etc.) prior to beginning.

The substrate should be cleaned with 70% isopropyl alcohol, using a non-colored cloth for best results.

Any surface scratches on the substrate will have a tendency to telegraph through the graphic. To remove small scratches or dents, rapidly fan a heat gun over the affected area. Care must be taken not to leave the hot air in one place for too long, as the surface can be deformed.

Suitable Paints

- Acrylic Laquers
- Two-Part Polyurethanes
- Vinyls
- Some water-based paints may be suitable, depending upon the application

Suitable Paints Continued

Oil-based enamels generally do not have the good adherence properties of solvent based systems on the substrate. The use of primers may improve the adherence of non-solvent based systems, though the adherence is usually minimal.

Adhension Test

The paint system chosen should always be tested for adequate adhesion. To test for adhesion, conduct the Cross Hatch Test after the paint has dried for at least 24 hours:

- Make 11 parallel cuts 1/16" apart with a razor blade knife. Make 11 similar cuts at 90 degrees to cross the first set.
- Across the scored area apply a strip of strong tape, such as #610 Scotch tape. Press firmly.
- Immediately remove the tape by pulling it back upon itself at 180 degrees in one rapid motion.
- There shall be no removal of the paint squares to obtain a good adhesion rating.

Application

Paints can usually be applied with a brush or roller; however conventional air spray equipment will provide a more consistent appearance.

Consult paint manufacturer's literature for recommended application technique and thinning requirements.

Drying

The substrate should not be dried at temperatures in excess of 150°F. For drying and cure times, consult paint manufacturer's literature.

Edge Treatment

When the substrate is cut to size during fabrication, edge cells are exposed. Although these cells do not allow paint or water to be absorbed any further than the first layer, the filling or chemical collapsing of these cells before painting can offer close to the same texture or appearance as the substrate surface after painting.

Filling exposed cells (10–13 mm)

- Spot putty or glazing compound used in the auto body industry works very well.
- Fill edge cells with spot putty using a stiff, flat blade. Fill the cells; do not build up the edge.
- When dry, usually 3-4 minutes, sand lightly to remove blade marks and any build up of putty.

Collapsing exposed cells (1–6 mm)

- Use a PVC solvent such as, Methyl Ethyl Ketone (MEK) or Tetrahydrofuran (THF).
- Sand the substrate edge to remove all saw or router marks.
- Apply PVC solvent to sanded edge with acrylic glue applicator bottle. With protected finger, rub solvent onto edge of the substrate. The more you apply and rub, the more cells you collapse.

Edge Banding

For thicker substrate gauges, 1 mm or 2 mm PVC material can be adhered to the edge using a PVC solvent.

Advantages/Disadvantages of Paint Types				
Paints	**Type**	**Gloss**	**Advantages**	**Disadvantages**
Matthews Map	2 part acrylic polyurethance	Will match gloss required	Excellent outdoor weatherability. Resists solvents, hard coating, no primer required. 16 standard colors.	2 part system. Slow drying. Experience necessary in spraying technique to get good finish. Irritating vapors.
Spraylat Lacryl 20 Series	Automotive quality acrylic lacquer	High	Single component. Good adhesion. Custom colors only. Weather resistant.	Translucent. Best used on white Ion PVC only. Not a hard finish like Map. Flammable.
Wyandotte Grip-Guard	2 component acrylic polyurethane. Use with 10 AHK 31050 primer	Will match gloss required	Good solvent resistance. Good weathering. Needs no top coat.	2 part system. Slow drying. Experince necessary in spraying technique to get good finish. Irritating vapors.
Wyandotte Grip-Flex	1 part thermoplastic acrylic	To match gloss, use Grip-Flex clear top coat	Good outdoor weatherability with Grip-Flex clear top coat: 10-AFT 02-200	Must use top coat for optimum performance. Needs no primer. Good thermoformability.
Wyandotte Meta-Flex	1 part thermoplastic acrylic	Will match gloss required	Use clear top coat for best weathering. Hard coating. Needs no primer.	Must use top coat for optimim performance.
Sherwin Williams Polane	2 part aliphatic polyurethane	Will match gloss required	Good adhesion and weatherability.	2 part system. Slow drying. Experince necessary in spraying technique to get good finish. Irritating vapors.
Hydrocoat Finishing Products, Inc.	Water based: Vinyls, lacquers and polyurethanes	Use top coat for high gloss	Good adhesion and compatibility. Water clean-up.	Surface must be grease and dirt free.
Carbithane 11 and 12	Acrylic polyurethane	Satin and Series, Carbit Paint Co.	Good adhesion.	Slow drying. Experience necessary in spraying technique to get good finish. Irritating vapors.

Advantages/Disadvantages of U.V. Protection Types			
Primers	**Type**	**Advantages**	**Disadvantages**
Matthews Paint Corp. Map Clear	2 part acrylic polyurethane	No primer required. Excellent outdoor weatherability.	Irritating vapors. Spraying provides most consistent finish.

Primer Types		
Primers	**Type**	**Advantages**
Consumers Paint Factory 1 Shot Vinyl Primer #5004	Water Soluable	Improves adherence of enamel
Ronan Paint Corp. Prime- All	Water Borne	Improves adherence of enamel
Masterchem Industries Kilz.	Solvent Based. Exterior or Premium.	Improves adherence of enamel

CUTTING

Knife Cutting

Ion PVC in 3 mm can be fabricated with this method. The substrate can be cut by hand with mat knives, utility knives, and razor blades. Mat cutters make smooth cuts, either right-angled or beveled. Cardboard and glass cutters also work well.

The key to getting a smooth, clean cut is to use a very sharp thin blade held at as low an angle as possible to the board, which reduces friction. If a straightedge is being used as a guide, it may be necessary to make the cut in more than one pass.

Shearing with a guillotine shear is generally not recommended.

Saw Cutting

Sheets can be cut with hand, circular or saber saws. Wood-cutting saws can also be used. Fine-tooth hack-saws are not suitable since the finer tooth spacing creates excessive friction and produces an undesirable finish.

For best results, use saw blades that are identified as triple chip tooth configuration or “plastic cutting.”

Troubleshooting with Saw Cutting

Should rough edges result, it may be from one or more of the following reasons:

- Dull cutting tool.
- Inadequate support of the work piece.
- Saws not adjusted closely to work, get weave of the blade.
- Vibration of the cutting tool.
- High friction temperature on the cutting surface.

Milling

- The substrate can be machined on the usual types of milling machines: universal, horizontal and vertical. To avoid indenting the surface when clamping, place flat pieces of wood or plastic between the work and the clamps.
- Tool geometry and working conditions are summarized in the chart below.

Specifications & Working Conditions Chart for Cutting

Cutting Methods	Applications: Advantages/ Disadvantages	Recommended Blade/Bit Goemetry	Recommended Working Conditions	Recommended Blade/Bit
Circular Saws	Used for making cuts on radial arm or panel saws. Can stack up sheets if more than one piece is required at same length. Edge finishing may be needed since open cells are exposed by cut.	Angled or curved teeth with alternative chamfer cutting nippers or set. Must be carbide-tipped. Well-rounded spaces between teeth. Rake angle: 5°- 10°. Free angle: 10°- 20°. Distance between teeth 3/16"- 1/2".	Cutting speed: up to 10,000 FPM. Feed: up to 100 FPM.	1. No-melt Plasti-Kerf. 2. Triple-chip Carbide blade 3. Many veneer type blades.
Band Saws	Used for making curved cuts. Get very smooth edge – very little additional edge finishing required.	No rake, 8 teeth per inch. Hard edge type.	3,000 SFM	Do-All straight knife of "V" tooth blade.
Saber Saws	Portable. Good for cutting curves, bevels and intricate patterns. Not good for straight cut.	10 - 15 teeth per inch. Hard edge type.		2-pack blade package from Central Plastics Distributors. Use their green blade for Ion PVC material.
Milling		Rake angle: 5°- 20°. Free angle: 10°- 25°.	Cutting speed: 3,000 - 3,300 FPM. Feed rate: 8"- 20"/min.	

Edge Finishing

Smooth edges can be achieved with a file, plane or sander. Conventional tools and methods for working wood or plastics can be utilized. Edges can be polished with solvent. More information on this topic is in the painting section.

Surface Finishing

- Short bursts of hot air from a heat gun can be used to remove small surface scratches and small dents.
- Surface finishing with cutting tools is possible. Grinding or polishing is not recommended since this may damage the surface and expose cut cells.

Routing

Specifications & Working Conditions Chart for Routing				
Method	**Applications: Advantages/ Disadvantages**	**Recommended Blade/Bit Goemetry**	**Recommended Working Conditions**	**Recommended Blade/Bit**
Routing	Used particularly for making slots prior to heat bending. Can be stationary or portable, depending on type of operation desired.	High-speed carbide router bits. Various cutter head configurations.	Cutting speed: 3,000 FPM Feed: 10"/min	Most high-speed carbide bits, available at hardware stores.

Die Cutting/Punching

Die cutting and/or Punching is a method for the rapid production of flat shapes or cutouts. Typical applications would include the die cutting of:

- Letters and shapes.
- Openings in a sheet used as part of an assembly.
- Puzzle pieces.

Prior to die cutting, the substrate can be painted or screen printed. After die cutting, the pieces may have additional fabrication including: heat bending, fastening, gluing, routing or machining. 3 mm Ion PVC is recommended for die cutting.

Steel Rule Die Cutting Process

Cutting with steel rule dies (SRD) is the most common, which work basically the same way as a cookie cutter.

SRD are made of a 1"- wide strip steel with one pre-sharpened edge. The cut strips are called "rules." The strip steel is typically made in a thickness range of .014"– .166". The strips are bent to the shape of the design's trim line and held in place in a block called a "die body."

- In order to facilitate ejection of the part, strips of a compressible material such as neoprene are glued along the perimeter and protrude above the cutting edge of the rule. The strips can also be glued to the top or bottom platen to hold the substrate in position.
- During die cutting, the SRD assembly is fixed under the top platen, and the substrate is placed on a steel bottom platen. Pressure is applied to force the rules of the SRD through the often preheated substrate.
- The platens are then opened and the parts removed. In some cases, additional work such as finishing the cut edge might be required.

The key elements to consider when die cutting are:

- The Substrate
- The Press
- The Steel Rules
- Ejection Rubber

Substrate Considerations:

Temperature of the sheet

- To get the best cut, it is advisable to preheat the material to 100°– 130°F. The use of a press which contains hot platens can reduce the fracturing.
- Ion PVC is a thermoplastic material and becomes more brittle with decreasing temperatures. With the sheet temperature below 75°F, the rule makes a clean cut about two-thirds of the way through and then fractures the last third of the cut.

Thickness of the sheet

- The quality of the die cut part is reduced as a thicker-gauge substrate is used. Ion PVC 3 mm is the recommended thickness for this process.
- It is possible to cut pieces thicker than 5 mm, providing the rule has the correct gauge (point) and bevel, the substrate is warm enough (100°– 130°F), the right back-up plate is used and, most importantly, the cutting edge is kept sharp at all times. With thicker parts (5 mm+), it may be necessary to post-finish the cut edge.
- With a sheet thickness less than 5 mm, it is possible to form curves with radii less than 1/8". With thicker gauges, the minimum radius must be increased.

Press Considerations

- The substrate is typically die cut on flat bed presses, which can be either a "moving platen" type or a "clam shell" type.
- The key press consideration is proper "make ready", or preparing the press bed (anvil) to assure that the steel rule cuts evenly through the substrate without dulling the steel rules.
- Typically, the substrate is cut on a "hard anvil."
- "Make ready" for this type of die cutting utilizes carbon paper.
    - The press is lowered to the point where the steel rule just touches the anvil.
    - The places where the rule fails to touch the anvil are built up with one-mil thick shim-tape.
    - This process is repeated until a complete imprint of the steel rule is apparent.

"Make ready" is very important because the platen of the press does not necessarily close evenly. This can be caused by misalignment, uneven cutting loads or by deflection of the platen. As a rule of thumb, a four-post press will deflect one mil per foot. Steel rules that have been dulled by improper make ready will cut poorly, have increased cutting loads and can contribute to cracking problems.

Back-Up Plate

One problem with steel plates is that the die might not completely penetrate the substrate which can result in fracturing at the base of the cut. An alternative to a steel plate would be to use additional substrate or chipboard as a back-up. This would allow the die to penetrate beyond the thickness of the substrate so that a cleaner cut could be obtained.

Steel Rule Consideration

Steel rules are flat strips of steel with a uniform height. One edge of the steel rule is honed to yield a cutting surface. The key properties of cutting rules are hardness, flexibility, bevel type, thickness, uniformity of height and edge preparation.

1. Steel Rules That Apply To This Substrate

Cutting Rules

- Most common when die cutting the substrate. These rules are used to cut the edge. Cutting rules are either center bevel or side bevel, which indicates where the cutting edge is located.
- Center bevel rules result in equal forces being placed on both sides of the piece to be cut and are used when both the inside and the outside of a cut needs to be saved, e.g., as in a puzzle. This distribution of forces can be important when attempting to minimize cracking.
- Side bevel rules have one side that is essentially flat and the opposite side is sloped or beveled. The flat side should be placed toward the substrate that will be kept, with the bevel facing the scrap piece. This results in additional compressive force being placed on the scrap side. Cracking tends to be directed in this direction.

2. Edge Preparation

Grinding

- Ground edge rules have micro-scratches on the cutting edge. This can result in a blade that has a reduced cutting force.
- The disadvantage of this type of rule is that it is difficult to maintain the uniform blade height.

Drawn Edge

- Drawn edge blades are made by drawing the blade through a die.
- This produces a uniform blade height and a smooth blade surface.

As a guide for cutting substrate, we suggest that the following thickness (point) rules be used:

- For normal parts, 3 point (.042") or 4 point (.056").
- For intricate parts using a thin gauge (under 4 mm) substrate, 2 point (.028").
- For a very thick gauge (5 mm+), or if a wide cut separating adjoining pieces (some puzzles, etc.) is desired, 6 point (.084").

3. Length Of Bevel

A long bevel will result in less deformation as the substrate is sheared. The length of the bevel is defined as the distance from the tip to the point where the honed (beveled) portion ends. The bevel should be 3/16"– 1/4" in length.

Strippers/Ejectors

Ejection and stripping rubber is essential when cutting the substrate. It serves two purposes. The first purpose is to eject the part from the die after the press opens. The second purpose is to prevent cracking.

FORMING CURVES

The forming of curves can be accomplished with the substrate to provide a unique dimensional effect. Curves are typically formed by heat forming.

Heating Formation

It is possible to cut sheets to final dimensions and perform some machining operations prior to heat bending. Spray painting, screen printing, machining, gluing and fastening operations can be performed after heat bending.

The steps in the heat bending process are:

- Heat the substrate in an area along the line where the bend is to be made. The width of the area is determined by the gauge of the sheet and the angle of the bend.
- After the sheet has attained the proper flexibility, bend to obtain the desired radius and angle.
- Hold the substrate in position to cool. Cooling may be accelerated by contact with cold metal, a moist rag, compressed air or fans.

Heating Parameters:
Characteristics of the Substrate

The substrate requires less time to heat than solid materials. For optimum bending, the temperature of the substrate should be in the range of 250°– 300°F.

In general, the substrate should be allowed to "soak" (i.e., heated at a lower temperature for a longer period of time, instead of at a higher temperature for a shorter time).

Type of Heaters

Direct contact heating bars can be used for 2 mm - 6 mm substrate thicknesses provided that the surface temperature of the bars is kept below 300°F. (A higher temperature may melt the surface or leave an unsightly impression on the substrate).

The substrate should be set directly on the bar to get better contact. Continue heating until the substrate is pliable enough to bend.

To avoid direct contact heating, one may prefer to purchase or construct an IR heater recessed slightly below the surface of a table:

- Nichrome heater wires, Calrod heaters or silicone blanket heaters work for this use.
- A rheostat must be used to adjust the intensity of the heat.
- For substrate thicknesses 3 mm and thicker, the area to be bent should be heated from both sides by alternately flipping it back and forth over the heater until the sheet becomes pliable.

Effect of Thickness

- Heating time and temperature: Increase heating time approximately 75% per each 1mm increment in thickness. Keep the temperature setting constant.
- Application of heat: With 1 mm and 2 mm, heat the substrate on one side only–the side forming the inside of bend. Above 2 mm, heat either sides; or heat one side, flip over, and heat the reverse side.

Effect of Radius:

The following heating widths are recommended:

- Very small radius = 2x the thickness of the substrate
- Average radius = 3x the thickness of the substrate
- Large radius = 4x the thickness of the substrate

To obtain very large radii, the following techniques can be used:

- Use Calrod heaters with reflectors to broaden heating area.
- Use hot air guns.
- Construct a heater to get a very wide heating area. Use a perforated steel sheet heated with gas. Drape over a waxed cardboard tube (sleek tube) to make bend.
- Silicone blanket heater used in conjunction with a rheostat to control heat.

To make very sharp bends:

- Use a "V" groove 90 degree carbide router bit. Score the side of the sheet which forms the inside corners. Typically route about halfway through for a 90 degree corner with a slight radius.
- Heat the routed area until the substrate will flex easily.
- Bend the sheet and place in cooling guide.
- Apply PVC solvent to seam to add strength to the corner.

1. V-Rout near edge of panel, approximately 90% penetration

1. Heat Bend
2. Solvent Bond

Bending & Cooling:

Guide and Frames

A bending guide or frame can simply be a piece of wood or metal with the correct angle required for the part.

To facilitate cooling, both the guide and table can be constructed of metal.

Bending

When the proper flexibility is attained, quickly remove the substrate from the heater.

Position and bend the heated area over the guide. If only one side is heated, the heated side forms the inside of the bend.

Immobilize the part in the formed position until it has cooled.

Bending Continued

To test whether or not the substrate has been sufficiently heated:

- While the material is still being heated, hold one end of the sheet and flex the other end.
- When it flexes easily, proceed with bending.

Cooling

Cooling is accomplished by ambient air or contact with a moist rag or cool metal. Fans or compressed air can also be used to facilitate the cooling process.

The cooling time increases with the thickness and size of the substrate.

Other Heat Bending Techniques

In addition to conventional heat bending, one could utilize a technique called drape forming. In this procedure, the whole substrate is first heated until pliable, then clamped to a mold and allowed to cool.

If more sophisticated parts are desired, use a vacuum forming process.

Cold Forming is not recommended for Ion PVC.

FASTENING

Tips on Sign Installation with Post

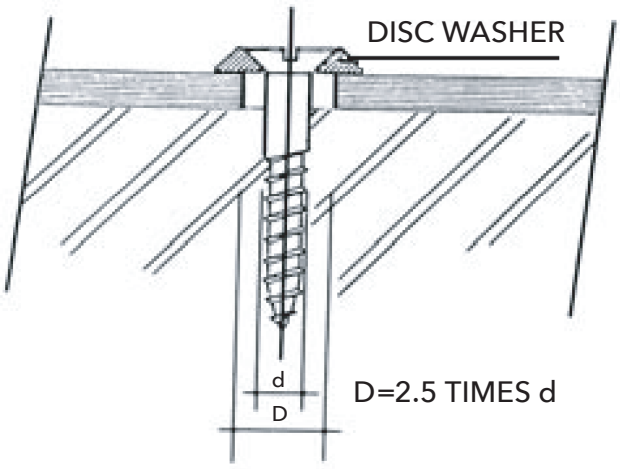
The following data has been compiled as a general guide for the mounting of Ion PVC. Unusual designs falling outside the examples given may require certain modifications when considering Ion PVC.

- Bolt holes should always be larger than the bolt shaft to allow for thermal expansion and contraction, thus eliminating the possible stress at bolt fixing points. The use of washers spread the compressive load when bolts/nuts are tightened. Never over-tighten – this will only weaken the connection.
- Split timber posts are the best to use because the PVC is supported evenly on both sides. If steel or aluminum poles are used, nylon bolts and washers give the best results. In all cases, never skimp on the number of fixing points. Use at least three on the average-sized sign. They should be evenly spaced and away from the top and bottom edges.

Screwed Joints

For the attachment of Ion PVC, basically all known through bolts can be used.

While outdoor mounting of ION PVC is not recommended for applications longer than 1 month, it is recommended that the bolt shank be passed through the PVC in prepared holes or suitably dimensioned slots that leave adequate clearance between the bolt shank and the PVC (image below). The screws should only be tightened firmly enough to allow the sheet to expand and contract in all directions without warping or buckling. Tapping screws or screws with form-fitted passage of the shank through the sheet should be avoided, but are allowed for interior uses with predictably low temperature variations. The diameter of the hole or length of the slot should not be less than 2.5 times the shank diameter of the fastener. Disc washers should be used to cover the holes or to bridge the slots and they should be large enough to ensure adequate load distribution. Precise centering of the screws in holes and slots is essential to permit free movement of the sheet in all directions.



Riveted Joints

The measures that are used for screwed joints also apply to riveted joints. For this reason full rivets, whose shaft enlarges during the clenching operation so that the clearance to the hole diameter diminishes, are not suitable for outdoor mounting of Ion PVC. Blind rivets (pop rivets) are suitable for fastening Ion PVC to metal bases which are mounted by the drawing of aluminum or the steel mandrel.

For the United States surface temperature differences of 100°- 180° Fahrenheit between extremes (winter -30° Fahrenheit, summer +150° Fahrenheit) must be assumed in exterior usage.

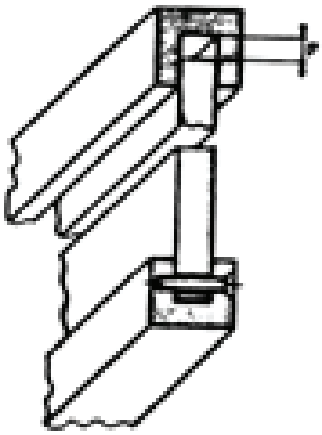
Distances Between Fastening Points for Screw & Rivet Joints	
Sheet Size	**Distance Between Fastening**
2 mm	6-8 inches
3 mm	12-16 inches
4 mm	20-28 inches
5 mm	31-43 inches
6 mm	47-70 inches

Frame Fastening of Flat Sheets

Besides the inherent rigidity of Ion PVC, which is dependent on thickness, all possible exterior stresses, e.g., wind pressure, etc., must be taken into consideration in frame fastening.

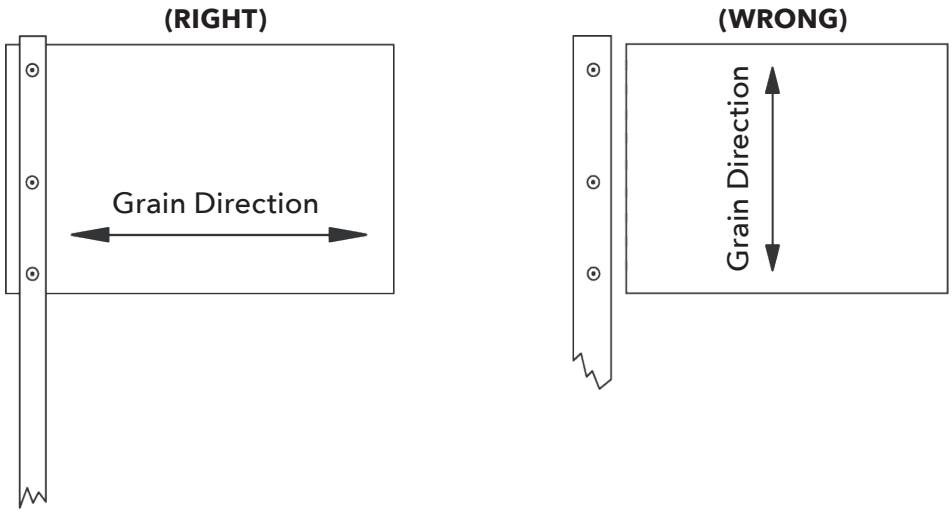
Dimensional changes due to thermal expansion (or contraction) must be taken into consideration by leaving sufficient clearance between the sheet edge and the frame.

These are suspended attachment frames. Leave a space in the lower section, as well as in the side sections to allow for PVC expansion. One pin in the middle of the rail can keep the PVC centered in the frame.



Grain Direction

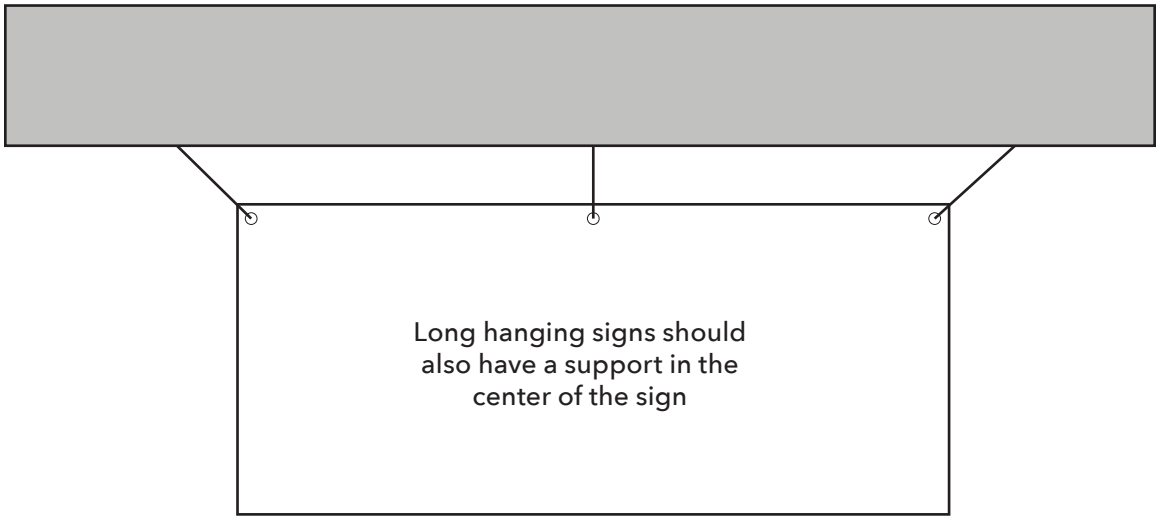
Ion PVC is an extruded P.V.C. product and a **(RIGHT) (WRONG)** directional grain is seen along the length of the sheet. Because Ion PVC has a greater flexural strength along the extrusion direction, it is always advisable to cut signs so that the grain direction is horizontal to the post or pole fixings. This will allow Ion PVC to "flex" with the wind pressure and ensure the best performance.



Hanging Signs

Ion PVC may be successfully used as interior hanging signs. As Ion PVC is an extruded sheet product, thin gauges or large hanging signs may require additional support. The addition of an aluminum or thick walled plastic "C" channel across the top, bottom, or around the perimeter may be needed to alleviate any tendencies to warp. When the additions of supporting channels are not an option, the following suggestion may also be used to help prevent bowing. Holes should be located 2-1/2 times material thickness from edge.

Point to point dimensions on the celling should be greater than point-to-point directions on Ion PVC.



Drilling

Ion PVC can be drilled with conventional, high helix, high speed steel or carbide-tipped metal bits. Quick removal of chips can be achieved by a process of high-revolution, slow-feed and occasional lifting of the drill bit. High pressure air can be used to evacuate the immediate area from chips. Smaller drills run at faster speeds than large drills.

Pressure should be released near the termination of through holes to prevent breakthrough. Cutting edges must be kept sharp to prevent poor surface finish and undersized holes.

Specifications, working conditions, and suggested drill bits are summarized in the chart below.

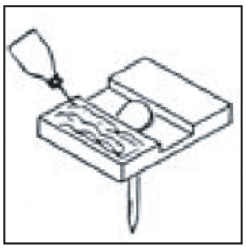
Specifications & Working Conditions Chart for Drilling

Method	Applications: Advantages/ Disadvantages	Recommended Blade/Bit Goemetry	Recommended Working Conditions	Recommended Blade/Bit
Drilling	For all holes up to 1" diameter. Larger holes can be cut with a hole saw.	Carbide-tipped, high helix preferred. Angle at tip: 100°- 110°. Pitch angel: 30°	Cutting speed: 150-1,000 FPM (defined as PRM x circumference of bit; smaller diameter runs faster). Feed rate: .001- .010 in./rev. (rate should be decreased as depth increases).	1. Do-All D-175B high helix 2. Plasdrills

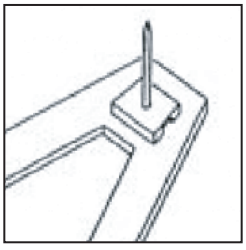
Concealed Fastening on Brickwork of Cut-Out Advertising Letters & Figures Made Out of Ion PVC

The system described here is a method of concealed fastening, not visible to the observing public. For the sake of aesthetics, a certain distance between the type print and the backing wall is often desired, whereby the system is ideally suited. The mounting is quick, easy and inexpensive.

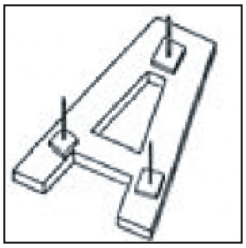
The system consists of square mounting plates constructed out of Ion PVC with an encased pin or special nail for brickwork.



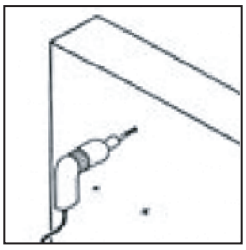
Construct a mounting plate with Ion PVC as shown. Drill hole 2.5 times larger than shank of the pin, but smaller than the head of the pin. Apply THF solvent to upper side of mounting plate with an acrylic glue applicator bottle.



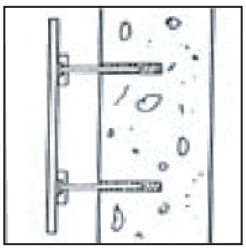
The treated side of the mounting plate is pressed into position of the Ion PVC cut-out letter and pressed firmly. Run a bead of the THF solvent around the seams of the pad and the letter and let the capillary action drag the solvent into the seam.



Repeat step 2 for the desired number of fastening points according to the letter type and size.



Mark the fastening points on the wall to be decorated. Holes, which are sufficient in diameter to hold the nail or pin, are drilled with an impact drill.



The holes are filled with mortar, a curable plastic material or a prime filler. The letter with the attached metal pins is then pushed into the prepared holes, holding the desired distance from the wall.

Outdoor Use

Ion PVC is recommended for temporary outdoor applications up to one month.

Thermal Expansion

Expansion/Contraction (in.) vs Temperature Change for Common Sheet Sizes				
Total Temperature Change (°F)	48 inches	60 inches	96 inches	120 inches
20	.032	.040	.064	.079
0	.064	.079	.127	.158
60	.095	.119	.190	.238
80	.127	.158	.253	.317
100	.158	.198	.317	.396
120	.190	.238	.380	.475
140	.222	.277	.444	.554

Calculate maximum expansion for the length of the panel

Total contraction during winter temperatures is calculated as follows:

- Maximum winter temperature change x coefficient of linear expansion x sheet length =

Total expansion during summer temperatures is calculated in the same manner:

- Maximum summer temperature change x coefficient of linear expansion x sheet length =

Calculate maximum expansion/contrction for width of panel in the same manner

Total contraction during winter temperatures is calculated as follows:

- Maximum winter temperature change x coefficient of linear expansion x sheet length =

Total expansion during summer temperatures is calculated in the same manner:

- Maximum summer temperature change x coefficient of linear expansion x sheet length =

Holes

Holes diameter = Expansion/contraction + bolt shank diameter

Length = Expansion/contraction + bolt shank diameter

THERMOFORMING

Ion PVC is a slightly expanded thermoplastic sheet material which may be thermoformed by all conventional methods and techniques. Standard machines used for thermoforming work with Ion PVC.

With regard to forming capability, extensibility, and detail definition, Ion PVC has certain limitations. The air entrapped in the closed cells cannot be plasticized by the heat and can affect the molding and stretching of the sheet. Ion PVC is most suitable for large-faced and smoothly-contoured parts.

Draw ratios between 1:1 and 1:1.25 are readily attainable with Ion PVC. Larger ratios can be accomplished with auxiliary equipment such as plug assist or pressure assist forming. The radius and depth of draw is generally limited to the extent that the surface of the material can stretch.

Heating Cycle

Because Ion PVC is moderately expanded, it reacts differently than solid plastic materials and the working cycle is generally shorter. Small panel ceramic or quartz sandwich heaters are the most efficient type of heating. Care must be taken to not overheat the surfaces during the heating cycle in order to avoid degradation.

For more uniform temperature distribution, preheat Ion PVC material in a circulating air oven at 140° F.

Processing Temperatures

Thermoforming Processing Temperature Range									
1		2		3		4		5	
Mold & Set Temperature		Lower Processing Limit		Orienting Temperature		Normal Forming (core) Temperature		Upper Processing Limit	
°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
115	46	240	116	260	127	275	135	350	177

1. Mold & Set Temperature:

The Set Temperature is the temperature at which the sheet hardens and can be safely removed from the mold.

2. Lower Processing Limit:

This is the lowest temperature possible for the sheet before it is completely formed. Material formed at or below this temperature could have severely increased internal stresses that later can cause warpage, and lower impact strength.

3. Orienting Temperature:

Biaxially orienting the molecular structure of thermoplastic sheet approximately 275% to 300% at these temperatures and their cooling greatly enhances properties such as impact and tensile strength.

4. Normal Forming (core) Temperature:

This is the temperature which the sheet should reach for proper forming conditions under normal circumstances. The normal forming temperature is determined by heating the sheet to the highest temperature at which it still has enough strength to be handled, yet below the degradation temperature.

5. Upper Processing Limit:

The Upper Processing Limit is the temperature at which the sheet begins to degrade or decompose. It is crucial to ensure that the sheet temperature stays below this temperature.

Rules to Follow When Designing Molds

1. Make your part no bigger than absolutely necessary.
2. Make the ratio of part height to part minimum width as small as possible.
3. Make all outside radii and inside fillets as large as possible.
4. Allow as much draft on all parts as possible.
5. Always design to a reference point in the mold for trimming or hole placement.
6. Mold in details, such as ribbing or domed surface, for adding stiffness.
7. Design in details for positioning other components to be added.

Mold Construction

When deciding between Male or Female molds one should take into account the following points:

- Which side of the part needs the detail?
- Male molds are cheaper than female molds.
- Closer tolerances can be held on male molds.
- With female molds, the flange area wall thickness is the greatest while the bottom of the cavity is the thinnest. By using a male mold, this thickness variation is just the opposite.

Tips

- Provided it is stored indoors or properly sheltered, Ion PVC does not need be dried before forming. It does not absorb any hydroscopic moisture.
- Plug-assist forming, using normal equipment, is necessary for more complicated shapes. Because of the lower heat capacity of Ion PVC, low conductivity materials must be used for the plug.
- Molds must be designed to facilitate ready flow of material. Sharp edges and narrow recesses should be avoided. Radii should not be less than 1.5 to 2 times the original sheet thickness.
- Double-sided (sandwich type) heating is strongly recommended, especially for thicker sheets, Ion PVC of 3 mm gauge and thicker can be thermoformed only with a double-sided heating arrangement. When heated above 150° Fahrenheit, sheets shrink slightly in the extrusion direction. Provide for the firm clamping down of sheets or for controlled slip-in.

STORAGE GUIDELINES

Ion PVC is to be stored inside in a dry and clean area. Material must be stored horizontally.

MATERIAL IDENTIFICATION AND INFORMATION

Ingredients	Precent (%)	Occupational Exp. Limits	
(Common Name)	(By wt.)[1]	(TWA) ACGIH	(PEL) (OSHA)
Polyvinyl Chloride	70-85	10.0 mg/m^3	15.0 mg/m^3 Total [(1)] 5.0 mg/m^3 Resp. [(1)]

This product is an "article" as defined in 29 CFR 1910.1200. It will not result in exposure to hazardous components under normal conditions of use.

Physical Properties

- **Appearance and Odor**: Odorless, plastic sheet
- **Melting Point**: >350°F
- **Specific Gravity**: 0.5 - 0.9 g/cm^3 range
- **Solubility**: Insoluble in water

MSDS Information:
Fire and Explosion Data

- **Auto Ignition**: N/A
- **Flash Point**: (ASTM D-1929) >700°F
- **Extinguishing Media**: CO_2, dry chemical, or water spray
- **Special Fire Fighting Procedure**: Self-contained breathing apparatus should be worn
- **Unusual Fire & Explosion Hazards**: PVC will burn in the presence of supported combustion, and will emit hydrogen chloride gas, benzene, water, carbon monoxide, carbon dioxide, and smoke.

Reactivity Data

- **Stability**: Stable
- **Incompatability**: None Known
- **Decomposition Products**: Reference "Unusual Fire and Explosion Hazards"
- **Conditions to Avoid**: None Known

Health Hazard Data

These products are not considered to be a health hazard in the form in which they are sold (sheet, panel). However, if these products are abraded, melted, welded, cut or processed in any manner that causes release of fumes or dusts, hazardous levels of fumes or dusts may be generated from these materials or constituents of these materials.

Effects of Overexposure

- **Acute**: Physical irritation of the eyes may result from overexposure to high concentrations of dust or chips from certain fabricating operations.
- **Chronic**: Studies have shown that workers exposed for long periods to high concentrations of respirable PVC dust may retain the dust in their lungs. There is no evidence of a toxic response associated with such PVC dust retention.
- **Special Precautions**: Avoid prolonged inhalation of high dust concentrations and ingestion of material. Wash hands before eating, drinking or smoking. Wear proper eye and respiratory protection when working in areas of high dust concentrations. Care should be taken during thermoforming operations. When temperatures exceed 350°F, decomposition of the material may occur.
- **Emergency & First Aid Procedure**: If contact with eyes, wash immediately under water for at least 15 minutes. For inhalation exposure, remove to fresh air. Contact a physician.

Storage, Handling and Disposal Data

- **Waste Disposal**: Care must be taken when using or disposing of material debris to prevent environmental contamination. Dispose of the debris in accordance with the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act and all state or local laws/regulations regarding disposal.
- **Storage and Handling Precautions**: Store in a flat dry area. Exercise caution in all thermoforming procedures.

Personal Protection Data

- **Primary Routes of Entry**: Inhalation and ingestion
- **Respiratory Pretection**: An approved NIOSH/MSHA respirator must be used when engineering controls cannot be implemented to control dust concentrations. Reference OSHA 1910.134 for specific requirements.
- **Ventilation**: Local exhaust. Reference OSHA 1910.94f or specific requirements.
- **Eye**: Eye protection must be worn when working in dust concentrations and during sawing or other operations which might cause flying debris. Reference OSHA 1910.133 for specific requirements.
- **Protective Glove**: Gloves should be used to prevent cuts or scrapes.

Regulatory

- **Reach**: Pursuant to Title II article 7 of the regulation this product is exempt from registration and notification and is therefore compliant with the REACH regulation.
- **RoHS**: Ion PVC products are compliant with the RoHS standard.

Important

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