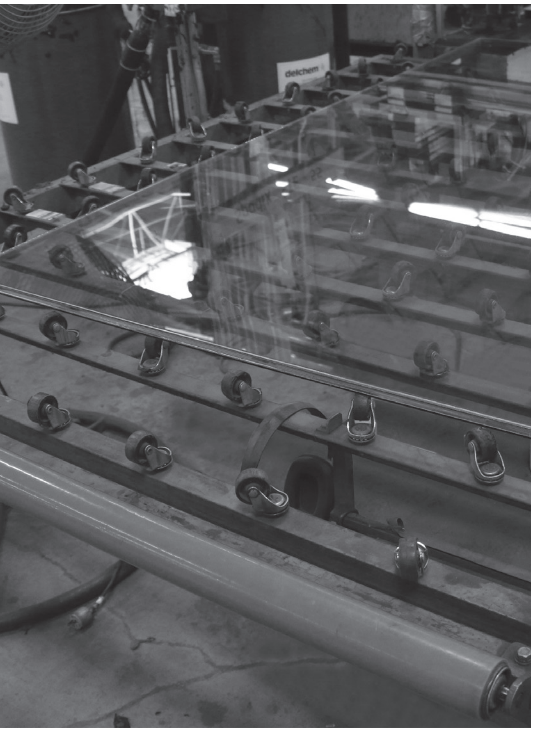
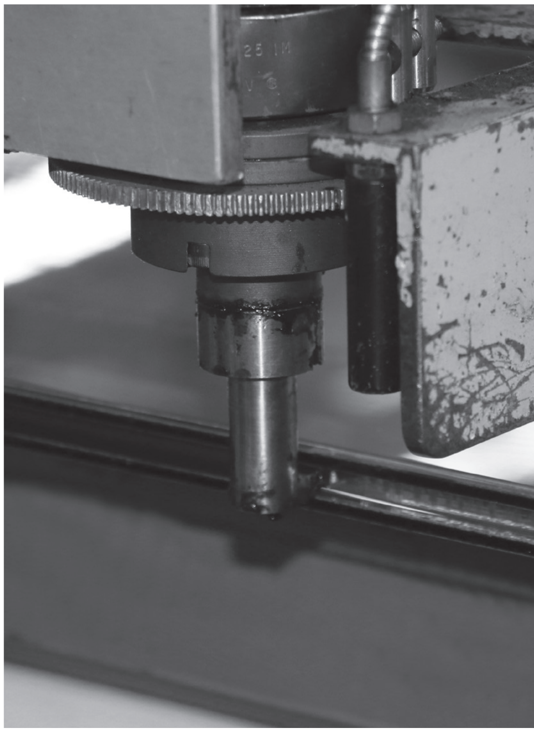
Commercial Sealants & Waterproofing

Insulating Glass Application Guide





EnerEDGE®

warm-edge spacer

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I. Basic Use of the EnerEDGE® Warm-Edge Spacer Product and Function of Its Elements

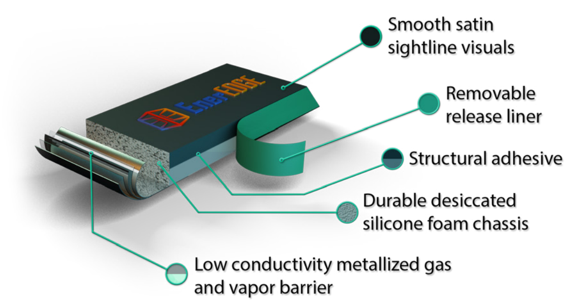
The EnerEDGE product is a warm-edge insulating glass spacer intended for use in a wide range of insulating glass constructions, primarily in fenestration applications. As supplied, it consists of four (4) functional elements:

i. The cellular silicone rubber spacer chassis, which is pre-desiccated to initially dry the IG's airspace and assure a long service life when over-sealed with a quality, low permeance IG sealant.

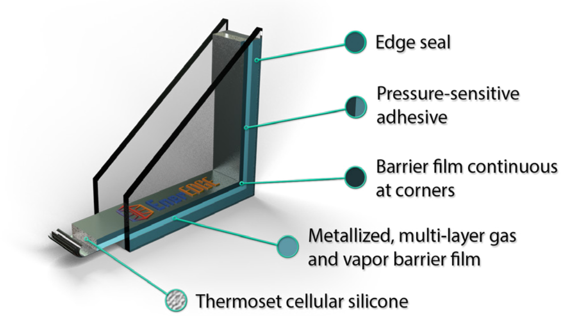
ii. An outboard metallized foil barrier (laminated to the cellular foam spacer chassis), which acts as a gas barrier, protecting both the airspace cavity from water vapor ingress and preventing cavity loss of insulating fill gases.

iii. Two strands of protective release liner, which are removed for spacer application and discarded.

iv. Two bands of the bond line adhesive, which is an acrylic Pressure-Sensitive Adhesive (or PSA) designed to bond immediately to glass, allowing quick handling in processing and glazing.



EnerEDGE warm-edge spacer



Typical glazed application of spacer

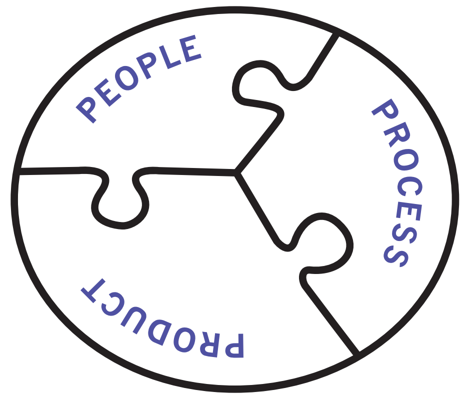
These elements work in concert with the applied perimeter applied sealant to create the following:

- Separation of the multiple glass lites used to create an insulating glass unit
- A cavity that can remain gas-filled for the long term, to further enhance thermal performance
- A very low edge conductivity within the IGU (insulating glass unit), via the cellular structure
- A pleasing perimeter sightline, with high aesthetics and color flexibility
- A perimeter structure to which muntins and attachments can be affixed, enhancing daylight opening aesthetics
- A confined pocket to receive the sealant and avoid primary sealant ingress, typical of traditional dual seal systems that use PIB strands
- A finished IGU structure that allows for effective resistance to glazing pressure within a sash

II. Overview of Necessary Inputs for IG Production

Application of EnerEDGE Warm-Edge Spacer requires the synchronized readying of the three (3) critical P's typical of most production systems: Product, Process and People. These are detailed as a quick reminder below:

- **PRODUCT:** Besides spacer, a serial rack of cut-to-size glass pairs, grids and attachment clips, fill gas, accessories and the applied sealant are all needed to be readied in an organized fashion.
- **PROCESS:** Items supporting a capable process are production requirements documents, product application manuals and bulletins, optional low-e coating deletion equipment, glass cutting and washing equipment, conveyors, application and topping stations, compression press, labeling devices, gas filling equipment, secondary seal application equipment, transport racks, and QC support equipment such as dimensional gauges, and gas-fill validation.
- **PEOPLE:** Trained and supervised operators, line management, IGU QC and technical personnel plus vendor support technical teams are all involved in a sustainable IG production system.



III. General IG Work Area Items for Awareness and/or Avoidance in the Fabrication Process

A. ISOLATION AND TEMPERATURE CONTROL

It is generally good practice to locate the IG assembly area in an area that has some physical isolation from the general production operations. In the IG process between washer exit and assembly topping, it is a good practice to locate in an enclosed, positive pressure environment with a sealed floor to mitigate airborne dust from sash and frame fabrication processes or receiving/shipping areas that allow airborne contaminants into the IG fabrication area.

One item that is sometimes questioned *but is not a serious risk requiring mitigation* is the ambient environment's atmospheric moisture. Even in relatively humid seasons and climates, this is handled by the desiccant within the spacer, as long as the spacer is protected during application and between usage extractions. It is more effective to isolate the individual spools in use, rather than attempt to control the entire IG fabrication area.

Temperatures for IG fabrication are best if between 60 to 100 °F (15 to 37 °C).

B. COMMON CONTAMINANTS TO AVOID

Additional precautions should be taken also to avoid **airborne contaminants** that might be intentionally or inadvertently introduced into the clean assembly room/area. Items to be vigilant against are as follows:

- Spray lubricants containing oils or silicone fluids that will inhibit adhesion of spacer or applied sealants, as these are often difficult to wash away and/or see the immediate effects of.
- Food Items: In addition to being a workplace hygiene concern, this also brings a risk of glass, bond line or airspace contamination with food and beverage traces unintendedly getting into or on the sold products.

Carefully inspect IGU assembly areas daily to guard against unexpected contamination.

Lastly, a daily housekeeping review and implementation of a 5S visual work area control system will assure that the efforts established through the above will be maintained.

IV. Glass Lite Fabrication Recommendations

General glass preparation recommendations applicable to most common insulating glass systems surround the sub-processes of cutting, coating edge deletion and cut lite handling:

A. GLASS CUTTING:

- Best practice dictates using only approved cutting fluids from either the water-soluble or full-flash cutting lubricant. These will either fully wash or evaporate away once the washing process is complete.

> **TECHNICAL ALERT:** See Technical Service Bulletin No. G 1.1, Section 3 on "Glass Cutting" for the list of approved cutting fluids, or request testing of an unlisted cutting fluid via Tremco Technical Services.

- Once the lites have been cut, glass-edge cut quality is to be monitored as a critical element of IGU durability. While it is a primary function of the perimeter sealant to ensure longevity, the cut-quality of the glass edge ensures a measure of control against premature stress cracks in glazing and in service. Contact both your glass provider and your glass cutting equipment manufacturer for tools to identify and guard against cutting defects (such as rough cuts/shark's teeth, serration hackle deeper than 25% of thickness, flare or wings), as well as best practices on cutting wheel selection by wheel diameter, glass thickness and coating types in use.

B. LOW-E COATINGS AND EDGE DELETION:

- It is recommended that vapor deposition coatings be edge deleted, as best practices should consider the risks associated with possible ingress of water and acidic solutions. This is the key driver in our recommendation to delete soft coat low-e.
- While ultimately it is the decision of the IG fabricator to delete a coating, recommendations should be sought from the providers of the coated glass and applied spacers and sealants used.

> **TECHNICAL ALERT:** See Technical Service Bulletin No. G 1.1, Section 4 on "Recommendations Regarding Adhesive Compatibility and Edge Deletion of Coated Glass" for detail on best practices associated with low-e use.

V. Glass Washing and Drying

A. INPUT GLASS RACKS

Input glass racks should be organized to present the cut sets of glass in the desired order of production. Care should be taken to ensure that the washer's capability to handle any variation in glass thicknesses is within the glass washer's capabilities.

B. WASH WATER TEMPERATURES, DETERGENT USE, RINSE WATER HARDNESS AND DRYING

The glass washer needs to provide the following requirements:

- Wash water temperature should be in the range of 120 to 140 °F (48 to 60 °C).
- Detergent use should be minimized, as benefits diminish if completeness-of-rinse is compromised in any fashion. A quick check is to see minimal foam in the wash tank, and no foam in the primary/first rinse tank.
- Best practice for a clear final rinse is via a non-recirculating system, if only for surety of low mineralization of dissolved solids; final rinse hardness should be <50 ppm as best practice, with progressive potential interference with sealant adhesion up to <200 ppm. Treatment systems to reduce rinse water mineralization through de-ionization or reverse osmosis are recommended if hardness exceeds 200 ppm. Water softeners are generally to be avoided, as these systems exchange, rather than remove mineralization.
- All spray nozzles in all washer sections are to be free-flowing to completely cleanse the glass and brushes.
- The air drying section needs to be supplied through clean blower filters to minimize contamination and maximize airflow. Generally feed glass lites coating-up at shallow angles to the washer's air knives, in order to maximize air-curtain water removal and drying potential.

The final requirement is to supply clean, dry glass at production requirement speeds/Takt times.

TECHNICAL ALERT: See Technical Service Bulletin No. G 1.1, Sections 5 and 6 for information on glass washing, and in particular Section 7 on "Tests and QC to Help Assess Glass Cleanliness."

VI. EnerEDGE Warm-Edge Spacer Materials (Size Selection and Care of Product)

A. SIZE SELECTION

Size selection of spacer is straightforward in that sizing provided is pressed to obtain the nominal dimension present in the part's description. Care should be taken in advance to select the size of the spacer to best satisfy the desired unit thickness required.

- First determine the full acceptable range of the finished overall thickness of the assembled and glazed IG unit, considering the maximum and minimum allowable range for the finished IGU.
- Determine the nominal mid-point of this range; this will accommodate symmetrical tolerances.
- Subtract the total glass thicknesses from measurement of typical "as actually supplied"; avoid use of only industry nominals which often are not the statistical midpoints.
- Compare the desired airspace to available sizes, and verify that the resulting assembly will be acceptable when finished and delivered as a finished IGU to glazing.

TECHNICAL ALERT: See Technical Service Bulletin SSG 1.1 for a listing of EnerEDGE Spacer Dimensions.

B. CARE AND STORAGE OF SPACER PRODUCT

Care of both the unopened and open spools of EnerEDGE Warm-Edge Spacer are as follows:

INITIAL INSPECTION AND PRE-USE STORAGE:

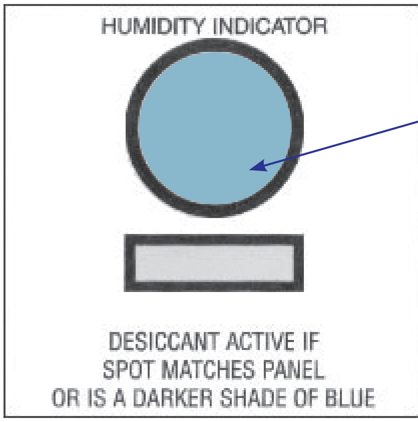
- Receive and store boxes of EnerEDGE in a vertical orientation to keep winding pattern intact.
- The EnerEDGE materials are supplied on spools within sealed, low permeability bags that protect the critical desiccating function of the spacer. Inspect the supplied boxed spools for shipping damage upon receipt, should a freight claim need to be filed.
- Store material off the floor on pallets until eminent use is intended; then condition a day in advance to use where temperatures are in the range of 65 to 90 °F (18 to -32 °C).
- While the shelf life of the product is 3 years from the date of manufacture, do not open multiple spools of the same size in advance of use.

STORAGE AND CARE of EnerEDGE DURING USE:

- When opening the foil bags for initial use, trim just within the heat seal to provide sufficient surplus bag material for resealing.

Opening Bag

- Also within the packaging are paper stock **humidity indicator cards**.
  - When opened and immediately viewed for a normal **BLUE color spot**, the indication is that the package has remained dry during transit and storage, and is a confirmation of a good bag seal and usable product.
  - A **PINK indicating spot** within the card means that the product within that spool has been exposed to moisture and suffered a loss of desiccant activity.



Note “Blue-in-circle” as “GOOD” and “Pink-in-circle” as “CONCERN”; rectangle is the reference blue for “GOOD”.

If the humidity indicator card shows pink when the box is opened, perform the desiccant activity test found in the Appendix of this manual. Contact Tremco Technical Service for assistance if needed.

TECHNICAL ALERT: Review Technical Service Bulletin IG 5.1 covering EnerEDGE Desiccant Test Kit and Instructions (see appendix).

- Lidded spool stands ready the spacer for dispensing but also protect the spacer during use by limiting open exchange of ambient airflow with the exposed surfaces of the spooled product. This limits true open time to less than 15 minutes (versus hours) while a single spool of a particular size is in use.

Limit spacer open time before IG assembly to 15 minutes, and time after IG assembly, (but before sealing) to 30 minutes.

POST-USE STORAGE OF EnerEDGE SPOOLS:

- Return the unused material spool to (1) a Tremco-supplied storage drum, or (2) an intact foil bag and reseal for undefined future use within shelf life.
- Spools for immediate reuse in daily/future shifts can be returned to poly bags and twist-tied as a short-term protective seal.

VII. Equipment for EnerEDGE Warm-Edge Spacer Application

A. Robotic/automated application steps are proprietary to each automated equipment manufacturer supplying an integrated system. Details on these are left to discussion by manufacturer and are outside the scope of this manual; other recommendations apply.

B. Basic manual application using trained operators with pneumatic hand tools and semi-automatic air float tables deals with the semi-automatic, operator-based application equipment using air float handling of the applied lite, the covered reel stand, a stripper to remove the release liner (photo below), plus one of multiple pneumatic notching hand tools for application.

ROBOTIC APPLICATION EQUIPMENT PROVIDERS:

Bystronic:
www.bystronic-glass.com

Erdman Automation (including IGIS line):
www.erdmanautomation.com

Forel:
www.forelspa.com

Lisec:
www.lisec.com

Semi-automatic to manual application

General preparatory steps to starting spacer application are as follows:

Familiarize yourself with the operation of the liner stripper. This device must remove the two strands of release liner at the rate that the operator consumes spacer as it is pulled through after each corner during the application cycle. Instruction sheets for support of these devices should be consulted for details.

C. Selection of corner notch type and supporting hand tool

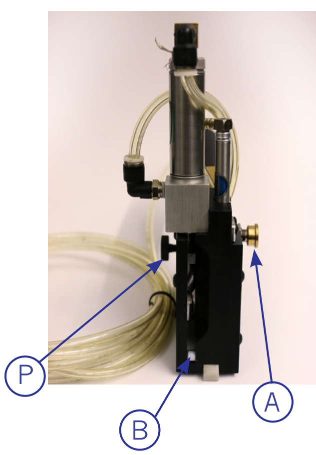
Hand Tool Selection is based on desired corner notch style, and is dependent on sealant type; see general options that follow:

- **Inside notching** removes a small diameter slug inboard of the foil barrier, preserving the integrity of the foil barrier at the three notched corners.
  - This corner notch type is required for use with sealants where permeability is 3 to 6 g/m^2/day, (where ¼" (6.4 mm) minimum inset of applied seal coverage is required). It can be used elsewhere as best practice for maximizing unit longevity and with any suitable sealant; see Section 13 for further discussion.
- **Outside notching** refer to manufacturer instructions with tool and contact Tremco Technical Service with any questions.
- All foam spacer application tools are "right handed" and trace the glass in a clockwise fashion, right-to-left on the tables.
- For either selection, verify that the application area, the application table and especially the tools are clean and contaminant free, and that the table's air floatation, glass lite suction and/or rotating and glass cup indexing functions are all operational to the equipment manufacturer's specifications and required levels of maintenance.

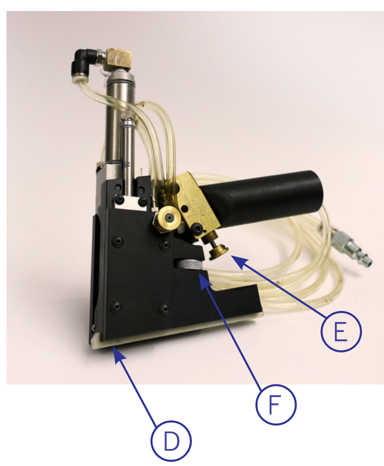
VIII. Hand Tool Application and Corner Notching Techniques

A. INSIDE-NOTCHING HAND-TOOL SET-UP (INSIDE PUNCH TYPE)

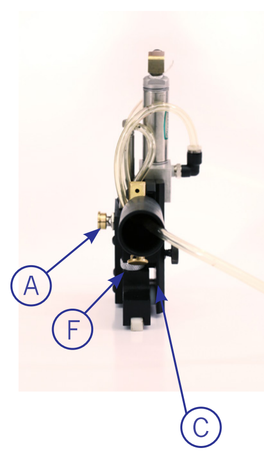
Front View



Outside View



Back View



Referenced Parts:

A. Final Cut Trigger (brass)

B. Bottom Guide Roller

C. Down-Pressure Wheel

D. Guide Block

E. Notch Trigger Button (brass)

F. Knurled Wheel for Down-Pressure Adjustment

P. Pressure Wheel Locking Screw

Tool Marking Legend:

G. GLASS EDGE start marker

- This is the trailing edge of the black runner base

P. PRESSURE wheel locking screw

S. SPACER END start marks at rear

- White for 3/16” (4.8 mm) inset
- Yellow for 1/4” (6.4 mm) inset

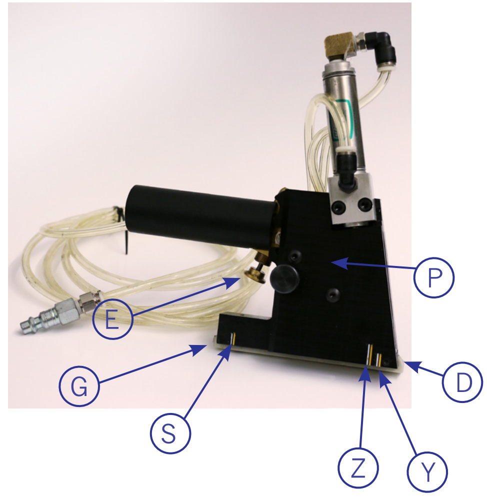
Y. CORNER punch marks at front

- White for 3/16” (4.8 mm) inset
- Yellow for 1/4” (6.4 mm) inset

Z. FINAL cut marks

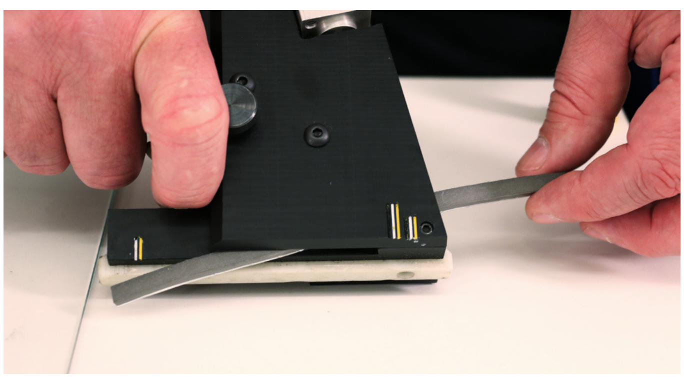
- White for 3/16” (4.8 mm) inset
- Yellow for 1/4” (6.4 mm) inset

Inside View

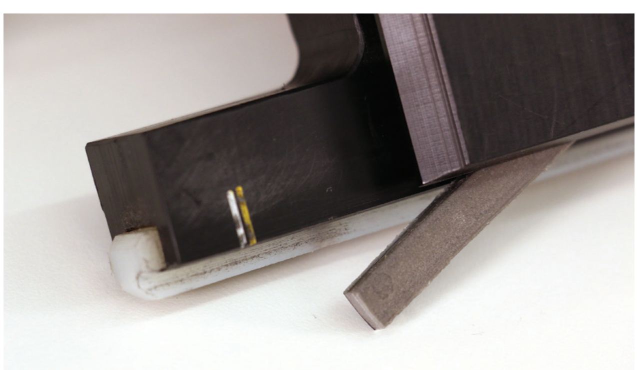


Spacer set-up of inside-notching hand tool
Set the down pressure of the tool for a particular airspace size:

1. Loosen the Knurled Wheel F clockwise to open the spacer path after loosening Pressure Wheel Locking Screw P.
2. Feed the spacer through the tool from the left through the front of the tool, between the Bottom Guide Roller B and the Down Pressure Wheel C.
3. Readjust the Down-Pressure Wheel ‘down’ to allow for 1/32” (.8 mm) protrusion of spacer below tool base that allows for adhesion of the spacer.



Feeding spacer through inside notching tool



Pre-cut start for corner, front notch

Prep the starting end of the spacer by cropping a short length of tape from the leading edge of a fresh spool, in order to establish a clean square cut (for the ultimate finish at the 4th corner) as follows:

4. With the foil-side of spacer facing the operator, feed the spacer through the tool from the front, until the spacer is through the tool; hold the spacer flush to be parallel to the Guide Block D.
5. Use your thumb to first action Cutting Blade Trigger A; this cuts through full section.
6. Spacer is now cropped and ready to apply at the starting corner.

Application sequence from the starting corner:

7. Position the tool's Guide Block D against the applied lite at the start-stop corner, and align the trailing edge (Start-Marker G) of the black base with the glass.

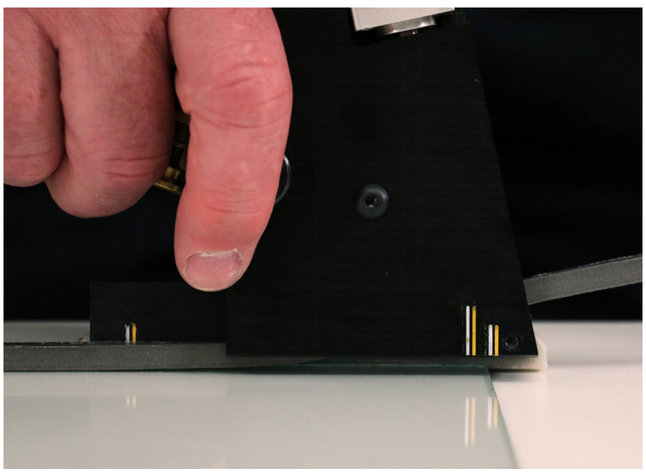
8. Feed spacer through to the tool's Start-Mark S at back of tool:

    - White for 3/16" (4.8 mm) inset

    - Yellow for 1/4" (6.4 mm) inset

9. Tack the trailing edge to the glass using your forefinger.

Start of application



Corner notch indexing

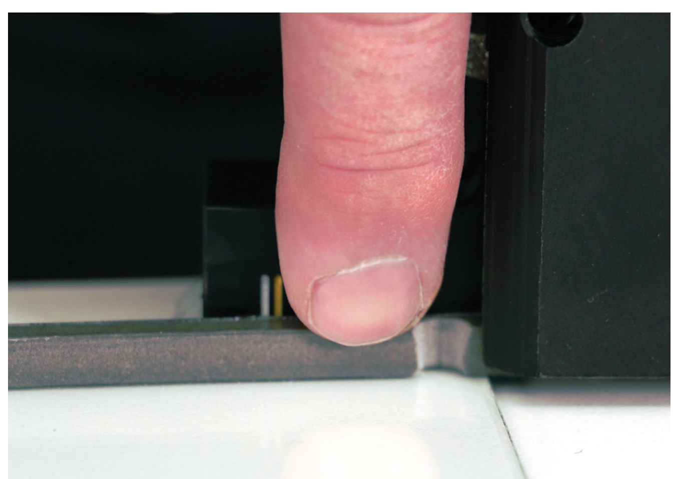
Application of spacer to glass edges, through one complete rotation cycle:

10. Support spacer being fed into the tool with left hand, while at the same time guiding the tool from right-to-left to the next corner; light down pressure to the spacer as well as against the glass edge is all that is needed.

11. Stop where Corner Punch Mark Y at the front of tool aligns with the next glass edge (White for 3/16" [4.8 mm] inset, Yellow for 1/4" [6.4 mm] inset), and pull Notch Trigger E.

12. Rotate the glass by releasing it from the table, while still keeping tool on the side just applied (use of a right hand forefinger can assist in keeping the tool in place at this desired position).

13. Advance tool along edge just finished until the full notch is exposed; then tack the right side or trailing edge of the notch with tip of the forefinger.



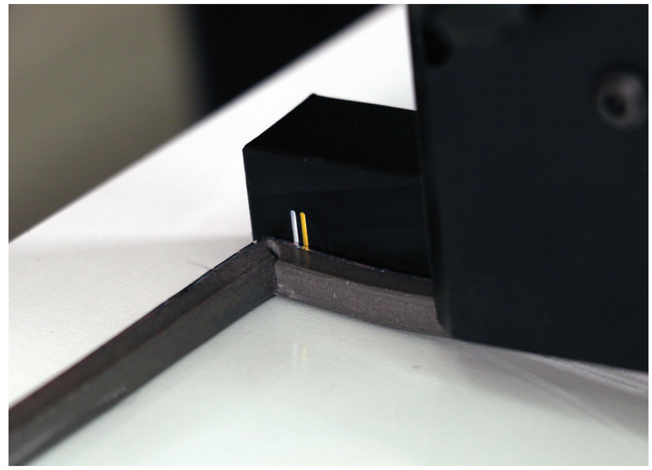
Tacking behind corner notch

14. Advance the tool further still until front of tool is about 1.5” (38 mm) past the glass edge.

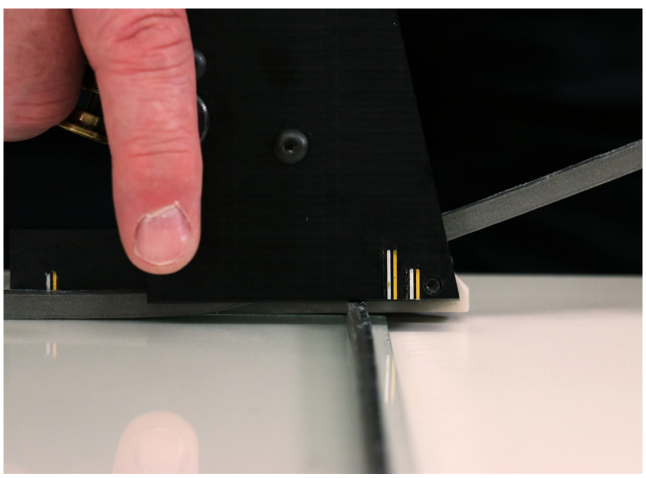
15. Tilt and turn the tool up and around (out of plane with the glass), rotating and pivoting around the point in space that is the outside of the spacer’s miter. This keeps adhesive from transferring to the glass at the sealant channel in the corner.

16. Once rotation to a full 90° is complete, also tack the left side of the notch to the glass to enable the application for the next pass.

17. Repeat steps #10 through #16 for sides 2 and 3.



Rotating at corner



Final indexing and lift

Side #4 and final corner’s spacer cut-off:

18. Apply spacer as on the three previous edges, but lift up at the point where the tool would contact the start-point application; advance the tool while above the starting point of the spacer until Final Cut Marks Z align with glass edge (White for 3/16”, Yellow for 1/4”).

19. Cut through full spacer by Trigger Button A.

20. Pull the tool off the spacer and align and tack together the spacer end. Apply barrier tape at the appropriate step with respect to gas-filling.

IX. Muntin and Capillary Tube Insertion

After the inset application of spacer is complete, the optional accessories to be added commonly include muntin bar/grid/Georgian bar assemblies and capillary tubes.

A. Muntins and Muntin Installation: These recommendations cover obtaining assurances that muntin materials, finishes and touch-up coatings are low volatility, determining muntin cutback and use of proper muntin end clip materials.

- ***Clean and Dry Muntin Components:*** Be sure that the muntin bar stock is low in volatility; customary painted aluminum has little risk, but polymer stock and all organic finishes need to be free from volatiles that could pose a risk to passage of the volatile fog portion of testing to your applicable IG standard. The same concern applies to muntin end clips, which further require the material to be hydrophobic so as not to adsorb and release water vapor as added moisture loading for the spacer desiccant to handle.
- ***Muntin Cut-Back:*** This concerns the planning for the routine under-sizing of muntin cut lengths for bars within the muntin assembly. It is dependent on four factors:
  - The ***height of spacer*** used, typically 3/16" (0.187" = 4.8 mm) or ¼" (0.250" = 6.4 mm); this is doubled for the two heights across or down.
  - The ***inset of the spacer*** from the glass edge; this is doubled for the two heights across or down:
    - typically 3/16" or 4.8 mm for hot melt butyls, and
    - typically ≥ 1/4" or 6.4 mm for higher permeance sealants/plural components.
  - The end-clips' base thickness of 0.045" (1.14 mm); this is doubled for the two clips across or down.
  - Lastly, the recommended insertion clearance of 1/32" (0.031" = 0.79 mm).
  - For most common constructions, muntin cut-back offsets can be selected from the chart below:

Muntin Cut-Back Recommendations / Example Calculation Results

(IG Manufacturer to verify calculations with actual component dimensions specified)

	EnerEDGE Standard-Height Spacer 3/16" (4.8 mm)	**EnerEDGE Pro** Heavy-Height Spacer ¼" (6.4 mm)
Use with low-perm hot melt butyls, allowing application inset of 3/16"	***7/8" (0.875" = 22.2 mm)***	***1" (25.4 mm)***
Use with higher-perm sealants, requiring an application inset of 1/4"	***1" (25.4 mm)***	***1-1/8" (1.125" = 28.6 mm)***

- ***If muntin cutback is too great,*** then the fit will be loose and engagement of the muntin clip's lip to the acrylic sealant too little. Muntin assemblies risk misalignment or movement in shipping or service.
- ***If muntin cutback is too little,*** then the fit will be too tight, forcing difficult insertion, spacer lean, reduced and compromised sealant depth and moisture vapor path (MVP).

B. Muntin component assembly:

Following the determination of cutback rules and calculation of grid cut lengths specific to each glass lite, muntin stock can be cut to actual required lengths. Be sure to avoid cutting lubricants that might contain slow-flashing volatiles that could jeopardize passage of volatile fog testing. Assembly with intersection cross joiners (available from your grid supplier) can proceed, and proprietary, spacer-specific end-clips can also be inserted. These come in a variety of designs to accommodate both the insertion detail needed to mate with each grid profile used, as well as in a variety of offsets to reasonably center the muntin assembly within the airspace cavity.

Be sure to verify that all clips fit snugly with the same orientation relative to lip facing down for contact to acrylic bondline adhesive at insertion. Touch-up painting should be minimized and is only permitted if it poses no risk in volatile fog testing failure.

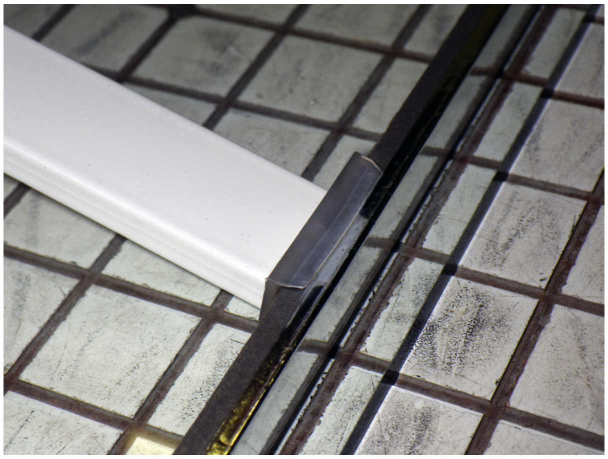
Lastly, stage the assembled muntin assemblies on portable grid racks that present these in the desired order of sequence, right at the point of assembly (at topping station or optionally "drop-only," just after spacer application is complete).

C. Muntin assembly insertion:

Consider where to best drop the grid assemblies and then where next to align the grids in terms of the application and topping stations (these functions can be considered separately to minimize unit-to-unit cycle time). Gloves can be worn to avoid touching the glass surfaces. Large muntin assemblies and the topping that follows require easy access, so wide units need an easel or tilting topping table. Square the applied lite against table or easel's squaring stops, preferably with vacuum assist to secure the applied lite.

- First position the muntin assembly to lightly fit completely within the traced perimeter that the spacer creates as a border.
- Next, align using the tilting topping table or easel's grid lines (via visual "best fit" parallelism).
- Firmly press into place to securely tack the grid clip to the acrylic bond line adhesive.
- If cutbacks were correct, the muntin assemblies should fit inside the spacer evenly relaxed without requiring the spacer to bend in or bend out.

D. Capillary tube use, preparation and insertion (limited and special usage)



Dropped grid inside IGU

The use of capillary tubes can be an option as a solution to physical design challenges posed by exposure to extreme temperature and resultant pressure changes and/or pressure changes commonly a result of elevation differences between point-of-manufacture and final installation site. Transportation period only elevation differences pose diminished risks, not on par with full service life differences that elevate glass breakage rates. Regardless of reason to deploy capillary tubes, risks related to the added processes are to be determined by the IG manufacturer as to suitability for purpose. Open capillary tubes are mutually exclusive to gas-filled IGU, but other solutions now exist to pressure-balance high altitude units that are argon-filled. Consult Tremco Technical Services for additional information.

In proceeding with capillary tube use, consider the following:

- Selection of capillary tube stock should be specified as soft, bendable and very narrow in diameter to avoid spring-back or kinking of the tubing; supply the workstation with typical 12” (30.5 cm) lengths. (This and longer lengths increase the length of the diffusion path created.)
- Inspect tubes to verify that cutting has not closed the inside opening.
- Tubes should be pre-bent using simple mandrel jigs to assure visual and functional reproducibility.
- Insert the tubes at the topping station just before or just after the top glass lite is applied and secured.
- Develop detail so that insertion is within the airspace and not against the glass where the contact will interfere with perimeter dual-sealing that could create a path for moisture vapor ingress. For example, the center of the 4th corner is one option, where upon exit, the tube follows the backside of the spacer for the majority of the tube’s length and passes through the sealant cavity near its end. This will assist in securing the tube during transport and glazing.

X. Topping of IG Spacer to Applied Lites

The equipment needed to receive the applied lites (now with spacer, muntin bar assemblies and optional capillary tubes) includes either a tilting air float table with grids, an off-line vertical easel as an alignment rack or an automated topping machine, press or multi-functional gas press. Recommendations for manual topping and final IG assembly are as follows:

i. Verify that applied lite is square to topping stops/blocks/guides, and that these parts are all in good condition and not excessively worn.

ii. Assure that the cavity about to be enclosed and sealed is clean and free from debris; limited use of a clean and filtered air jet can facilitate this if dust or unplanned debris need quick, contact-free removal.

iii. Use two stops at the base and one along the vertical in most set-ups.

iv. Contact the acrylic adhesive and use firm hand pressure to set the adhesive in two or more opposing locations along the perimeter.

v. Advance the unit to the compression press to complete perimeter wet-out of the acrylic PSA.

XI. Final Post-Assembly Compression and Wet-out of PSA

After matching and topping assembly is completed, perimeter wet-out of the bond line's PSA is required. This requires that a platen or roller press capable of providing an over-compression or press-setting of minus 0.040" (1 mm) is in place and installed to perform this critical function; hand pressing alone is not an assurance that these two functions will reliably be met. Pressing over a wide range of plant temperatures is possible given the use of high performance acrylic adhesives with this equipment in place.

- **Under-compression** elevates the risks of "blow-by" or inadequate structure in green handling and may jeopardize gas retention pre-sealing, depending on methods deployed.
- **Over-compression** increases the risks of glass breakage, albeit small.

Use visual inspection to verify wet-out; proper compression will ensure that maximum structural integrity is immediately achieved and that applied sealant blow-by is avoided.

XII. Gas Filling Options

A. EQUIPMENT TYPES:

There are many types of gas filling equipment available that affect the sequencing and processing steps. These vary in the following ways; the control systems used to insure high fills, the stage in the IG assembly process when the filling takes place, and the flow rate at which gas-filling occurs.

- ***FILL CONTROL SYSTEMS**, time-fill vs. sensor-fill equipment:*
  - **Time-fill systems** consider the IGU's cavity volume to be filled (Volume required = L x W x air space), and then use time at a required flow rate. Charts or software dictate the times for filling. Volumetric gas flow meters are used to dispense the required volume of fill gas using the set flow rate and a time to dispense is specified for each unit (Volume required = flow rate [liters per minute] x required minutes to fill). Typical over-fill factors of 200 to 300% for low cost argon (to as low as 50% for expensive krypton), ensure that sufficient air is purged from the IGU's. Time-fill methods require a secondary means to verify that minimum fill percentage has been achieved if either timer set point or cycle completion is operator dependent.

- **Sensor-fill systems** are similar, but in addition to the inflow lance's stream have added a second stream to sample the exhaust gas and use technology to determine how close the unit is to being filled with the desired fill gas. This control system allows the user to target a minimum fill percentage, at which time the fill cycle stops and the unit can be barrier taped and perimeter sealed for unit completion. **Sensor-fill systems are recommended**. They provide direct, primary assurance that gas-filling is done to a calibrated minimum fill percentage. This creates the primary control that is so critical in ensuring thermal performance.

- ***FILL LOCATION WITHIN ASSEMBLY,*** *open-cavity, pre-topping vs. semi-auto one-hole or two-hole fill strategies:*
  - Open-cavity fill systems are via automated gas presses, and these devices sequentially both fill and assemble the entire IGU cavity within an enclosed chamber all at once. This requires that the barrier tape is in place at the 4th corner, prior to this automation step. The tape is usually applied immediately after application, at the same process station as where muntin insertion is handled.
  - One- and two-hole filling strategies usually depend on the barrier tape at the 4th corner being left off until gas-filling is completed and are done after pressing. The 4th corner is usually left open when used as the single access point for one-hole approaches, while two-hole systems usually utilize a pierced fill hole made at the base of the IGU that can recover and spring closed after filling, creating a zero-diameter penetration given the resiliency of the silicone spacer's rubber base.

- ***FILL RATES,*** *slow-fill vs rapid-fill equipment:*
  - **Slow fill equipment** types use flow rates ranging from 1 to 12 L/min.
    - A long, full-height tubular fill lance is passed through the open 4th corner, acting as the single top hole, and positions the open end of the lance to the interior base of the IGU.
    - This is done to create a slow, bottom-to-top laminar exchange of the heavier fill gas to float the air up and out the 4th corner hole at the top.
    - Most slow-fill equipment types use the relatively simple time-fill control systems
    - Krypton filling is commonly done via slow filling, given the expense of this gas and the need to absolutely minimize the overfill factor.
  - **Rapid-fill equipment** types typically use flow rates from 20 to as high as 200 L/min.
    - All automated gas-presses are open-cavity, rapid-fill systems
    - In semi-auto systems requiring operators, these systems vary considerably as to the technology used. These proprietary systems must ensure that either:
      - ↳ the exhaust gas (air) is removed via vacuum pump at the same rate that the fill gas is injected to avoid overstressing the glass lites and edge seal system, or
      - ↳ the exhaust hole is of sufficient diameter to vent at the same rate that is used to fill.

B. DETAILS RELATED TO GAS FILLING

- Effects of gas-filling gridded IGU with muntin bar in the airspace cavity:
  - Units with internal muntin bars usually have air-filled hollows that dilute the initial gas fill of the IGU cavity. This dilution occurs through diffusion immediately after gas filling and perimeter applied sealing is completed. As a result, it is recommended that you design your IG fill system to target initial fills that are 1 to 2% higher than might be targeted for IGU that were non-gridded. This will provide a single process for all IGU fabricated, regardless of the presence of internal grids.

- Barrier tape application before the over-sealing of gas filling holes:
  - This step is recommended at all 4th corner holes, and also in locations where punched fill holes are used. This prevents applied sealant intrusion and augments unit performance by keeping the barrier film intact whenever possible.
  - Barrier tape can only be eliminated at the lower fill-hole location in two-hole systems if (1) the fill-lance is a piercing-type narrow diameter lance and (2) the applied IG sealant used over this style of fill-hole is a low permeability, butyl hot melt sealant.
  - After gas filling is complete and working within a vertical harp cart from the top down, "tweezers-apply" ¾" (19 mm) lengths of the correct barrier foil tape in the right width for the airspace selected. The tape width must be undersized enough to not contact the glass, but also wide enough to completely cover the diameter of the fill-hole remaining after all lances are removed.

C. FILL-LEVEL VERIFICATION

- After units are gas filled to a targeted level, the IGU fabricator must determine what additional verification of fill level might be required. Sensor fill systems (one and two-hole, plus open cavity automation) provide a primary assurance of fill percentage through their operation, but time-fill systems usually do not. It is recommended that a non-destructive method such as the Gasglass manufactured by Sparklike be used. Intrusive sampling (directly for the fill gas or empirically for oxygen in the air) is also a technique that can be used. Consult with Tremco Technical Services for additional details.

XIII. Sealant Application

A. SEALANT FAMILY SELECTION AND INTERACTION WITH INSET

In general, the applied sealant has at least three major functions that should be considered when selecting a sealant type by polymer family. These functions are as follows:

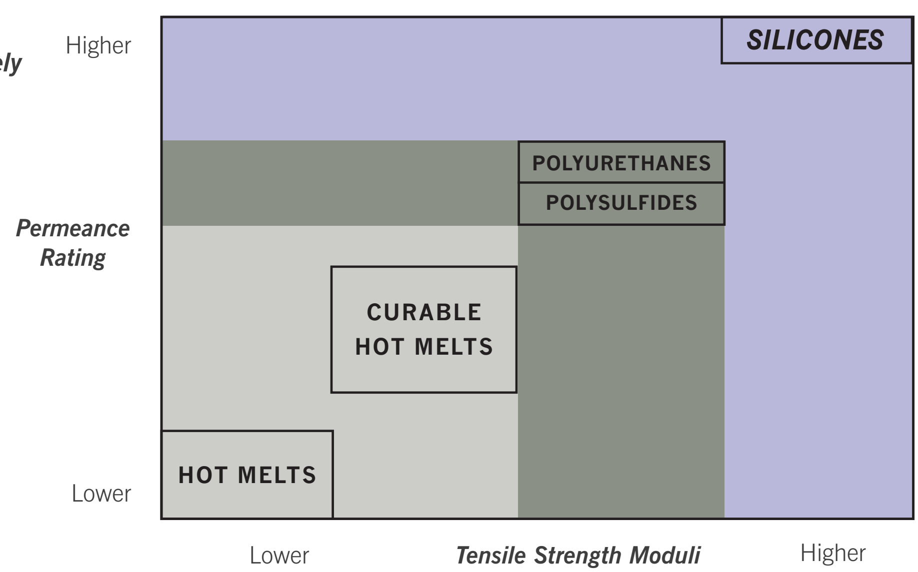
1. Create a waterproofing barrier for the IG seal to resist contact with unplanned liquid water or water-borne contaminants, which are sometimes present during IG shipment or after sash installation when water gets past glazing details. This function of a sealant (provided by its adhesion promoters) is generally validated through vendor R&D and certification testing, where condensed water substantially coats the unit perimeter during high humidity and weather cycling.

2. Slow the diffusion rate of "moisture in" and "fill gas out" across the applied sealant depth.

   - This item is well documented on most IG sealant manufacturer's Technical Data Sheets. Sealants with permeance ratings above ~3 g/m^2•24 hr generally demand a thicker inset for the applied sealant depth, given higher values. Sealants with very low permeance ratings might be looked at as being able to be applied in very thin inset depths, but tensile elongation increases with progressively thinner inset depths. Workmanship challenges also makes sealant depths < 0.188" (4.8 mm) progressively more impractical. Treat 3/16" (4.8 mm) as the minimum recommended sealant depth for quality low permeability sealants, unless extensive testing indicates otherwise.
   - Major families of IG sealants (listed in order of generally increasing permeability) are one-part hot melt butyls, curing hot melts (moisture reactive), 2-part polysulfides, and polyurethanes.
     - Silicones are excluded from this listing in that they have very, very high permeance rates. DO NOT SEAL WITH SILICONE, as it provides an inadequate moisture vapor and gas retention barrier for long service.
   - The category of desiccated foam IG spacers require an applied sealant with low-to-moderate permeance in order to best slow moisture vapor ingress, and with equal importance, slow argon gas loss to a negligible level.

3. Augment the structure of the desiccated foam spacer/PSA system to resist compression, tension and shear forces that the IGU might experience. This functional element of performance should carry the note that progressively softer thermoplastic hot melts elongate or shear the most for a given inset thickness. It can likewise be noted in a very general way that curing sealants offer more structure per unit thickness, but often have higher permeance rates, and hence can work to minimize the gas transmission path distance between glass and foil barrier in a different way.

The two functions of permeability and tensile modulus can be related and loosely generalized in the graphic to the right:



B. QUALIFIED SEALANTS

- Determine which perimeter sealants best suit your IG design and IG processing requirements. Obtain the sealant manufacturer's data sheets of candidate sealants under consideration, and verify IG design parameters intended with the sealant manufacturers' technical resources.

> **TECHNICAL ALERT:** See Technical Service Bulletin No. IG 1.1, "Listed Sealants for Use over EnerEDGE" for detail on sealants that have been successfully used to fabricate IG units with desiccated foam spacers. This list does not by itself ensure performance, but when combined with quality workmanship does indicate that this combination of sealant and spacer carries the expectation of highest performance.

- **In summary, specifying a sealant with a low moisture vapor transmission rate, applied reliably with sufficient depth to resist elongation, is our recommendation to optimize performance in both certification testing and in service.**

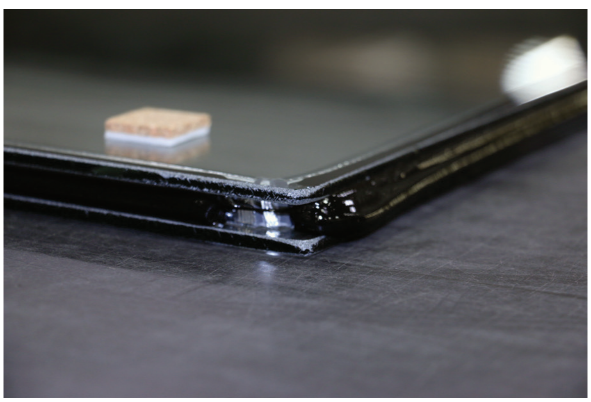
C. UNIT PREPARATION FOR SEALANT APPLICATION

- Verify that all operators are equipped with at minimum the supplier's recommended PPE, suitable to dispense the sealant type intended (either hot-applied or using plural component dispensing).
- Verify that the IG units about to be sealed have the correct inset, with clean and contaminant free glass surfaces in the perimeter's sealant channel and if required, that they have been gas-filled. Lastly, verify that the barrier tape is in place at the 4th corner and at any additional argon fill port locations.
- Verify that the sealant application systems are ready for operation.
    - Pre-heat hot melt pumps and dispensing units; then verify temperatures with thermometers at start of shifts and resuming work after breaks.
    - Validate mix ratios (daily for plural components).
- Purge sealant to fresh material before using for production IG, and seal immediately (particularly after gas-filling), without delay to the normal cycle time.

D. WORKMANSHIP AND QUALITY RECOMMENDATIONS

- **GENERAL:**
  - Verify that the spacer inset matches that tested.
  - Acrylic adhesive wet-out should be checked to guard against "blow-bys"' (where sealant locally flows into the IGU's airspace, passing over and across the bond line PSA.
- **FOR HOT MELTS:**
  - Using one-piece-flow, apply sealant within the manufacturer's recommended temperature range, as "too cool" will create inadequate adhesion to spacer and glass, while "too hot" will slump, string and potentially degrade the polymers and adhesion promoters of the sealant.
- **FOR PLURAL COMPONENTS:**
  - Using one-piece-flow, apply sealant using the manufacturer's recommended mix ratio, as "too rich" will create inadequate mechanical properties and compromise adhesion to spacer and glass, while "too lean" will not cure in the desired time or with the desired sealant properties.
  - Seal as a "full-fill" rectangular section and not "hour-glassed" anywhere along the IGU perimeter, and pay special attention to corners to ensure full-fill at these critical areas, and reject any units with voids.
  - Verify adhesion via butterfly adhesion tests, as recommended by your sealant manufacturer.

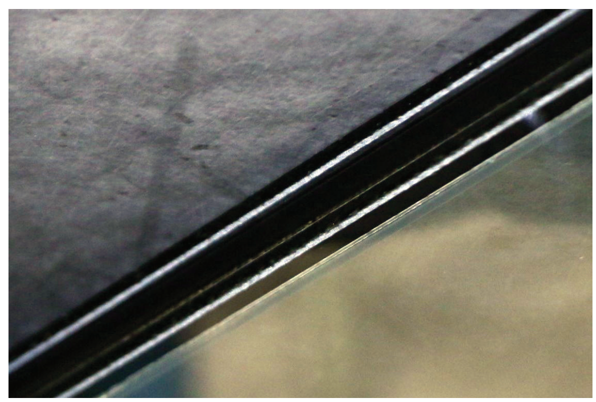
INCORRECT



Corner void

Scalloped sealant profile

CORRECT



Full fill

XIV. Racking and Shipping of EnerEDGE IG Units

- After sealing is finished and when IG units are complete, rack for storage, transport or immediate glazing:
  - Use racks that provide cushioned, intermittent, easy-release silicone rubber runner strips in a high durometer, in order to avoid sealant re-adhesion on MVB damage.
  - Regularly clean glass chips from the base runners of your glass racks.
  - Ensure that all glass lites of the IGU are evenly and fully supported on 90° racks.

90° Racking

- Store units inside, protected from general weathering exposures and freeze-thaw until glazed in a sash. Consult your sealant supplier for additional recommendations particular to temperatures for your sealants used, but recall that adhesion continues to develop after the initial cool down of a hot melt (or skinning of a plural component), and that the ongoing development of these adhesion reactions are tied to desired ambient temperatures in the range of 65 to 100 °F (18 to 38 °C).

XV. Creating a Good Glazing Environment Through Design

Be certain that the final service environment of the glazed IGU precludes prolonged contact with water and water-borne contaminants. Provide a continuous interior air barrier, an exterior watershed, Shore A 80-90 rubber setting blocks and 3/16” x 3/8” (4.8 mm x 9.5 mm) minimum venting weep slots located at the cavity low point.

TECHNICAL ALERT: See Technical Service Bulletin No. SSG 3.2, “Recommendations for Residential Window & Door In-Plant Glazing” for the details of the industry-recommended techniques of capturing, supporting and protecting IGU for long service life.

XVI. Process Equipment Maintenance (Level 1 Checklist)

- Check cutting wheels at glass cutting if break-out is irregular.
- Provide daily replacement of glass washer wash and rinse tank’s contents.
- Verify clean, dry process air if nozzles are used to purge IG cavities prior to topping.
- Provide monthly verification of air-float intake air filters.

XVII. Appendix: Dessiccant Activity Test and QC Log

Appendix

Technical Bulletin IG 5.1

EnerEDGE® Desiccant Test Kit and Instructions

STEP 1 – Use an approved vial available from Tremco or other approved suppliers. Kimble Chase 60965D-7 with closure.

STEP 2 – Use an approved humidity indicator card available from Tremco. Expose the card to ambient air until round spot turns pink. These cards are reusable.

STEP 3 – Place the humidity indicator card into the vial with the indicator side facing out. This allows the result to be easily read.

STEP 4 – Without removing the liner, cut enough pieces of EnerEDGE® approx. 1/8” to 3/16” long to fill the vial.

STEP 5 – Fill the vial to the top with pieces of EnerEDGE®. Place the cap on securely.

STEP 6 – If the round spot turns blue, typically within 1 hour, the spacer is usable.

STEP 7 – If after 1 hour, the indicator remains pink, repeat the test with fresh spacer taken 2 layers underneath the original spacer. If this fails, contact your Tremco representative.

Date	Product Code	Process Order Box Number	Package Condition	Spacer Dimension	Desiccant Activity Pass/Fail	Comments	Signed

Please contact Tremco Technical Service at 866-209-2404 with any questions regarding this bulletin.

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