

NUCOR BUILDINGS GROUP

SINGLE CURB

INSTALLATION MANUAL

DUE TO THE PROCESS OF CONTINUOUS IMPROVEMENT, THE PRODUCTS AND PROCEDURES IN THIS MANUAL ARE SUBJECT TO CHANGE WITHOUT NOTICE

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1.0 GENERAL

1.1 PURPOSE OF THIS MANUAL

This installation manual is provided to builders and their erectors as the recommended procedure for the step by step installation of a curb system onto a Nucor Building Group (NBG) trapezoidal & vertical roof system after the roof has been installed. **NOTE: Prior to the roof being installed, ALL roof framed opening support members must be in place.**

This manual is intended to be used in conjunction with the corresponding roof system erection manual and the project's erection drawings to help plan and organize the installation of the roof curb system.

This manual is supplied for both the trapezoidal roof and the vertical rib roof systems. The drawings and pictures represented in this manual show the curb installation on a trapezoidal roof panel. The vertical rib roof curb installation will be the same.

1.2 INFORMATION ON THE ROOF CURB PACKAGE

ALL roof curb accessories will be supplied by the Curb Supplier. A general list of accessories: tube caulks, tape mastics, rib covers, fasteners, weather stripping, backer channels, flash collar etc.

2.0 SAFE ROOF ACCESSORY INSTALLATION

2.1 REGULATIONS

Regulations set forth by the Occupational Safety and Health Act, local, state, and/or federal agencies should be adhered to at all times. NBG is not responsible for injury, damage, or failure, which may be the result from failing to meet any of these regulations. In compliance with the Hazard Communication Rule 1910:1200, Safety Data Sheets (SDS) have been provided for your use and safety. These data sheets should be made available to all personnel that come in contact with these products. These data sheets will give you the necessary information to properly handle such materials and what to do in case of an emergency. (The SDS can be obtained from your local division should you need a replacement copy).

2.2 ERECTOR'S RESPONSIBILITY

The erector of the roof system is responsible for the safe execution of this manual. These instructions are intended to describe the sequence and proper placement of parts. They are not intended to prescribe comprehensive safety procedures. The procedures in this manual are believed to be reliable. However, NBG **shall not be** responsible for injury, damage, or failure due to the misapplication of these procedures, improper erection techniques, or negligence

2.3 WALKING AND WORKING ON ROOF PANELS

DO NOT use a roof panel as a working platform. An unsecured panel could collapse under the weight of a person standing between purlins or at the panel end.

An approved and safe walking platform should be used in high traffic areas to prevent the roof panel from being deformed, scratched, or scuffed

2.4 SAFETY EQUIPMENT

The use of safety equipment for the roof curb installation is recommended at all times during the installation process. However, when using lanyards, ensure that the clasp, belt hooks and wire cables are covered in such a manner that they will not scratch the panel surface if accidentally dragged along the panel.

2.5 PANEL OVERHANG

DO NOT stand on the end of unsupported (cantilevered or sheared edge) panels at the eave, ridge or the cut roof framed opening. Standing on the cantilever portion may result in panel collapse.

2.6 POINT LOADS

When properly supported by the structural steel, panels are designed to support uniform loads, which are evenly distributed over the panel surfaces. Point loads that occur in small or concentrated areas, such as heavy equipment, ladder, or platform feet, etc., may cause panel deformation or even panel collapse.

2.7 SLICK SURFACES

Panel surfaces and structural steel surfaces are hard, smooth, and nonabsorbent, which causes these surfaces to be very slick when wet or covered with snow or ice. Even blowing sand or heavy dust can make these surfaces difficult to walk on without slipping.

Unpainted panel surfaces are often coated with oil to accommodate the panel-fabrication process. Although designed to wash away or evaporate during normal weather, the oil on new panels can be extremely slick, especially during periods of light rain and dew.

Caution must be exercised to prevent slipping and falling onto the roof surface or even sliding off the roof. Non-slip footwear is a necessity and non-slip working platforms are recommended.

2.8 ELECTRICAL CONDUCTANCE

Metal panels are excellent electrical conductors. A common cause of injury is the contact of metal panels with power lines during handling and installation. The location of all power lines must be noted and, if possible, flagged. The installation process must be routed to avoid accidental contact with all power lines and high voltage services and equipment. All tools and power cords must be properly insulated and grounded and the use of approved ground fault circuit breakers is recommended.

2.9 FALSE SECURITY OF INSULATION

Blanket and rigid board insulation block the installer's view of the ground below the roof. Serious injury can occur when the installer gets a false sense of security because he cannot see the ground and steps through the insulation.

2.10 SHARP EDGES

Some edges or panels and flashing are razor sharp and can cause severe cuts if proper protective hand gear is not worn. Be careful not to injure others while moving panels and flashing.

2.11 SAFE ROOF INSTALLATION SUMMARY

- **EXTREME CAUTION SHOULD BE EXERCISED WHEN WALKING ON ROOF PANELS.**
- **OILS USED DURING THE ROLL FORMING PROCESS AND/OR NATURAL MOISTURE MAY CAUSE THE PANELS TO BECOME SLIPPERY.**
- **DO NOT STEP ON PANELS WITH CREASED EDGES.**
- **DO NOT STEP ON OR NEAR THE EDGE OF A PANEL.**
- **DO NOT STEP WITHIN 5 FEET OF THE END OF A PANEL.**
- **DO NOT USE LOOSE PANELS AS WORK PLATFORMS.**
- **DO NOT WALK ON UNSECURED PANELS.**
- **DO NOT WALK ON TRANSLUCENT PANELS**
- **SECURE ALL LOOSE PANELS AT THE END OF THE WORK DAY.**
- **USE EXTRA CARE WHEN WORKING ON STEEP SLOPES.**
- **DO NOT STEP NEAR THE SHEARED EDGE OF PANEL AT A ROOF FRAMED OPENING LOCATION.**

IN COMPLIANCE WITH THE HAZARD COMMUNICATION RULE 1910:1200, SAFETY DATA SHEETS HAVE BEEN PROVIDED FOR YOUR USE AND SAFETY. THESE DATA SHEETS SHOULD BE MADE AVAILABLE TO ALL PERSONNEL THAT COME IN CONTACT WITH THESE PRODUCTS. THESE DATA SHEETS WILL GIVE YOU THE NECESSARY INFORMATION TO PROPERLY HANDLE SUCH MATERIALS AND WHAT TO DO IN CASE OF AN EMERGENCY

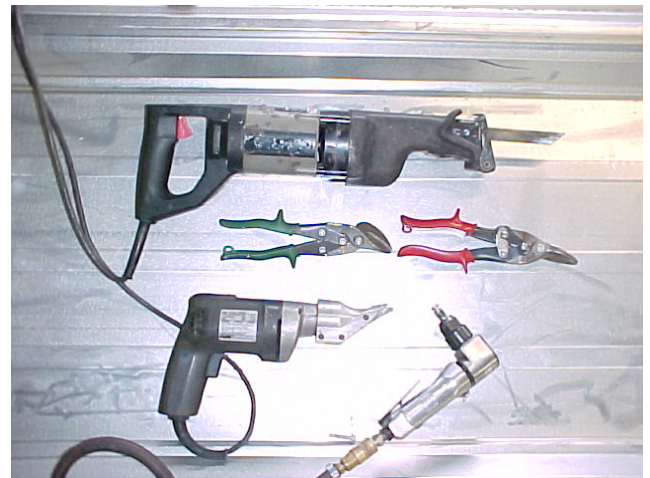
3.0 INSTALLATION BASICS

3.1 PROPER TOOLS

Before starting the roof curb installation, be sure that the proper equipment and tools are on hand. The tools must be in good operating condition and operators should adhere to safety precautions at all times.

The following tools and equipment should be considered for efficient installation of the trapezoidal & vertical rib roof curb system. Actual tools and equipment required may vary due to variations in building type and construction:

- Manual 90° hand crimping tool
- Manual 360° hand crimping tool
- Screw Guns-designed for use with self-drilling screws
- Socket Extensions-6" for screw guns
- Hex Socket Heads-5/16" and 3/8", magnetic
- Electric Drill -1/4" capacity
- Drill Bits-assortment
- Sheet Metal Cutter-or power shears or nibblers
- "C" Clamps-vise grip type
- Pop Rivet Tool-1/8" capacity
- Sheet Metal Shears-left and right cut
- Steel Measuring Tapes-12', 50', 100, and 120'
- Blue Chalk Line (Not Red)
- Air nibbler (if possible)
- Brooms
- Marking Pens (do not use pencils)
- Caulk Guns-for 1/10 gallon mastic tubes
- Power Source and Extension Cords-capable of handling the total equipment requirement.
- Power saw and/or jig saw with non-abrasive blades.



Small 90° Hand Crimper (Top)
Small 360° Hand Crimper (Bottom)

3.2 **MASTIC**

TEMPERATURE EFFECTS

Temperature extremes must be considered during installation of the roof due to the sensitivity of mastics. The recommended installation temperature range is 20-120 degrees Fahrenheit. At colder temperatures, the mastic stiffens resulting in loss of adhesion and compressibility. At hotter temperatures, the mastic becomes too soft for practical handling. On cold but sunny days, the panel surface may become warm enough to accept the application of heated mastic even though the air temperature is below 20 degrees Fahrenheit.

When overnight temperatures fall below freezing, the mastic should be stored in a heated room so it will be warm enough to use the following day. On hot days, the mastic cartons should be stored off the roof in a cool and shaded area. While on the roof, mastic rolls should be kept shaded until actual use.

In very cold weather, it is recommended that the fasteners be tightened slowly and only tight enough that the mastic is in full contact with the panel or flashing. Then on the next sunny day, complete the tightening process after the sun warms the panel and flashing surfaces.

CONTAMINATION

To assure proper adhesion and sealing, the mastic must have complete contact with adjoining surfaces. Contaminants such as water, oil, dirt, and dust prevent such contact. The panel and flashing surfaces **must be dry and thoroughly cleaned of all contaminants**. Before applying tape mastic, the mastic should be checked for contaminants. If the mastic surfaces are contaminated, it must not be used.

During cool weather, condensation or light mist can accumulate on the panel and flashing surface and not be easily noticed. It is recommended that the mastics always be kept under protective cover and that the panel and flashing surfaces be wiped dry immediately before installation.

Tape mastic is provided with a protective paper to reduce contamination. Incomplete removal of the protective paper will prevent the mastic adhesion to the panel or flashing surfaces. Always check that the protective paper is completely removed. **DO NOT** remove the protective paper until immediately before the panel or flashing is installed over the mastic

During cold weather, the fasteners must be tightened slowly to allow the mastic time to compress. If the fasteners are tightened too fast, the fasteners may strip out before the mastic compresses adequately, or the panel or flashing may deform in the immediate area of the fastener, leaving the rest of the mastic insufficiently compressed.

INSIDE CORNERS

An inside radius, such as where the panel flat meets a rib, is usually the most critical area to seal. A common mistake for the installer is to bridge the mastic across the inside radius.

When the lapping panel or flashing is pushed into place, the bridged mastic is stretched and thinned. The mastic may then be too thin to adequately seal this critical area. When tape mastic is applied at an inside radius, it is recommended that the mastic be folded back, then push the mastic fold into the radius.

3.3 **FASTENERS**

SCREW GUNS

Use torque control screw guns for driving self-drilling screws. Maximum 2000 RPM screw guns with torque adjustable clutch are necessary to attain efficient drilling speeds. High tool amperage (4 AMP MIN) is required to achieve the proper torque for secure fastening.

Do not use impacting tools.

To assure proper voltage to the tool, extension cords should be checked for proper wire size and cord length:

- 16 ga. wire, max cord length = 100'
- 14 ga. wire, max cord length = 200'
- 12 ga. wire, max cord length = 300'

SOCKETS

Use good quality magnetic sockets. Good fitting sockets reduce wobble and stripping of the screw heads. They also minimize objectionable paint chipping and scuffing on colored screws and minimize damage to the protective coating on unpainted screws.

Magnetic sockets collect drill shavings, which will build up and eventually prevent the socket from seating properly on the screw heads. One method of removing the drill shavings is to roll up a ball of tape mastic and push the socket into the mastic.

When the socket is removed from the mastic, most of the drill shavings will be embedded in the mastic thereby cleaning the socket. This process should be repeated as often as needed to keep the socket clear of drill shavings.

SOCKET EXTENSIONS

A 4" or 6" socket extension is recommended for installing the panel clip screws. With the extension, the screw can be driven straight down without tilting the screw gun to clear the panel or clip.

INSTALLATION

Before starting the screw, the materials to be joined must be pressed together with foot or

hand pressure. The pressure must be maintained until the screw has drilled through all the materials and the threads have engaged.

Most self-drilling screws require 20 pounds of pressure to maintain the drilling action and to start the thread cutting action. Also, applying such pressure before starting the screw gun will usually prevent tip walking or wandering. If too little pressure is applied, the drill point may not cut into the metal and the point will heat up and become dull. If the pressure is too heavy, the bottom material may be deflected away, causing a standoff condition, or the drill tip may be broken or split. Screws must be held perpendicular to the panel or flashing surface during starting and driving.

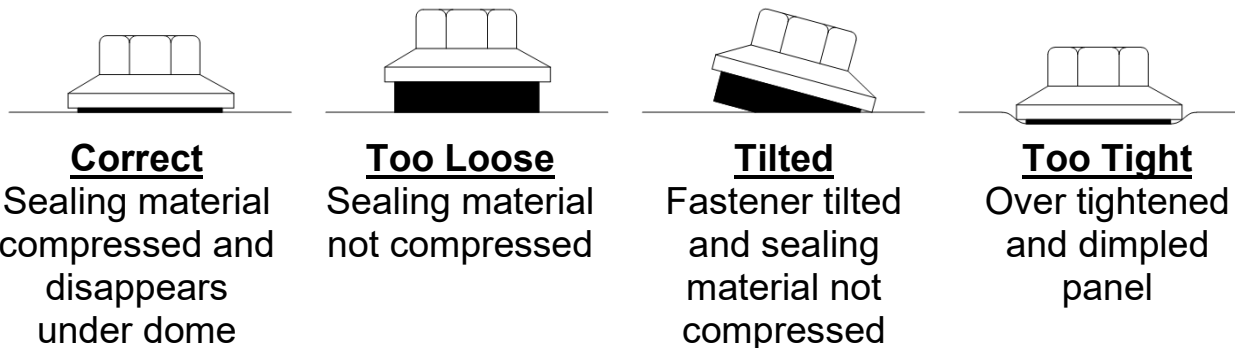
For proper seating of the fastener-sealing washer, the panel or flashing surface must be clean and drill shavings must be removed from under washers before seating. The fastener must be driven perpendicular to the panel surface so that the washer can seat level without warping or cupping.

Do not over-drive screws. Over-driving can strip the threads and/or damage the sealing washer. Use screw gun with torque control set to function properly for the combination of fastener size, hole size, and material thickness.

The fastener should be driven tight enough to uniformly compress the washer but not so tight that the washer splits or rolls out from under its metal dome. The recommended procedure is to tighten the fastener until the sealing washer just disappears under the metal dome. **Refer to the chart on the following page for a proper fastener-seating diagram.**

As a standard practice, NBG offers oversized (goof) screws. Upon stripping or breaking a screw, the screw must be immediately removed and replaced with the goof screw. Do not defer the screw replacement to be remembered and fixed later, or to be found by the clean-up crew. The majority of such screws are easily overlooked until they cause leak problems later.

THIS CHART SHOWS PROPER FASTENER SEATING PRACTICE



Correct
Sealing material compressed and disappears under dome

Too Loose
Sealing material not compressed

Tilted
Fastener tilted and sealing material not compressed

Too Tight
Over tightened and dimpled panel

3.4 FIELD CUTTING OF PANELS AND FLASHING

ABRASIVE SAW PROBLEMS

Abrasive saws (circular saws with friction disks) are not recommended for cutting roof panels or flashing. Abrasive saws create high heat that may burn away the protective cladding from the panel edge, causing the edge to rust.

Also, abrasive saw dust contains fine, hot steel particles, which accumulate on panel and flashing surfaces where they rust and can cause staining and rusting of those surfaces.

Rust caused by abrasive saw damage or abrasive dust particles are excluded from warranty claims.

SHEARING METHODS

It is recommended that panels and flashing be cut with shears or nibblers to provide a clean, undamaged cut. On shear cut edges, the protective cladding extends to the edge of the cut and is often wiped over the edge to further protect the base metal. Whenever possible, fit

the material so that the factory cut edge is exposed and the field cut edge is covered.

When field cutting complex shapes, it is usually easier to cut out a 1" wide strip using both left- and right-hand shears. The 1" cutout provides clearance to smoothly cut the flats and the clearance to work the shears around tight corners.

When making repetitive cuts (such as cutting panels at a hip condition) it is recommended that a template be made from a piece of drop-off panel or flash to provide fast and accurate marking of the field cut. When using panel material for the template, cut off the top portion of the panel ribs so that the template is easily laid onto the panel being marked.

MARKING PANELS

Avoid marking the panels for cutting, etc., in a manner that will leave visible markings, stains, etc., on the finished roof surface. Use chalk or felt tip ink markers. **DO NOT USE GRAPHITE (LEAD) PENCILS ON UNPAINTED PANEL SURFACES; THE GRAPHITE WILL CAUSE RUSTING OF THE SURFACE.**

4.0 FLOATING CURB LOCATION AND LAYOUT

4.1 CURB LOCATION

Once the roof is installed the erector needs to locate the inside four corners of the roof framed opening. To do this, you need to come up from underneath and drill through the roof panels at each corner (see FIG 1).



FIG. 1

After the four corners are located and drilled, return to the topside of the roof. Once there, carefully cut away a portion of the panels to expose the corners of the curb but not cutting the insulation (see FIG 2).

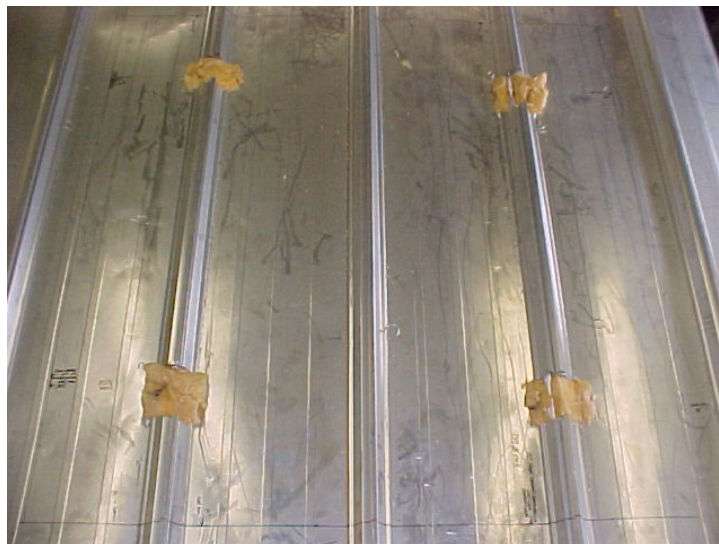


FIG. 2

Trapezoidal Rib Panel shown, Vertical Rib Panel similar.

4.2 CURB LAYOUT

After the four corners of the curb have been located and cutout. The next step is to layout the placement of the floating curb. The details below are based off an **example** single curb system where the dimensions are 60" x 60" inside clear. The cut dimensions are shown from the inside of the roof framed opening. ALL standard floating curbs (single or double curb system) come with a side flange width of 12 1/2" and the top and bottom flange length of 13 1/2".

The basic formula for figuring out the panel cutout is as follows:

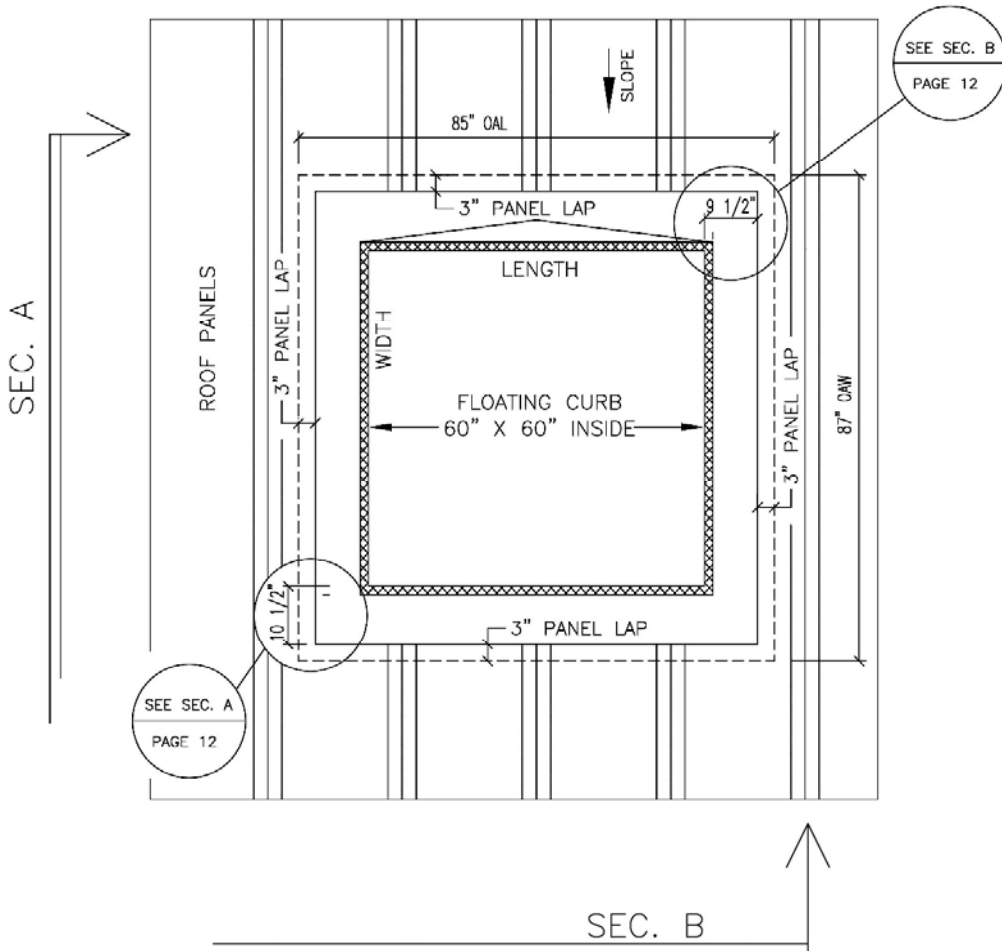
Overall outer curb flange length or width – 6" = R.O. cut-out

Our example:

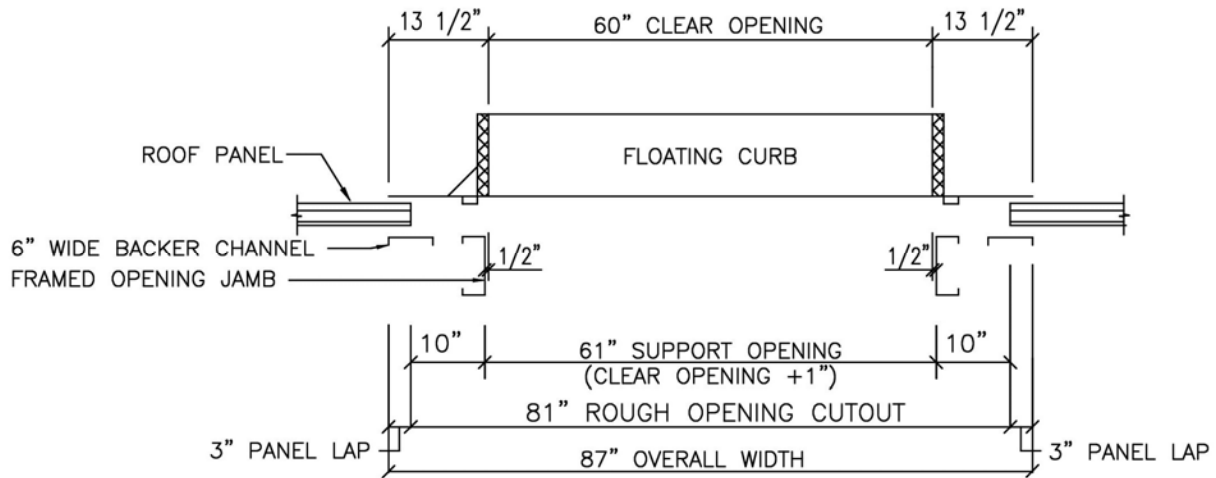
85" O.A.L. (curb length side to side) – 6" = **79" Rough Opening**

87" O.A.W. (curb width upslope to downslope) – 6" = **81" Rough Opening**

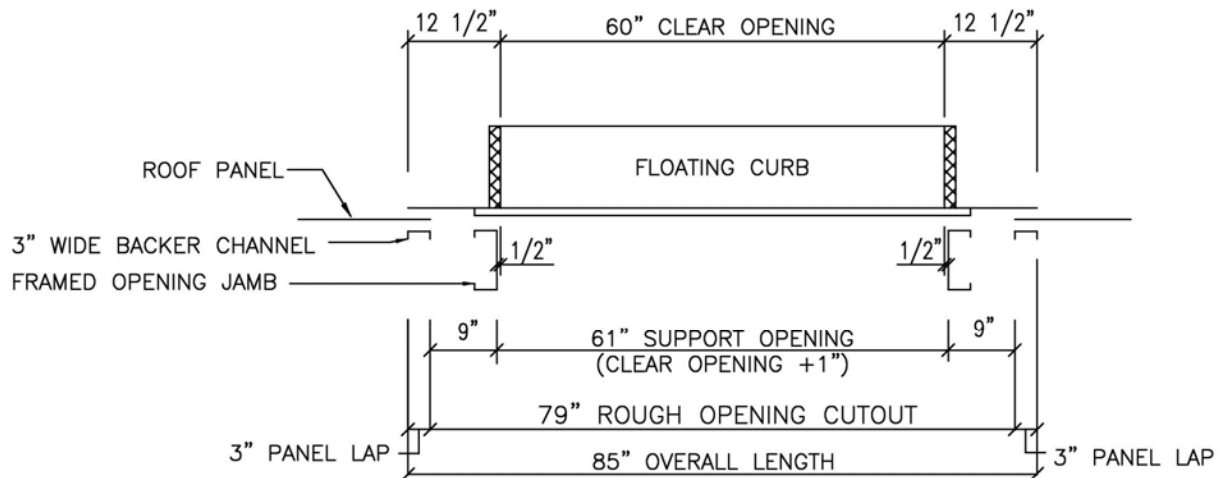
The attached details will show the cut dimensions from the inside of the roof support members for this example. Your R.O. cut-out will vary due to different curb sizes. NOTE: if the edge of the flange falls inside the trapezoid it is acceptable to cut the flange back. Must leave a minimum of 3" from edge of flange to outside of curb wall.



Note that the support framing opening is 1" larger than the clear opening of curb. The curb opening should be 1/2" inside the support opening around the full perimeter.



SEC. A



SEC. B

**4.3 CUTTING OUT THE ROOF FRAMED
OPENING**

Double check the overall floating curb measurements to ensure that the proper R.O. is achieved. **Remember:** Overall outer curb length/width – 6" = R.O. cut-out (See FIG 5). To select the proper cutting tools (See FIG 6). FIG 7 shows the completed R.O. cutout with the insulation intact.

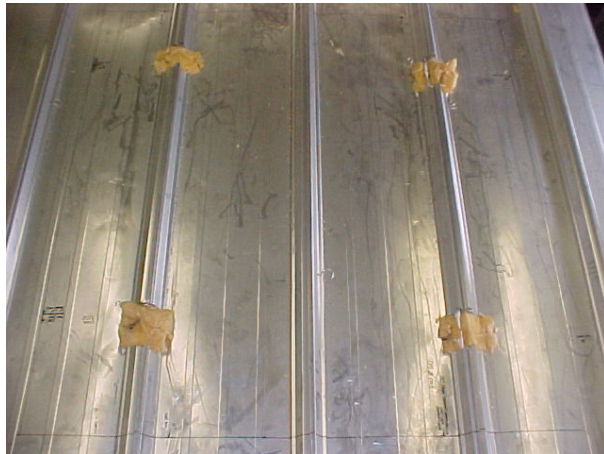


FIG 5

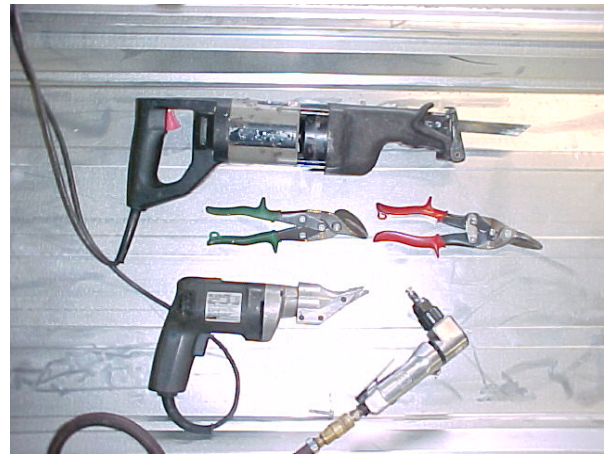


FIG 6

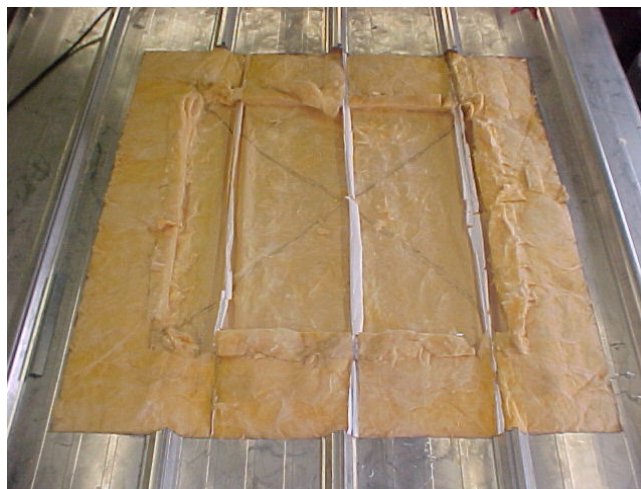


FIG 7

Trapezoidal Rib Panel Shown, Vertical Rib Panel similar.

5.0 BACKER CHANNELS

5.1 LAYOUT OF BACKER CHANNELS

After the R.O. has been cut out and before the curbs can be installed, it is necessary to layout and install the backer support channels supplied with the curb. This consists of (2) 14 ga. side channels 3" wide and (2) 14 ga. end channels 6" wide with two 1/2" side bends (see FIG 8) The side backer channels are 12" longer than the R.O. and the upslope/downslope backer channels are 6" longer than the R.O. Only the end channels are coped 3" on each end for lapping purposes.

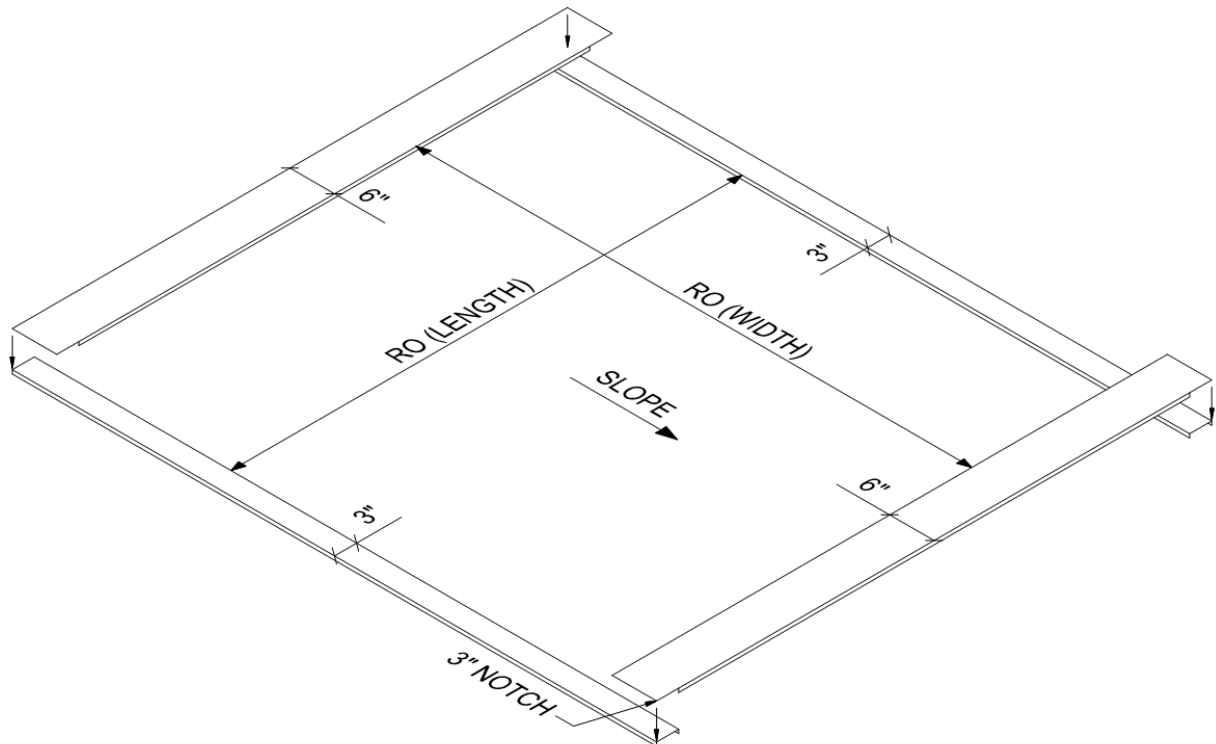


FIG 8

5.2 INSTALLING AND FASTENING THE BACKER CHANNELS:

After the channels have been notched, place loosely under the perimeter of the panel edge. The use of a flat pry bar will aid in the installation (see FIG 9). Once the channels are installed, temporarily hold in place by using vise grips. Then fasten with a pop rivet (not by NBS) OR a small pan head self-drilling screws (not by NBS) (see FIG 10).



FIG 9



FIG 10

Finished picture of the backer channels installed (see FIG 11):



FIG 11

Trapezoidal Rib Panel Shown, Vertical Rib Panel similar.

6.0 INSULATION TIE OFF

6.1 INSULATION TIE OFF:

The next step is to remove the insulation backing from the liner within the roof opening area, then cut the liner from corner to corner. Place double sided tape (not by NBG) on the perimeter of the roof curb support members (see FIG 12). Press the folded liner firmly in place (see FIG 13).



FIG 12

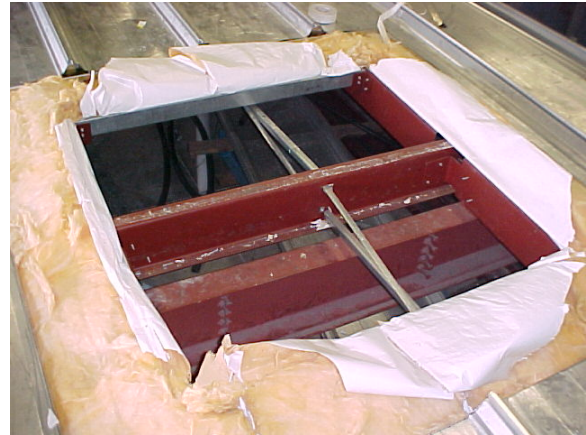


FIG 13

7.0 FLOATING CURB INSTALLTION

7.1 LAYING OUT THE FLOATING CURB:

Prior to installing the outer curb, it is necessary to mark and cutout on the curb the main panel ribs. To start, mark a 3" lap line the full perimeter of the roof framed opening (see FIG 14). Next, set the curb over panel. Line-up the flanges with the 3" lap marks (see FIG 15).



FIG 14



FIG 15

The next step is to transfer the major rib locations onto the curb flange. To do this, use a small adjustable T-square and place it about 1/4" from the edge of the major rib (see FIG 16). After you have transferred the rib locations to the curb flange, measure in 3 1/4" as shown in FIG 17. Trapezoidal rib panel finished notch should measure 3 1/4" x rib width + 1/4". For vertical rib panel the notch should measure 3 1/4" x 1/2"



FIG 16

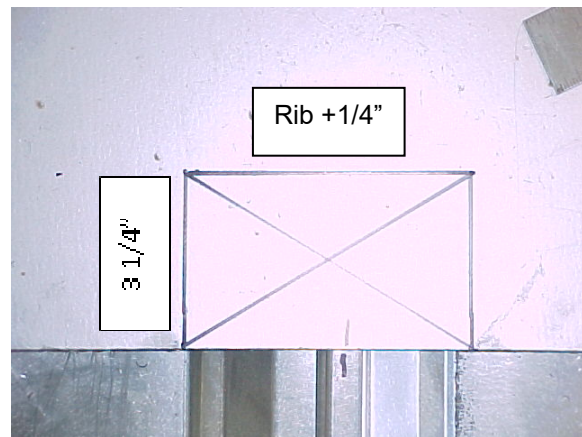


FIG 17

7.2 CUTTING OF THE CURB FLANGE

After marking out all the major rib locations, cut out using a non-abrasive saw (see FIG 18).



FIG 18

7.3 CLEAN-UP

The next step is to clean off ALL debris, oil and metal shavings from around the roof curb opening (see FIG 19).



FIG. 19

Trapezoidal Rib Panel Shown, Vertical Rib Panel similar.

7.4 DRY FIT CURB

Prior to installing the tape mastics and tube caulk it is a good idea to dry fit the curb. That way the erector can do additional trimming if needed. This will ensure proper curb fit-up once the mastics are in place.

7.5 TUBE CAULK AND MASTIC PLACEMENT

After all the debris is cleaned from the roof curb area, place 2 ½" tape mastic the full perimeter of the curb opening. **NOTE:** That the tape mastic is just butted up to the edge of the major rib.

**FIG. 20****7.6 INSTALLATION OF THE FLOATING CURB**

After the mastic and the tube caulk are installed, set the floating curb carefully in place (see FIG 21). After the floating curb has been set, fasten around the perimeter with #12 X 1 ¼" w/washer fasteners, 1" from the edge, spaced 3" O.C. in the predrilled holes.

**FIG 21**

8.0 INSTALLATION OF RIB COVERS

8.1 MAJOR RIB PREPERATION (90° CRIMP)

In order to have proper fit up of the plastic rib covers, the upper part of the major rib needs to be manually crimped to form a 360° crimp. To begin this process, you first need to crimp the panel with the manual 90° panel crimper into a 90° crimp. Start by placing the open crimper on top the rib (see FIG 22), next apply pressure downward to both handles. Note the position of the handles of the finished crimp, they are slightly past horizontal (see FIG 23). This ensures a properly crimped upper panel rib. **Note:** This crimper works on both panel types. (Trapezoidal Rib and Vertical Rib Panels)



FIG 22



FIG 23

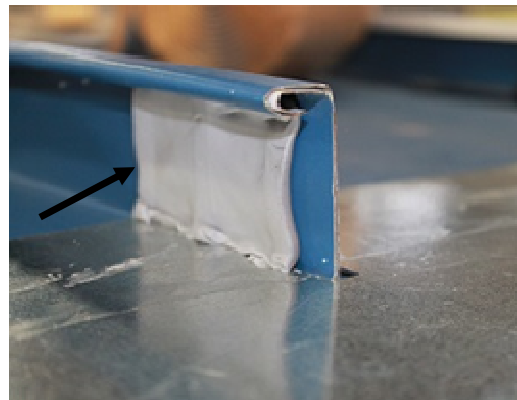
Trapezoidal Rib Panel Shown, Vertical Rib Panel similar.

At this point it is recommended to place a 1 ½" long piece of 2 ½" wide tape mastic on the vertical and horizontal part of the seam as shown in FIG 24 & 24a.



Trapezoidal Rib Panel w/ 90° Crimp

FIG 24



Vertical Rib Panel w/ 90° Crimp

FIG 24a

8.2 MAJOR RIB PREPERATION (360° CRIMP)

Next is the process of manually crimping the panel rib into the final 360° crimp. To start, place the open 360° crimper on top of the pre-crimped rib (see FIG's 25 & 25A) Make sure that the flat side of the crimper is on the panel rib shoulder and the crimper hook is under the female lip (See Fig. 25A). Note the angle of the crimper. Next, apply outward and downward pressure to the handles to start folding down the top rib. Continue the outward and downward pressure until the rib is flat. (See FIG's 26 & 25A). **Note:** This crimper works on both panel types. (Trapezoidal Rib and Vertical Rib Panels)



FIG 25



FIG 26

Trapezoidal Rib Panel Shown, Vertical Rib Panel similar.

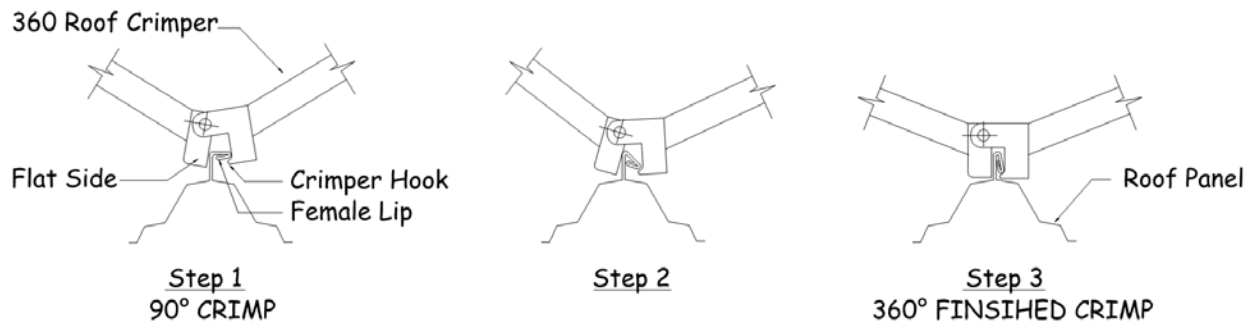


FIG 25A

Trapezoidal Rib Panel Shown, Vertical Rib Panel similar.

8.3 MASTIC AND TUBE CAULK PLACEMENT

Prior to the plastic rib cover installation, proper tube caulk and tape mastic placement is necessary to ensure a weathertight seal. The first step is to apply a bead of butyl tube caulk around the perimeter of an inside void closure and slide it into the trapezoid of the panel (see FIG 27). The next step is to place a small amount of butyl tube caulk in the end of the upper part of the panel rib (see FIG 28). Next take short pieces of 2 ½" tape mastic and place around the perimeter of where the rib cover is going to be placed as well as up and over the trapezoid. Then take another piece of 2 ½" tape mastic and place it so that it covers the panel void end of the cut rib. Merge the panel void tape mastic together with the base mastic to form a good seal (see FIG 29).

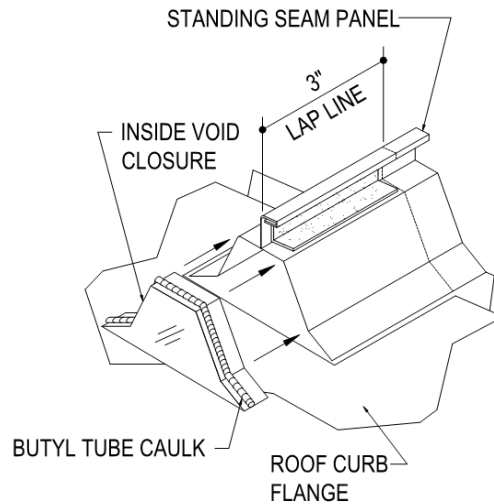


FIG 27



FIG 28



FIG 29.

Trapezoidal Rib Panel Shown, Vertical Rib Panel similar

For Trapezoid Rib Panel: The next step is to prep the plastic rib cover. To do this, apply a generous bead of butyl tube caulk to the upper portion of cap (see FIG 30). Then place the cap directly over the rib, lining it up with the edge of the curb flange and push down firmly in place. Fasten with #12 x 1 1/4" w/washer fasteners at the dimple locations (see FIG 31). **Note:** There are left and right handed trapezoidal rib covers.



FIG 30



FIG 31

Right handed rib cover shown

For Vertical Rib Panel: The next step is to prep the metal rib cover. To do this, apply a generous bead of tube butyl caulk in the upper portion of cap (see FIG 30a). Then place the cap directly over the rib, lining it up with the edge of the curb flange and push down firmly in place. Fasten with (7) #12 x 1 1/4" w/washer fasteners (see FIG 31a). **Note:** For the vertical rib panel, the rib covers are non-handed metal covers that are supplied by the roof curb manufacturer.



FIG 30a

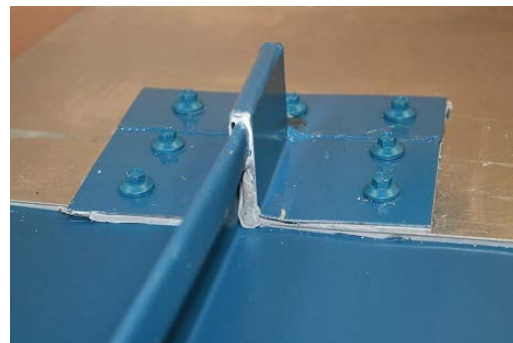


Fig 31a

9.0 FINAL CLEANUP

9.1 CURB AND PANEL CLEANUP

After all of the curb system has been installed, it is necessary to clean off of the curb flange and panel of any and ALL loose debris, water, metal shavings, oil and dirt etc. **NOTE:** It is also necessary to trim away any excess mastic and tube caulk from around the flanges and plastic rib covers (trapezoidal rib panel), metal rib covers (vertical rib panel) (see FIG 32).



FIG 32