3M™ Heat-Activated Acrylic Foam and Acrylic *Plus* Tape Application Guidelines

March 2013

Supersedes Application Guidelines dated February 2008

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Tape Selection and Part Design
Sealing Tape Selection Chart

General Description

3M supplies several different tapes with heat-activated adhesive for providing immediate, consistent, and durable bonds to rubber. These tapes are specifically designed for sealing applications. This selection chart is intended as an initial guide for obtaining the appropriate 3M™ Heat-Activated Acrylic Foam and Acrylic *Plus* Tapes for general applications.

Using this Chart

While this chart gives an overview of some characteristics of the different tapes, the specific tape to be chosen will depend on the characteristics of the intended application including the paint system used on the vehicle or the surface that will receive the seal. Since applications vary with materials, stress, procedures, environmental exposures, etc., it is important to determine through testing the most suitable 3M Heat-Activated Acrylic Foam or Acrylic *Plus* Tape for the specific application. This chart does not take into account every variable for each application.

Please consult with your 3M Automotive Division representative for further help and information.

Tape	Thickness Inches (mm)	Core Color	Adhesives HAA/PSA*	Liner	Heat-Activated Adhesive bonds to…						
					Neoprene	PVC	Alcryn® Melt Processible Rubber	EPDM	Santoprene® TPV	Kraton® Polymers	TPV/ TPE
3412	0.047 (1.2)	Gray	E2/DS6	Red with 3M logo				x	x		
4981	0.008 (0.2)	Clear	E2/A10	PE				X	X	X	X
5403	0.032 (0.8)	Gray	E2/AR7	Orange PE				X	X	X	X
5404	0.047 (1.2)	Gray	E2/AR7	Orange PE				X	X	X	X
5933	0.045 (1.2)	Gray	N1/AR7	Red PE	X	X	X				
5935	0.016 (0.4)	Gray	E2/AR7	Orange PE				X	X	X	X
ST1200	0.047 (1.2)	Black	E2/VR2	Red PE				X	X	X	X
WT4112	0.047 (1.2)	Black	E2/JL2	Red PE				X		X	

*HAA – Heat-Activated Adhesive (bonds to extrusion)
PSA – Pressure sensitive Adhesive (bonds to paint)

Note: Highly plasticized formulations should be tested for compatibility with tapes.

Tape Selection and Part Design
Seal and Vehicle Tape Land Design

General Overview

When designing a seal for tape attachment, consideration should be given to the material and grades used for the various portions of the seal, and how to best distribute the stress across the tape width when a force is applied to the seal.

Seal Design

Summary of Considerations:
Application success can be increased by adhering to certain principles that maximize the ability of the tape to consistently and durably bond the seal to the vehicle. These considerations include:

Seal Design:
Dimensional Recommendations:

Seal Length	= Sheet metal ± 2mm
Seal Foot Hardness	≈ 70 to 95 Shore A
Seal Foot Width	≥ Tape Width + 2 mm
Recommended Tape Width	≥ 10 mm
Hider Lip Height	≤ Tape Thickness - 0.5 mm
Recommended Tape Thickness	= 1.1 mm

Other Tips:
- Minimize load on tape, especially peel/cleavage
- Seal foot designed with hard nose or lip for manual positioning
- Design seal with installation tool in mind.

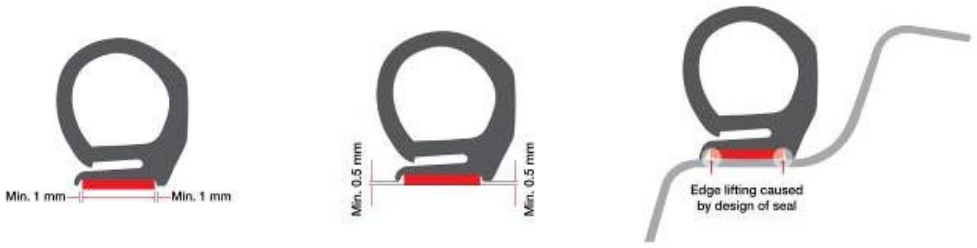
Vehicle Design:
- Apply the seal on a flat surface.
- Minimize tape placement over grooves, spot welds, etc.
- Avoid small radii that cause the seal to buckle or pull away, for example in the corner or hinge area of a door.
- Induced functional loads should be perpendicular to tape.
- Avoid peel and cleavage loads on tape.
- Design in positioning aids such as an edge or feature line.
- Include an edge with a constant distance to the seal for guiding of pressurization tool.

Maximizing Tape Effectiveness through Seal Design:
There are a number of factors to consider when designing seals. Consideration should be made as to how the bulb or sealing surface of the rubber affects the stress distribution on the tape.

Seal Design (continued)

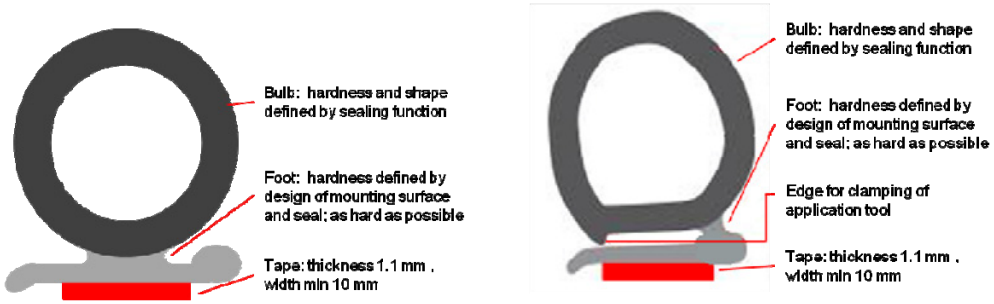
Tape Land Design Clearances:
When designing a seal profile, maintain a minimum clearance between the hider lip and sheet metal surface. Tape should stand proud of the hider lip by a minimum of 0.5mm to allow the tape to make contact with the vehicle and to avoid placing peel forces on the tape when the seal is installed.

The width of the tape land area should also exceed the tape width by a minimum of 1mm on each edge of the tape. This will prevent curvature on the tape when laminated, and also provide a larger lamination path process window.



Considerations in Seal Durometer and Bulb Design:
The durometer of the bulb portion of the seal will be determined by the intended function of the seal. The foot of the seal should be of as high a durometer as possible to provide a firm surface for transmitting force to the tape for wet-out of the tape onto the sheet metal surface. A minimum of 70 durometer is recommended.

To minimize forces imposed on the tape, a hinge point may be designed into the profile. The hinge may be located either centrally below the bulb or to one edge. These two possibilities are illustrated below.

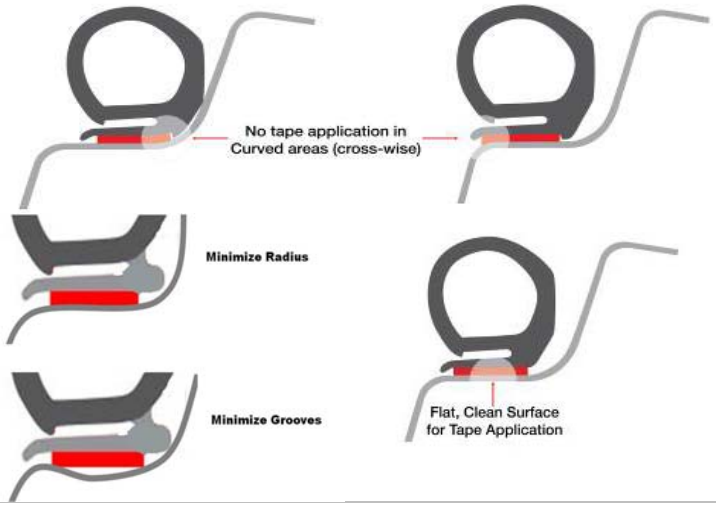


Seal Length:
Seals should be designed to closely match the length of the application area. A maximum of 2mm difference should be maintained if the seal is not trimmed as part of the installation process. Excessively short seals will be stretched in application, thus reducing adhesion force of the tape to the paint. Long seals will need to be bunched to fit, resulting in unsatisfactory appearance and sealing behavior.

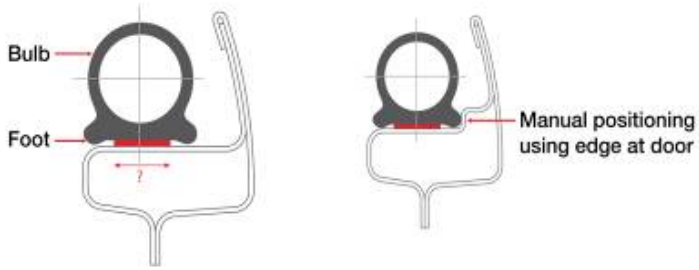
Vehicle Design

Considerations in Vehicle Tape Land Design:
The precise location of the seal on the vehicle can be designed to maximize the effectiveness of the tape application. This includes designing in seal positioning aids as well as optimizing the tape land area.

Tape Land Topography:
To maximize tape wet-out on the sheet metal and minimize induced stresses, the tape location on the vehicle should lie in flat sheet metal regions with minimal curvature across the tape width.



Tape Land Width:
The seal land area must be wide enough to accommodate the seal placement. Adding an edge to guide seal placement may be advantageous for proper seal positioning during installation.



Aperture Design:
In many cases a seal is designed to go around an aperture such as a door. For tight curves (for example, 90° corners with a radius of curvature of less than 4 inches), a molded section of rubber is often inserted into the seal. Tape can be applied to this section either in-line or in a secondary operation.

Seal placement around apertures should generally be designed so that the seal will curve perpendicular to the plane of the tape on the seal, rather than in the plane of the tape on the seal. The core of the tape will elongate and compress to accommodate the compression and elongation forces that are caused by this type of curvature. The maximum radius of curvature will depend on the seal design.

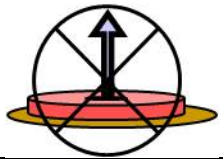
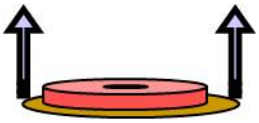
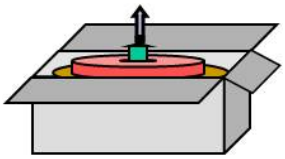
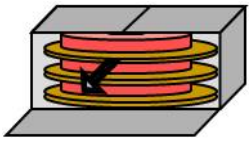
Curvature in the plane of the tape is possible, but will induce cleavage forces on the tape when the seal is large or of relatively high durometer. The minimum radius of curvature and arc of curvature depend upon the seal design and durometer, the tape chosen, and tape width, etc. Optimal designs must be determined empirically; contact a 3M application engineer for assistance.

Additional Factors

The paint system used on a vehicle may also impact the selection of the optimum 3M™ Heat-Activated Acrylic Foam or Acrylic *Plus* Tape for an application. Contact a 3M application engineer for information on matching tapes to paint systems.

For additional considerations not covered above, please contact a 3M application engineer to discuss your part design.

Lamination of Tape to Seals
Planetary Roll Handling

General Description	Roll quality is a delicate balance of tensions. External forces can disrupt the balance, causing the roll to separate. All attachment tapes can be subject to this, particularly longer rolls and narrower widths. Care is needed when handling so that rolls do not separate. Note that handling rolls of heat-activated attachment tape is typically more challenging than handling PSA tapes, because the heat-activated adhesive side does not stick to the backside of the liner.
Tip 1	Grabbing the roll by the core can disrupt roll tension, resulting in roll separation. Instead, lift the roll out of the box using the wafer. 3M packages two wafers between each roll for this purpose.  
Tip 2	Open the top of the box and remove the vertical cardboard piece from the center of the cores. Then close the top flaps on the box and carefully cut open the front of the box. The rolls can now be removed in a horizontal manner by pulling them out by the wafer. The vertical cardboard can be placed into the cores of the unused rolls to prevent damage in the warehouse.  
Tip 3	Carry the roll in a vertical position when transporting from the box to the machine. Carrying at an angle can introduce enough force, especially on narrow width rolls, to cause roll separation.  

Lamination of Tape to Seals
Principles of Heat-Activated Lamination

General Description	When laminating heat-activated acrylic foam tapes to rubber seals, there are three primary variables that affect the bond quality: temperature, pressure and line speed. The recommended starting points for these variables are provided below. These rules are general, and it is recommended that each application be evaluated for compatibility of the tape to the rubber formulation.
Substrate Preparation	In all cases, the extrusion must be clean! Typically the extrusion is laminated within 1 to 5 days after it is extruded. The first day allows for thermal and chemical shrinkage of the rubber to be completed and reach equilibrium. If the time period between extrusion and tape lamination is longer than 5 days, blooming of additives can occur, which could affect the ability of the heat-activated adhesive to bond to the extrusion. Therefore, if the extrusion is more than 5 days old or other signs of blooming are present, it is recommended that the taping surface of the rubber be cleaned with toluene or heptane.* ***Important Note:** State Volatile Organic Compound (VOC) regulations may prohibit the use of certain solvents/solutions. For example, the California South Coast Air Quality Management District (AQMD) prohibits use of this solution without a permit, and other California AQMDs prohibit use of the solution without a permit or a regulatory exemption. Check with your state environmental authorities to determine whether use of these liquids is restricted or prohibited. When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use.
Bonding Temperature and Line Speed	In a heat-bond lamination process, it is important to understand that the speed and temperature must be closely controlled. A lamination machine is recommended to meet these conditions. Attempts to apply the tape by hand using a heat gun will result in areas where the tape is poorly bonded. The characteristic of a good bond is a cohesive split of the acrylic foam (or the rubber substrate) when attempting to remove the tape from the rubber. The temperature required to activate the heat-bond adhesive on the acrylic foam is approximately 176°C (350°F). The heat-bond adhesive should be activated just prior to the tape coming in contact with the rubber. To obtain a uniform and consistent activation temperature of the adhesive on a moving web requires a heat source with a high temperature output. The output temperature setting chosen will depend on the speed at which the tape is being laminated to the rubber. For example, to run a Straub WL30 laminator at 30 FPM, the exit temperature at the nozzle on the end of the torch should be around 590°C (1100°F). To run at a faster speed, a higher temperature is required. The nozzle is designed to focus the heat onto the tape as close as possible to the point where it contacts the rubber.
Laminating Pressure	In a lamination process, the tape is kept flat against the laminating wheel and the rubber is supported from underneath by a profiled track or nest, so that the taping surface of the rubber is parallel to the tape. The pressure required to bond the tape to the rubber is approximately 208 kPa (30 psi). However, the pressure will vary depending on the profile of the extrusion. The objective is to apply enough pressure to wet-out the heat-activated adhesive onto the surface of the rubber, at a temperature above the activation temperature of the heat-activated adhesive.

Tape Stretch	Stretching the tape when laminating to an extrusion should be minimized. For this reason, extrusions should be cooled prior to tape lamination so that shrinkage after tape lamination can be avoided. The tape may be stretched slightly during lamination to match anticipated profile shrinkage; however, tape stretch must not exceed 4% in length.
Troubleshooting	Adhesion of tape to rubber should be checked periodically during production to ensure that proper lamination techniques addressed above are maintained. This can be done simply using a variety of techniques (see Procedures for Evaluating Tape to Rubber Bonding).
	Poor Adhesion to Rubber: Rubber must be relatively clean for good adhesion. If the extrusion has dwelled more than 5 days since formation, the surface should be wiped with heptane or toluene* to remove additives which may bloom from the surface of the rubber. Poor bonding to rubber can also be caused by improper lamination temperatures. Too low a temperature may fail to fully activate the heat-activated adhesive. Too high a temperature can melt the heat-activated adhesive so it can be blown off the surface of the tape, leading to a poor bond or sloppy edge on the bond line to the extrusion. Temperature should be appropriate to line speed (faster line speeds require higher temperatures).
	Liner Pop-Off (Loss of Liner Contact with Tape): Liner pop-off can be caused by several factors. For a full discussion, please refer to the Liner Pop-Off chapter of this manual. These rules are basic; if more in-depth discussion is desired, please contact your 3M Automotive representative. ***Important Note:** State Volatile Organic Compound (VOC) regulations may prohibit the use of certain solvents/solutions. For example, the California South Coast Air Quality Management District (AQMD) prohibits use of this solution without a permit, and other California AQMDs prohibit use of the solution without a permit or a regulatory exemption. Check with your state environmental authorities to determine whether use of these liquids is restricted or prohibited. When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use.

Lamination of Tape to Seals

Procedures for Evaluating Tape to Rubber Bonding

General Description

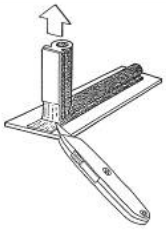
A strong bond of the heat-activated adhesive to the rubber is very important for long-term durability of taped seals on an automobile. One characteristic of a good bond is a cohesive split of the acrylic foam. A poor bond between the heat-activated adhesive and the rubber could result in a field failure over time.

The ideal place to check the bond is online, after the tape is laminated to the rubber and has had sufficient time to cool to room temperature. The following procedures are recommended as quality assessment tests.

Procedure 1

Edge Check:
By picking at the edge of the laminated tape with a finger nail or a utility knife, a judgment can be made as to the quality of the bond that the lamination process is producing. A poor bond of the tape to the rubber can easily be seen using this method.

Procedure 2



90° Peel:
Another method of determining the bond is to apply a laminated seal assembly to a substrate that the adhesive aggressively adheres to, such as anodized aluminum. After the assembly is applied to the substrate, peel back the rubber to a 90°angle and with a sharp instrument cut through the tape down to the rubber, but not into the rubber, to initiate a failure. After the tape is cut, pull the assembly away from the substrate by hand at 90° and continue to cut through the tape in an attempt to start the failure. This same procedure can be used in an Instron® tension tester to obtain a quantitative value.

Procedure 3

T-Peel Test:
The third method is to adhere an aluminum strip of 5mil thickness and a width slightly exceeding the tape to the pressure sensitive adhesive (PSA) surface of the tape. The dull side of the aluminum foil will adhere readily to the PSA surface of the tape and can be pulled off by hand or using an Instron® tension tester to obtain a quantitative result.

The failure mode should be observed—either rubber tear, foam split (cohesive failure) of tape, or adhesive failure of the heat-bond layer of the tape to the rubber. Either rubber tear or tape cohesive failure indicates a good heat-bond result.

Instron is a registered trademark of Illinois Tool Works Inc.

Post-Lamination Processing

Tabbing and Post-Processing

General Description

Several post-processing actions are often performed on seals. Tape is designed to allow the following activities.

Tabbing

Some taped seals are required to have a tab on the liner to facilitate liner removal by operators. The most common tabbing method for sealing applications is heat-bond tabs. Extended liner tabs and pressure sensitive adhesive (PSA) tabs may also be an option in some cases.

Heat-Bond Tabs:

Heat-bond tabs are formed by using heat and pressure to bond a film to the top surface of the liner near the end of the part. The most common heat-bond tapes used for this purpose are 3M™ Tabbing Tape 5400 and 3M™ Heat Tabbing Tape 5081. These are typically applied using the Straub™ Liner Tabbing Machine WL-50. The parameters of temperature, pressure and dwell time are controlled to ensure a good bond of tabbing tape to the liner. Done properly, the tabbing tape forms a permanent bond to the liner. The table below shows the recommended process conditions for both tabbing tapes:

	3M Tabbing Tape 5400	3M Tabbing Tape 5081
Temperature	149 - 204°C (300 - 400°F)	150 - 170°C (302 - 338°F)
Time	0.2 – 2.0 sec	1 – 2 sec
Pressure	10 – 60 psi	~80 psi

* Amount of pressure required is determined by firmness of substrate.

If one or more of the heat-bond settings (temperature, time or pressure) is too low, the tabbing tape will not adequately bond to the liner surface and the tabbing tape will peel from the liner during removal.

Excessive temperature and/or time may cause the liner to shrink or melt, which can cause the tabbed area of the liner to release from the tape and increase the chance of tape contamination.

Excessive pressure coupled with higher temperatures could cause the 3M™ Acrylic Foam Tape to take a compression set – not allowing it to return to its original thickness. The reduced thickness may limit the ability of the tape to make full contact with the vehicle.

Extended Liner Tabs:

Extended liner tabs are produced by leaving a small excess of tape past the end of the part. The tape is then removed from this area, leaving just the liner to be used as the tab.

Tabbing (continued)

Pressure Sensitive Adhesive (PSA) Tabs:
PSA tabs are made using a pressure sensitive adhesive tape bonded to the end of the liner. For 3M™ Acrylic Foam Tapes, the most commonly used PSA tapes are 3M™ Tabbing and Splicing Tape 5300 and 3M™ Splicing Tape 4240. 3M™ Acrylic *Plus* Tapes require the use of 3M™ Tabbing and Splicing Tape 5699. Accurate placement and full contact are required when using a PSA tab. The reliability can be increased greatly with the use of an "over-under" tab – one that is folded and applied such that it contacts both sides of the liner.

PSA tape tabs require more precise placement in order to be reliable. PSA tabs should be applied such that the adhesive makes full contact, especially out to the leading edge of the liner. Ideally the tab should be oriented at an angle to encourage the liner to be pulled from one corner:

Under tabs are significantly more reliable than PSA tabs applied only to the top surface of the liner. In this tab, the leading edge of the liner is lifted and the tab is applied to the underside of the liner:

Note: If a PSA tab is used with 3M™ Acrylic *Plus* Tapes, it is highly recommended that an under or over-under tab is utilized.

Quality Checks:
When evaluating tab performance, care should be taken to minimize the amount of liner that is lifted and to achieve full contact of the liner with the tape when replaced. This will minimize the likelihood of adhesive contamination due to liner lifting during shipment.

Straub is a trademark of Straub Design Company.

Heat-Set Bonding & Molded Features

Application of heat in a press often is used to mold a straight section of extrusion, to join two extrusion ends, or to post-apply molded features such as corners or small parts. 3M Heat-Activated Acrylic Foam and Acrylic *Plus* Tapes can withstand short-term (up to approximately 15 seconds) post-forming temperatures of 175°C (350°F) during these types of processes. Higher temperatures may cause the liner to shrink and detach from the tape. This may lead to tape contamination and deadening of the adhesive surface.

Coating

3M Heat-Activated Acrylic Foam and Acrylic *Plus* Tapes and liners can withstand normal coating oven cycles. Care should be taken to avoid excessive clamping of tape leading to heat set depression spots in the tape. Such spots will not exhibit good adhesion to vehicles.

Liner removal tabs may occasionally curl during these processes. Generally this is not a problem, but excessive curl and/or the action of the coating can cause bonding of the tabs to the seal. If this happens, it can be helpful to laminate a stiff backing to the tabbing tape prior to its application to the liner. This will prevent curling during coating operations.

*Note: It is the customer's responsibility to test and verify processes.

Post-Lamination Processing

Liner Pop-Off

General Description

3M strives for liners that stay with the product until installation; however, there can be cases where a tape-laminated part shows liner lifting or liner pop-off. This may lead to tape contamination and deadening of the adhesive surface. When liner pop-off occurs, it is most often during shipping of taped parts. The end customer may see small ripples where the liner is no longer adhered or a section where the liner is completely off the tape. The cause of liner pop off could be part mishandling or mismatched tension between the tape and the seal.

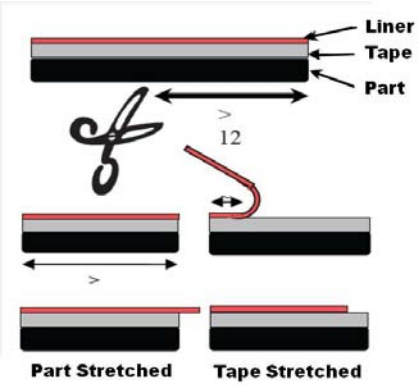
Part Storage & Handling

Liner pop-off may be observed when parts are removed from a shipping container. For flexible parts, the most common solution is to pack the taped parts such that the liner is on the outside of the curled or coiled part. This orientation makes the liner travel a slightly further distance than the tape and creates some natural tension to keep it in place. If the parts must be packed such that the liner is on the inside of the curled or coiled part, the part should be coiled smoothly with a large radius of curvature.

Seals shipped during extremely cold weather (below 0°C) have a higher risk of liner pop-off. Extra care should be taken to ensure that seals do not shift during shipment and that the liner is packaged to the outside of the coils.

Part Stretch

Testing for Part Stretch:
Mismatched tension can be created during the tape lamination process; either the tape or the part can be stretched. To determine if this is the case, cut a section of taped extrusion at least 12 inches long. Pull back the liner from the part except for the last inch. Carefully lay the liner back down onto the part, being careful not to add any tension to the liner. Observe the amount of length differential between the liner and the taped part. Liner longer than the taped part is indicative of the part being stretched during tape lamination. Liner shorter than the taped part is indicative of the tape being stretched during lamination.



1. Cut a 12-inch section of taped extrusion.
2. Peel back approximately 11 inches of liner.
3. Replace the liner on the tape.
4. Check for liner and tape match-up.

Eliminating Part Stretching

Lamination Tension:
Part stretch is not uncommon with extruded rubber parts. If tape is applied to stretched rubber, when the tension is released from the rubber, it will shrink back to equilibrium length. Since the tape is bonded well to the rubber and has a core which can accommodate these stresses, it too will shrink with the rubber. The liner, however, does not have the stress handling properties of the foam tape. It will maintain its original length and buckle as the tape shrinks back. There are different process checks that can be done to lessen part stretch during lamination. One option is to lower the tension on the rubber coming into the lamination area. Another is to lower the pressure at the lamination nip, but care is needed to be sure there is still adequate pressure for a good bond.

Extrusion Relaxation:
Taping fresh rubber is another possible cause of tension mismatch and subsequent liner disruption. Depending on formulation, it may take up to a week after extrusion for the rubber to relax. If the rubber is taped before it is fully relaxed, the tape will shrink as the rubber does. The liner, however, does not have the stress handling properties of the foam tape. It will maintain its original length and buckle as the tape shrinks back. Possible solutions include waiting to tape the rubber when it is fully relaxed, or determining the amount of shrink expected in the part and pre-stretch the tape accordingly during the lamination process (possible if less than 4% tape stretch is needed; excessive tape stretch will also lead to liner pop-off problems).

* Note: If taping extrusion that has been allowed to relax more than 5 days, clean the extrusion with toluene or heptane* before taping.

****Important Note:** State Volatile Organic Compound (VOC) regulations may prohibit the use of certain solvents/solutions. For example, the California South Coast Air Quality Management District (AQMD) prohibits use of this solution without a permit, and other California AQMDs prohibit use of the solution without a permit or a regulatory exemption. Check with your state environmental authorities to determine whether use of these liquids is restricted or prohibited. When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use.

Liner Shrinkage

The polyethylene liner supplied with 3M™ Heat-Activated Acrylic *Plus* Tapes is designed to be post-processed at customary temperatures for seal processes. However, after several minutes' exposure to temperatures above 140°C (290°F) the liner will noticeably soften and can wrinkle and shrink since the temperature limit for 3M™ Acrylic Foam Tape liner (orange liner) is approximately 90°C (200°F). If areas of the seal where the liner has been shrunk by post-processing operations are subjected to stress such as coiling or bending with a tight radius, the liner may pop off the tape. The solution is to position the part with the liner on the outside of any coils or curves in the packaged part.

Post-Lamination Processing
Packaging Guidelines

General Description	Care should be taken in packaging seals to avoid disruption of the protective liner over the tape adhesive during packaging and shipping.
Packaging	**Containers:** Rigid containers are preferred to minimize seal disturbance during shipment. Corrugated packaging may be dirty or dusty and should be inspected before use. Seals may be packaged in plastic or an inner plastic bag to minimize potential contamination from corrugated.
	Packaging: Seals should be packaged so that they are not bent to a sharp corner. Bending seals sharply can lead to liner pop-off, which will allow contamination of the tape adhesive and may lead to adhesion problems. It is best to package seals in a box that is large enough to fit the seal length or minimize the need for sharp bends. Continuous seals can be coiled in a box with the tape on the outside of the rubber to provide additional tension on the liner and prevent liner pop off. For discrete seals with liner removal tabs, care should be taken to avoid disturbing liner removal tabs during packaging to prevent the liner from losing contact with the tape. Foam guides can be attached in the packaging to prevent the seals from free movement within the box during subsequent shipping.
	Shipping Temperature: Seals shipped during extremely cold weather (below 0°C) have a higher risk of liner pop-off. Extra care should be taken to ensure that seals do not shift during shipment and that the liner is placed to the outside of the coils.
	Storage Environment: Tape should be stored indoors under conditions of 4°C - 38°C (40°F - 100°F) and 0 – 95% relative humidity. Optimum storage conditions are 22 °C (72°F) and 50% relative humidity. To prevent oxidative damage of the tape liner, the tape should not be stored in direct sunlight.

OEM Processing
Applying Taped Seals to Surfaces

General Description

This guideline covers the recommended procedure for applying pressure sensitive seals on automobiles, RVs and other surfaces. Following these procedures will give the most reliable bond of the seal to the vehicle.

3M intends this document to serve as a general guideline for creating an OEM processing standard. 3M is available to assist with the validation of a new process or with periodic checks of an existing process.

Installation Line Area

The installation area should be reasonably clean. Airborne dust, oils, etc., may contaminate the body and reduce the bond of the tape.

Seals should be applied early on the assembly line and prior to the installation of the door and body hardware. This is to minimize contamination of the attachment surface from oil and grease which comes from the air tools and operators' hands. Application prior to door installation also allows for a short dwell of the seal on the vehicle, building adhesion prior to stressing the seal.

Cleaning

High Performance Wipe Cleaning:
The body surface should be cleaned with Scotch-Brite™ High Performance Cloths**.** The cleaning should remove all contaminants and leave no residue. Cleaning with Scotch-Brite High Performance Cloths can be done manually or with an automatic system. Clean the body no more than 20 minutes prior to seal installation. Scotch-Brite High Performance Cloths do not require the use of solvents, but should be indexed after cleaning every five vehicles or when visually soiled. They may be washed and reused. Scotch-Brite High Performance Cloths can be purchased through your 3M sales representative.

Solvent Cleaning:
One commonly used solvent system is a 50/50 solution of isopropyl (rubbing) alcohol and water.*

- Use clean, lint-free wiping cloths or disposable wipes, and change at least every hour or when visually soiled.
- Reprocessed rags should not be used as they may contain waxes, residual solvents or other contaminants.
- Care should be taken, especially with automatic wiping, that the cleaning cloth does not rub against tires or any other surface that might contaminate the body surface.
- The isopropyl alcohol and water mixture should not be less than 50% isopropyl alcohol, but may have a higher concentration as long as the body surface is properly cleaned before the mixture flashes off.

If possible, avoid applying the seal after a water test operation. This operation often involves surfactants and dirty water that adversely affect adhesion.

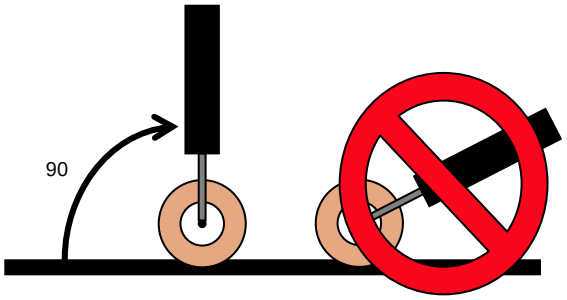
***Important Note:** State Volatile Organic Compound (VOC) regulations may prohibit the use of this alcohol/water solution. For example, the California South Coast Air Quality Management District (AQMD) prohibits use of this solution without a permit, and other California AQMDs prohibit use of the solution without a permit or a regulatory exemption. Check with your state environmental authorities to determine whether use of this solution is restricted or prohibited. When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use.

Cleaning (continued)	**Solvent Cleaning (continued):** After solvent washing, the body surface should be thoroughly dried. • This can be accomplished by wiping or through evaporation. • Evaporation can be accomplished by dryers (body heaters) or by time. • For wiping, use clean, lint-free cloths or disposable wipes. • Change cloths at least every hour or when soiled. • Reprocessed rags should not be used. * Note: There should be no production operation that could contaminate the body surface between cleaning and the seal application.
Application Temperature	Optimum application temperature is 15°C – 40°C (60°F – 104°F). The temperature difference between the parts to be bonded and the bonding surface should be as small as possible. In order to achieve the optimum adhesion level, the minimum requirement is that both part and body surface should be in the optimum application temperature range. It is not necessary to pre-heat a seal, although in some cases pre-heating may allow for easier placement. When the seal is pre-heated, it may become easier to stretch; in all cases, take care not to stretch the seal during application so that when the seal cools, it does not transmit additional force to the tape (see Seal Stretch During Application chapter of this guideline).
Manual Preparation	**Positioning Seal:** Remove the liner from the tape immediately prior to applying the seal to the vehicle, being careful to keep contaminants off the adhesive. Common sources of contamination are oil from the hands, lint from clothing and dust from tables and the floor. Do not touch the adhesive as the liner is being removed, since this can contaminate the adhesive. Apply the seal to the vehicle surface in the desired location, using finger pressure to hold it in place, being careful to position the seal properly without stretching.
	Seal Pressurization: Pressurizing the seal to the vehicle is the most critical part of a successful application, since the tape must be thoroughly wet-out to provide a good seal and prevent lifting of the seal in the field. *A rolling pressure is best to apply the seal*; rubbing with the thumb or finger may work for small areas but may be undesirable for both pressurization and ergonomic reasons. Do not rely on closing an aperture (e.g., a door or hood) to provide adequate pressure to wet-out the tape sufficiently for a good bond. Seals are designed to absorb this type of pressure through flexion of the rubber, and adequate pressure is not applied uniformly to the tape. Seal contours, geometry and materials vary widely. Specific recommendations on roller shape, configuration and installation force must be made on an application-by-application basis. The following are general guidelines.

Manual Preparation (continued)

Hand Rollers:

- Roller should be positioned perpendicular to the seal, rather than at an acute angle, to reduce seal stretch during application (see drawing).
- Proper perpendicular positioning of the roller also ensures proper force on the tape to ensure wet-out.



Application roller is held at a 90 angle to the body component surface.

- Hand rollers should be designed to ensure pressurization across the width of the tape. In some cases, a beveled roller will be beneficial.

Custom Application Tools:

3M can design tools specific to applications. The benefits of such hand tools are:

- The tool guides the seal to ensure proper placement.
- The roller is automatically aligned perpendicular to tape land surface to provide complete tape wet-out.
- The tool is designed for ease of use.
- The tool reduces operator variability.

Example of a custom-designed seal application tool

Contact your 3M sales representative or application engineer to discuss having a hand application tool designed for your application.

Robotic Application

Various robotic or automated assembly methods are possible with tape-attached seals. These systems need to be designed for specific seal and sheet metal parameters to apply the proper pressure through the seal to the tape and minimize stretch on the seal. The equipment should be designed to ensure that the critical parameters (for example, elongation of the seal, pressurization, etc.) can be consistently and reliably controlled. See the "Seal Stretch During Application" chapter of this guideline for information on measuring stretch.

Wet-out

Adequate wet-out (tape contact area) is essential to getting good, durable seal adhesion. There are several methods available to measure wet-out. At least 80% of the tape area should make contact with the surface for good adhesion. Please refer to the "Wet-out and Pressurization Measurement" chapter of this guideline.

Stretch	Excessive stretch during application is undesirable, as the rubber is elastic and will tend to return to its nominal state and will provide a constant force along the tape. The amount of stretch each tape can tolerate depends on a number of factors. Please refer to the "Seal Stretch During Application" chapter of this guideline for more information.
Removal and Reapplication of Tape-Attached Components	3M does not recommend relocating a seal once it has contacted the surface. If a seal must be relocated, be sure to follow these guidelines: • The seal is removed prior to final roll down (pressurization) so adhesive wet-out is at a minimum. • The seal is removed immediately after application to minimize adhesion. • The adhesive on the seal is not touched or contaminated in any way after it is removed. The seal is exposed to final roll down after reapplication to ensure proper wet-out.
Troubleshooting	Possible causes of inadequate seal adhesion include: • Check for adequate wet-out. Please refer to the "Wet-out and Pressurization Measurement" chapter of this guideline. • Verify that the surface is free of contamination. • Verify that seals are not being stretched during application. Please refer to the "Seal Stretch During Application" chapter of this guideline. • Verify that the adhesive surface of the tape is not contaminated before seal application. Remove the liner immediately prior to applying the seal to the surface. Be careful to prevent contamination of the tape surface -- do not touch surface of the tape after removing the liner. • Ensure that seal is being placed in the design intent location. For other troubleshooting ideas, contact a 3M application engineer.

OEM Processing

Wet-Out and Pressurization Measurement

General Description

Adequate pressure must be applied to a tape-attached part to assure contact with the vehicle and part retention. Wet-out testing confirms sufficient contact of the tape to the vehicle. Delivered pressure between the tape/body interface can be evaluated several ways.

Plant Wet-Out Test

1. Using a closed foam paintbrush, apply a very thin coating of water-based paint to the vehicle body where the parts will be attached.

   Note: Adding UV dye (1 packet per 8 oz. bottle) to the water-based paint will enhance the visual effect under a UV light. Packets of UV dye can be obtained from PPG Aerospace/PRC Desoto @ 317-290-1600.
   - Alternative materials (such as dry erase markers) can be used, although they should be evaluated for effectiveness and clean removal on an inconspicuous area of the vehicle.
2. Allow the paint to become dry to the touch. To verify dryness, check for paint transfer to your fingertips. Do not touch part interface area when checking for dryness. The paint is ready when none transfers to your finger. Depending on the ambient temperature and humidity, drying should be complete in about three to five minutes at room temperature. It is important to wait for the paint to be sufficiently dry before beginning the test. Paint that is too wet or too dry will not accurately determine wet-out. Some guidelines for identifying paint that is too dry are found below:
   - "Too-dry" Time Guide: Do not conduct a test when the paint has been on the vehicle for more than 20 minutes.
   - "Too-dry" Visual Guide: Do not conduct a test when the paint is over-dried, or when the paint has a "flaked" appearance on the adhesive surface of the tape after testing.
3. Ensure that any automated surface cleaning operations are disabled for the test vehicle(s) if the test paint needs to be applied before this stage on the production line to allow for proper drying.
4. Remove the tape liner, and process the seal to the body using the normal production process.
5. Remove the seal, being careful not to touch the tape. The paint will transfer to areas of the tape that are being adequately pressurized, yielding a "footprint" of areas that achieve proper wet-out. You may wish to cover the adhesive surface with clear packaging tape to avoid damaging the wet-out imprint.
6. Look at the tape surface and determine which areas have paint transfer. To determine wet-out, a grid made up of 1mm x 1mm squares may be used to measure percent tape wet-out to the body.
7. Upon completion of the test, remove the water-based paint from the vehicle using water and clean cloths. Using solvents or cleaners other than water makes cleaning more difficult.
8. Prepare the bonding surface of the body for the production part by cleaning with a 50/50 isopropyl alcohol/water wash*,

***Important Note:** State Volatile Organic Compound (VOC) regulations may prohibit the use of this alcohol/water solution. For example, the California South Coast Air Quality Management District (AQMD) prohibits use of this solution without a permit, and other California AQMDs prohibit use of the solution without a permit or a regulatory exemption. Check with your state environmental authorities to determine whether use of this solution is restricted or prohibited. When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use.

Pressure-Indicating Film

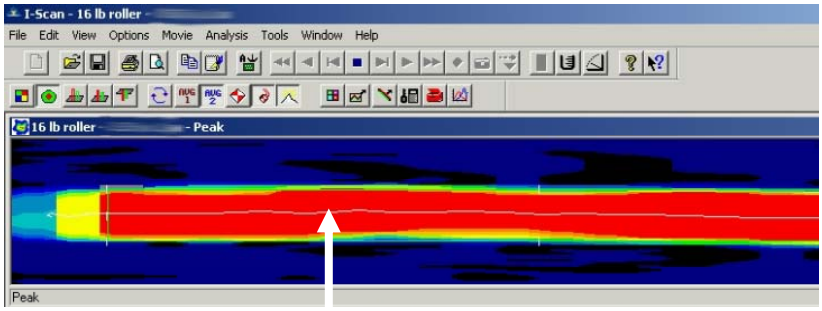
Pressure-indicating film works using permanent color changes to show distribution and degrees of pressure, with color intensity proportional to applied force. One type of pressure-indicating film, Pressurex® film, is supplied by Sensor Products Inc. This company offers products in six sensitivities to accommodate a wide range of pressure distribution.

Advantages of Using the Film:
Pressure-indicating films are easy to use and assembly-plant friendly. There are no additional or specialized tools needed for use. They are lightweight, portable and thin (4-8 mils). These physical properties allow them to be adapted to multiple configurations (nameplate, body side molding, cladding, etc) where they can conform to curved surfaces and be used in tight-fitting spaces. The films provide a permanent record of the pressure reading and are an accepted industry measurement (ASTM F2467).

Disadvantages of Using the Film:
The films must be handled with care so as not to activate the developing sheet prior to being placed on the surface. The pressure reading provided is approximate or relative; it is qualitative, not quantitative.

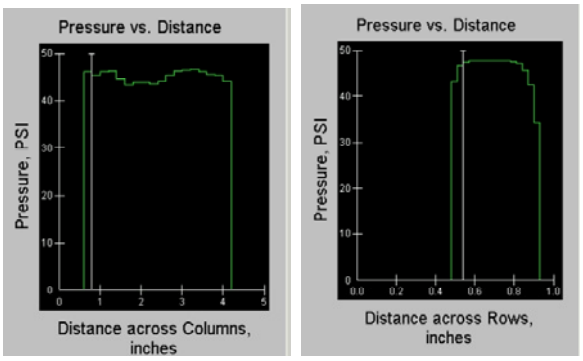
Computerized Measurement

The Tekscan® sensor unit is one brand of computerized equipment that measures pressure quantitatively through a pressure sensor and allows a more complete analysis of delivered pressure. There are several ways to look at the data with this unit. The main applicable functions are the ability to view the peak load transfer path and pressure distributions.



Peak load transfer path is mapped as a line on the scan

The peak load transfer path shows the distribution of pressure along the length of the part as well as indicates the path of the peak load. Under standard conditions, it is expected for the peak load line to be the centerline of the part.



Looking at the pressure across the columns and rows shows the pressurization down the length of the part and across the width of the part. In the case illustrated above, there is a 40 psi minimum requirement; and the graphs verify that minimum pressure was achieved across and down the entire part.

	Advantages of Computerized Measurement: The computerized tool provides quantitative data that can be analyzed multiple ways. The pressure map can be captured and played back in static and dynamic modes. Specific areas can be isolated and studied quantitatively.
	Disadvantages of Computerized Measurement: There are different sensors for different load ranges. They can be overloaded and thus destroyed, or they can be oversized and thus not provide good resolution. The sensors can also be damaged with improper handling and may be difficult to fit into low clearance areas. The cost of a computerized unit is not trivial and may add up quickly, depending on what options are chosen.

OEM Processing
Seal Stretch During Application

General Description

It is important to understand how stretch is induced in the seal during application. The exact amount of stretch an application can tolerate will depend on the tape used and the characteristics of the seal; however, it is best to minimize stretch during application. Regardless of how the seals are applied, the amount of stretch at points along the seal should be measured after application.

Measuring Stretch

Measuring After Application – Gap Method:

This method is normally used for out-of plane curvature.

1. After applying the seal using the normal application technique, pick the spot at which you wish to determine the stretch (e.g., the midpoint of an out-of-plane curve).
2. Mark that spot on the vehicle next to the seal, and then measure 10 cm (100 mm) on either side and mark that spot (tape or permanent marker work well for marking the three spots).
3. Using a razor blade, carefully cut through the entire seal at the middle marked point.
4. Pull back the seal from the cut point to the two outer points (100 mm on each side).
5. Depending on the seal profile and durometer, up to an hour may be required for the sections of seal to fully relax.
6. Carefully lay the two sections of seal back along their original application line and measure the gap between the two cut ends of the seal. The gap distance will correspond to the amount of stretch at the middle mark.

Seal has been cut and reapplied along original path; gap is measured with a ruler.

Mark the Seal Before Application - Direct Method

The seal should be marked every 10-20 cm along its length before application. Be sure to note the exact distance between each mark. Marking should be done with a very fine tip silver or gold permanent marker at the base (foot) of the seal, not on the bulb. A marking fixture (see below) can be made up to facilitate quick and precise marking of the seal. Provide enough markings to be able to measure applied seals around corners where stretch is likely to occur.

Seal marked every 10 cm with silver marker; shown with the marking fixture.

Close-up view of seal marking fixture. Deeper slits are made each 10cm, smaller slits are 1cm apart.

Measuring Stretch (continued)

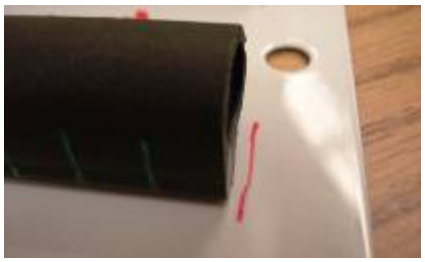
Measuring After Application -- Direct Method:
After applying the seal using the normal application techniques, re-measure the distance between markers. The percentage of stretch is then calculated from the difference between the free state marker-to-marker distance and the marker-to-marker distance after application.
If measuring around a curve, hill or valley, a length of wire can be used to track the exact path of the applied seal. Mark the wire to correspond to the pre-placed marks on the seal. Then, straighten the wire for measuring. When you encounter these complex geometries, you may measure more stretch than along a straight section. This does not mean that the overall application is inducing too much stretch.

Measuring Around Complex Geometries:
Using the gap method may be easier than the direct method. Before peeling back the seal, trace the edge with a marker so that you can replace the seal on the same line. When you encounter these complex geometries, you may measure more stretch than along a straight section. This does not mean that the overall application is inducing too much stretch.

Indications of Excess Stretch

Excess seal stretch during application can often cause the following failure modes:

- Creep of seal (seal pulls back from initial application position)—*see picture*
- End lifting or delamination of seal at end of seal – *see picture*
- Seal delamination on a concave surface (seal pulls away from surface)
- Delamination of seal in a plane when it goes around a curve (visible delamination at the apex of the curve).



Seal has “crept back” about 2mm from original position (indicated by red line).

Seal end on the right has crept back and lifted away from painted surface.

Troubleshooting

Reducing Stretch:
If excess stretch is noted, the following measures can be taken to reduce stretch:

- Constant application roller speed serves to minimize tension and stretch. Rapid acceleration can increase stretch and high speeds can adversely affect the application.
- Using a larger diameter application roller will reduce stretch applied to the seal.
- Excessive pressure can induce stretch. More pressure than that required to achieve 100% tape contact should be avoided. Please refer to the “Wet-Out and Pressurization” chapter of this guideline.
- Ensure that the seal is not being positioned incorrectly over a concave section or around a curve such that the corner or concave area is bridged by the seal.
- Add tension control to your application tool and minimize drag (see 3M for more details).
- Consider re-designing the seal to increase seal foot durometer or add a non-elastic cord (this may affect other areas of the application—consult with a 3M application engineer).

Consult with a 3M application engineer to discuss the measured stretch for your application and methods to reduce stretch if needed.

OEM Processing
Repairing Taped Seals

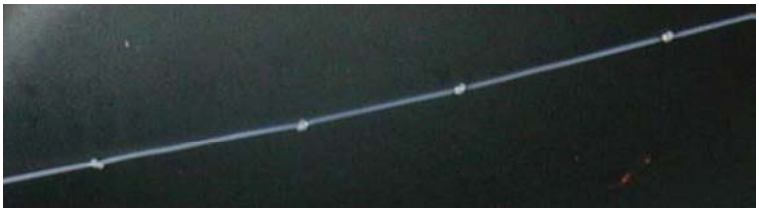
General Description

The following guideline offers specifics on removal, re-application, and repair of seals taped with 3M™ Heat-Activated Acrylic Foam and Acrylic *Plus* Tapes.

Removing Seals from Vehicles

Typically seals can be removed from the sheet metal by firmly pulling the seal away from the door as shown below.

If the seal is difficult to grasp and remove, try this method for removal of the seal:
Use a piece of monofilament line with several knots spaced about 1 inch apart. Use the knotted monofilament to saw through the tape and remove the seal without damaging the vehicle surface.

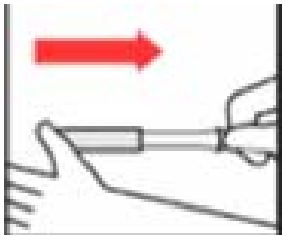


Alternately, the 3M™ Side Molding and Emblem Removal Tool (Part No. 08977) may be used, but it may scuff the vehicle surface.

* Note: Although seals may still have tack, they should not be reused due to damage of the tape and/or seal.

Removing Tape/ Residue from Vehicles

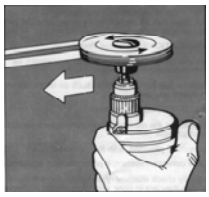
1. At one end of the residue, use your thumb to roll up the edge and initiate a peel.
2. Apply a strip of 3M™ Stretchable Tape 8884 on top of the tape/residue, making it slightly longer so that it overhangs the rolled-up edge. The aggressive adhesive on the 3M tape 8884 requires only light pressure. Applying excessive pressure will only increase the adhesion of tape/residue that you intend to remove.
3. Grasp the end of the 3M tape 8884 strip and the rolled-up edge of tape/residue together and slowly pull parallel to the vehicle surface. Pulling too quickly or at an angle may result in breaking the tape/residue strip.
4. Tape/residue should stretch release from the vehicle surface. It may be necessary to repeat steps 1-3 to remove all the tape/residue from the vehicle.



Alternative Tape/ Residue Removal

All tape/residue must be completely removed from the vehicle surface. In some occasions 3M™ Stretchable Tape 8884 may not remove all tape residue. In these instances, a 3M™ Stripe Off Wheel (Part No. 07498) will be needed to remove the tape/residue without damaging the vehicle surface.

The following technique is necessary for the removal wheel to work with the 3M™ Heat-Activated Acrylic *Plus* Tapes (black tape).



The wheel must rotate clockwise from the operators perspective and be applied to the tape from right to left. ***In other words, the wheel must be rotating into the tape to remove it without smearing.***

After removal of the tape/residue with the wheel, use 3M™ Prep Solvent-70* (Part No. 08973) or 3M™ Citrus Base Cleaner (3M ID#62-4615-4930-5) to clean away the residue. Then wipe with isopropyl (rubbing) alcohol and dry with a clean, lint-free cloth.

* Note: When using solvents, extinguish all ignition sources, including pilot lights, and follow the manufacturer's precautions and directions for use.

Securing, Positioning and Laminating Taped Door Seals

1. All tape/residue must be removed from the vehicle surface.
2. Application temperatures below 60ºF (15ºC) should be avoided. It is important that the vehicle not have any condensation on it (i.e., a cold vehicle moved into a warm shop). If necessary, warm the vehicle surface with a heat gun to obtain the recommended vehicle surface application temperature of 60ºF (15ºC) to 110ºF (43ºC).
3. Remove the liner and apply the seal to the appropriate location with firm pressure to assure good tape contact with the vehicle, resulting in good adhesion.
4. Check the edges of the seal to verify good tape adhesion. If necessary, roll the seal with a rubber roller.

Repairing Installed Seals that Show Minor Gapping

In some applications, minor gapping of the applied seals may occur. In these cases, it may be preferred to repair the gap rather than removing the entire seal, cleaning and reapplying a new seal. 3M recommends 3M™ Scotch Grip™ Rubber and Gasket Adhesive 847 or 3M™ Scotch-Weld™ Adhesive DP604NS to close minor gapping in seals. Instructions for filling gaps in seals are as follows:

1. Laminate a piece of 3M™ Filament Tape to the gapped area of the seal such that pulling on the seal will expose the gap.
2. As shown below, an artist's brush or small application bottle with brush can be used to place a very small amount of adhesive in the gapped area per the following procedures:
   For Scotch Grip Rubber and Gasket Adhesive 847:
   a. Apply a thin layer of adhesive to the loose seal.
   b. Lightly press the seal to the vehicle to spread adhesive on both surfaces.
   c. Pull the seal away from the vehicle and allow a dry time of 10 minutes.
   d. Position the part correctly, and press the part to the sheet metal firmly and hold for 5 seconds.
   e. The seal is ready for normal use after 5 minutes.

   For Scotch-Weld Adhesive DP604NS:
   a. Dispense just enough material so that both components dispense equally.
   b. Assemble the mix tip onto the cartridge.
   c. Apply a thin layer of adhesive to the tape.
   d. Within 2 minutes of dispensing the adhesive, position the part correctly, and press the part to the sheet metal firmly and hold for 5 seconds.

Appendix

Terokal® adhesive applied to gapped section of seal.

25 ml bottle used for applying adhesives

Different brush tops available for different viscosity adhesives.

Artist's brush may allow better control of the amount of adhesive used.

Terokal is a registered trademark of Henkel AG & Co.