Design Considerations for Smooth Sided Trailers

Technical Bulletin **January, 2011**

Introduction

Smooth sided trailers are created by using 3M™ VHB™ Commercial Vehicle Tapes for sidewall attachment rather than mechanical fasteners. The thicker 3M™ VHB™ CV62F tape (.062" thick) is used to bond the sidewall panels to the trailer frame. The thinner 3M™ VHB™ CV45F tape (.045" thick) is used to bond two panels together at the overlap seams. This bulletin highlights several considerations for improving the aesthetics and durability of smooth sided trailers to eliminate delamination. Three key items to consider are:

1) Choose the correct surface preparation to be used, prior to tape application, on the frame and both sides of the sidewall panels;
2) Allow for thermal expansion of the sidewall panels; and
3) Design the frame attachment face to be as flat as possible, and with adequate rigidity, to optimize both tape performance and panel appearance.

Advantages of Smooth Sided Trailers

The use of 3M™ VHB™ Commercial Vehicle Tape as a sidewall attachment method provides many advantages over traditional mechanical fastener methods such as self tapping screws and rivets. While functional, the mechanical fasteners distort the appearance of the sidewall and penetrate the sidewall panels, potentially causing leaks. With over 30 years of history in bonding sidewall panels on specialty vehicles, the use of 3M™ VHB™ Acrylic Foam Tape has been shown to be a durable alternative. The visual advantage of smooth-sided trailers is readily apparent, but the durability, leak resistance, corrosion resistance, noise and vibration reduction, option for reduced sidewall panel thickness or composite sidewall panels, and easier graphics application are additional, compelling reasons to utilize the taped sidewall attachment system. This guide will highlight several considerations for designing a trailer that uses 3M™ VHB™ Commercial Vehicle Tapes as a sidewall attachment system.

Summary of Design Considerations for Smooth Sided Trailers

Trailer Components	Key Considerations	General Guidelines
Frame and Sidewall panels	Choose best surface preparation prior to tape application.	1) Target to achieve minimum tape peel adhesion strength of 25 pounds/inch width of tape per 90 degree peel adhesion test based on ASTM D3330. 2) Work with 3M technical service engineers to determine best surface preparation on frame, clear washcoat interior of sidewall panel, and exterior color painted sidewall panel. 3) Typically fine abrading and/or the use of 3M™ Adhesion Promoter 111 will be the preferred surface preparations for most surfaces. 4) Use a minimum of 4 square inches of tape per pound of static load.
Sidewall panel edges and Upper and Lower Rail Extrusions	Allow for free expansion of sidewall panels.	1) Fasteners should not penetrate the sidewall. 2) Minimum of 1/4" expansion gap between panel upper and lower edge and the nearest constraint for 8 foot high trailer. 3) Width of channel between corner rail extrusions and frame should be slightly larger than the sum of two different layers of tape (3M™ VHB™ Tape CV62F and 3M™ VHB™ Tape CV45F) and two panel thicknesses at the overlap seam.
Frame	1) Design frame face to be as flat as possible. 2) Design frame to minimize extreme flexing.	1) Posts and frame rails should be aligned to provide a flat plane for adhesion. 2) The frame structure and **internal** walls should be able to carry the intended load of the trailer. 3M™ VHB™ Tape is primarily for exterior wall attachment and provides only minimal additional structural strength to the trailer.

I. Surface Preparation Considerations on Sidewall Panels and Frame

A. Surface preparation for sidewall panels

Both the interior and exterior finish of the sidewall panels must be considered when designing a smooth-sided trailer. The type of paint, paint additives and the surface finish of the paint are all important factors. Typical paint systems for these applications include a wide variety of polyester, acrylic, urethane, or epoxy paints. There are also some relatively new stain resistant or "dirt repelling" coatings that warrant special surface preparation considerations.

In virtually all cases where the interior side of the panel looks like bare aluminum, there is actually a washcoated clear paint on this surface. Best tape adhesion will generally result if a "LAM" grade or "LGB" grade interior finish is specified. These "laminating" grade or "laminating grade backer" washcoat paints are intended for improved tape, liquid adhesive, and sealant bonding.

B. Surface preparation for frame

Several types of framing materials are commonly used in trailer construction including bare steel, a wide variety of painted steel, galvanized steel, other types of treated steel, and bare aluminum. Any rust on bare steel must be removed. An effective technique to remove rust quickly and provide a good surface finish for 3M™ VHB™ Tape bonding is to use a 3M TN Quick-change Clean and Strip XT disc (aka "purple donut") in a right angle grinder. Good cleaning with a 50/50 mixture of isopropyl alcohol and water is always required after any abrading.

Caution: Coarse abrading (more coarse than 180X grit) on either sidewall panels or framing members will leave scratches or grooves that are too deep for the tape adhesive to fill and completely "wet out" – resulting in decreased adhesive strength. When fine abrading is required, always use 3M™ Scotch-Brite Hand Pad 7447 or 180x grit abrasive (or finer) on non-rusty metals or painted surfaces.

3M™ VHB™ Commercial Vehicle Tapes will provide an adequate bond to most surfaces, but some diligence is required to verify each specific application. The table below provides typical 90 degree peel adhesion values (ASTM D-3330) for 3M™ VHB™ Tape CV45F (overlap seam tape) and 3M™ VHB™ Tape CV62F (panel to post tape) applied to various test substrates typically used in trailers. Three surface preparation techniques were tested:

1) Clean only with a 50/50 mixture of isopropyl alcohol and water;
2) Fine abrade with 3M™ Scotch-Brite™ Hand Pad 7447 and clean with a 50/50 mixture of isopropyl alcohol and water; and
3) Apply 3M™ Adhesion Promoter 111 onto the surface with a disposable tissue.

I. Surface Preparation Considerations on Sidewall Panels and Frame *(continued)*

3M™ VHB™ Commercial Vehicle Tapes

Peel adhesion strengths with three different surface preparation techniques

3M™ VHB™ Commercial Vehicle Tape	Test Surface	IPA/water clean only. (lbs/in)	Fine abrade and IPA/water clean (lbs/in)	3M™ Adhesion Promoter 111 (lbs/in)
CV45F	Clear washcoated panel A	18.4	36.7	23.5
	Clear washcoated panel B	24.8	36.3	34.8
	Common white painted panel	13.0	36.0	35.8
	"Stain resistant" white painted panel	16.4	36.3	5.0
CV62F	Rusty steel frame	9.6	45.1*	40.3**
	Bare steel frame	30.6	31.3	39.4
	Galvanized steel frame	24.6	34.9	39.0
	Bare aluminum frame	41.3	42.5	42.2

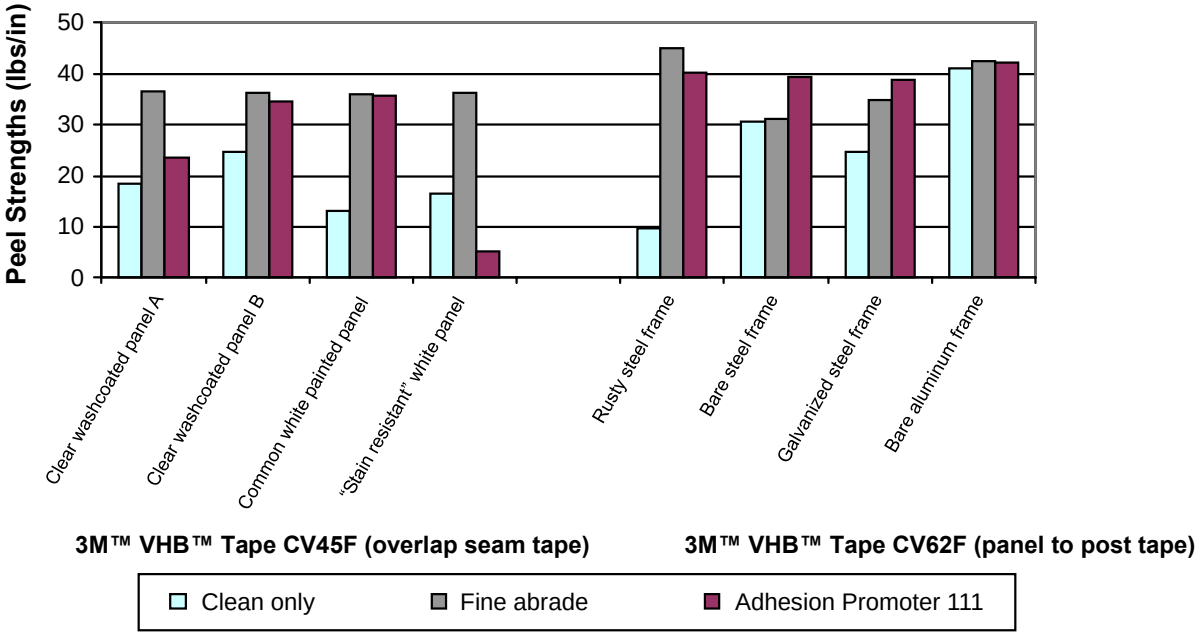
*Rusty steel was fine abraded with 3M Clean and Strip XT disc in a right angle grinder.

**This surface was abraded with XT disc above and cleaned with IPA/water prior to application of Adhesion Promoter 111.

3M™ VHB™ Commercial Vehicle Tapes

Peel adhesion tests on typical surfaces

73°F apply, 3 day 73°F dwell; 70°F test 12 lpm



The above data indicates that there are tape adhesion differences between similar looking materials. For example, different types of white paint or interior, clear washcoated paints will accept tape differently. It is best to keep track of the type of paint used on the sidewall panels (e.g. paint manufacturer, paint general chemistry like acrylic or polyester, and specific paint identification number). It is also best to work with 3M technical service engineers to initially suggest surface preparations for given paints or materials and then re-evaluate any suggestions if a different paint or material is being considered.

I. Surface Preparation Considerations on Sidewall Panels and Frame *(continued)*

Fine abrading, followed by a good cleaning, is the most “universal” surface preparation and works well on most painted surfaces and bare metals. The use of 3M™ Adhesion Promoter 111 is very effective on most paints and bare metals, but there are a few exceptions. Other testing has shown that the triple combination of fine abrading, cleaning, and the use of 3M adhesion promoter 111 is the “ultimate” surface preparation. Besides giving very good ultimate peel adhesion strengths, the adhesion build rate is also noticeably faster and the normal 60°F minimum suggested tape application temperature is slightly reduced.

C. Proper amount of tape

Typically sidewall panels are attached to framework posts that are 16 inches on center using 1" wide 3M™ VHB™ Commercial Vehicle Tapes along the entire length of the framework posts. As a general rule, for static loads, a minimum of four square inches of tape should be used for each pound of weight to be supported in order to prevent excessive, long term creep of the viscoelastic 3M™ VHB™ Tape.

II. Thermal Expansion Considerations for Smooth Sided Trailers

A. Background

A very common trailer construction is painted aluminum sidewall panels and bare, painted, or treated steel. The coefficient of thermal expansion (CTE) for aluminum is about 70% greater than steel. That means if both the aluminum and steel increase in temperature the same amount, the aluminum will increase in size about 70% more than the steel. Also, in direct sunlight, the panel temperatures will typically be considerably hotter than the steel framework. Black or dark colored sidewall panels made the thermal expansion differences even larger.

Assuming a CTE for aluminum of 12.3 (in/in °F x 10^{-6}), a CTE for steel of 7.3 (in/in °F x 10^{-6}), an 8 foot tall trailer, an assembly temperature of 70°F, a black painted aluminum sidewall panel temperature in direct sunlight of 200 degrees Fahrenheit, and a 100 degrees Fahrenheit steel frame temperature, we can easily calculate the differential expansion between the aluminum sidewall panel and steel frame along the 8 foot length:

200°F ΔL of aluminum panel = 70°F length x CTE of aluminum x ΔT (130°F) = .154".

100°F ΔL of steel frame = 70°F length x CTE of steel x ΔT (30°) = .021".

Therefore, the aluminum panel wants to expand .133" more than the steel frame. This differential expansion can cause severe buckling tendencies and possible panel delaminations. If the panel is constrained (e.g. with mechanical fasteners) in the vertical and horizontal dimensions, thermal expansion causes buckling in either the inward or outward direction. The surface distortions are clearly visible and create an oil can or pillowing effect. Mechanical fasteners or rivets cannot stop the buckling. The buckling occurs between each fastener or constraint.

Fortunately, the viscoelastic nature of 3M™ VHB™ Commercial Vehicle acrylic foam tapes will tolerate much of this differential expansion and minimize unsightly sidewall panel distortions, but designs that allow free expansion of the aluminum panels are highly suggested. If the 3M™ VHB™ Tapes are properly bonded to both surfaces, they will generally tolerate movement in the X, Y, or Z direction (up-down, left-right, out) to at least three times the thickness of the tape. For the 45 mil thick 3M™ VHB™ Tape CV45F, that would be 135". For the 62 mil thick 3M™ VHB™ Tape CV62F, that would be .186".

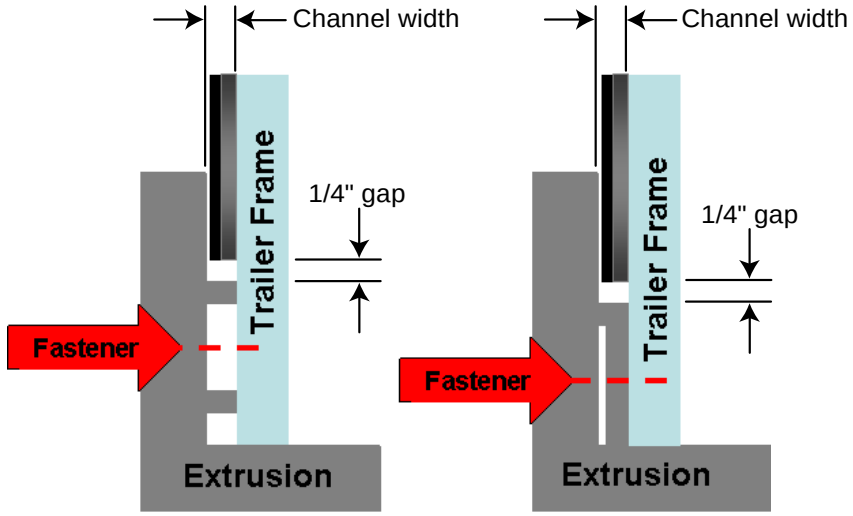
II. Thermal Expansion Considerations for Smooth Sided Trailers *(continued)*

B. Provide an open channel for expansion

The upper and lower extrusion is typically an extruded aluminum profile. These corner rail extrusions provide a finished look to the trailer, covering up any misalignment of the attached panels. They can also serve as a rub strip, minimizing sidewall damage, and provide a good location for conspicuity tape (lower rail). To provide an unconstrained, or free floating, sidewall panel attachment design, the extrusion must also provide an expansion gap for the sidewall panels.

Extrusions should be designed so that the sidewall can freely expand. In order to do this properly two items should be addressed:

1) Provide an open channel, between extrusions and frame, for the panels to freely expand and contract as shown in the illustrations below; and
2) Place the extrusion mechanical fasteners above or below the sidewalls such that no mechanical fasteners penetrate the sidewall panels.



Lower rail extrusion designs with "standoffs or spacer to create a channel for expansion

The thickness of this standoff or channel width will be defined by the combined thickness of the overlap seam, which has two panel thicknesses plus two tape thicknesses, as shown in the following calculation:

Channel Width = (2x panel thickness) + thickness of 3M™ VHB™ Tape CV62F (post to panel tape) + thickness of 3M™ VHB™ Tape CV45F (overlap seam tape) + .003" extra clearance

For a trailer using 30 mil thick aluminum sidewall panels, 3M™ VHB™ Tape CV62F (62 mils thick), and 3M™ VHB™ Tape CV45F (45 mils thick), the minimum channel width (size of the extrusion standoffs or spacer) at the overlap seams is 170 mils. These "standoffs" or spacer in the rail extrusion designs are required to prevent a "pinch constraint".

It is best to provide expansion gaps at both the top and bottom of the sidewall panels. However, if this is impractical, an expansion gap at either the top or bottom will still help considerably to minimize panel buckling and possible delaminations.

II. Thermal Expansion Considerations for Smooth Sided Trailers *(continued)*

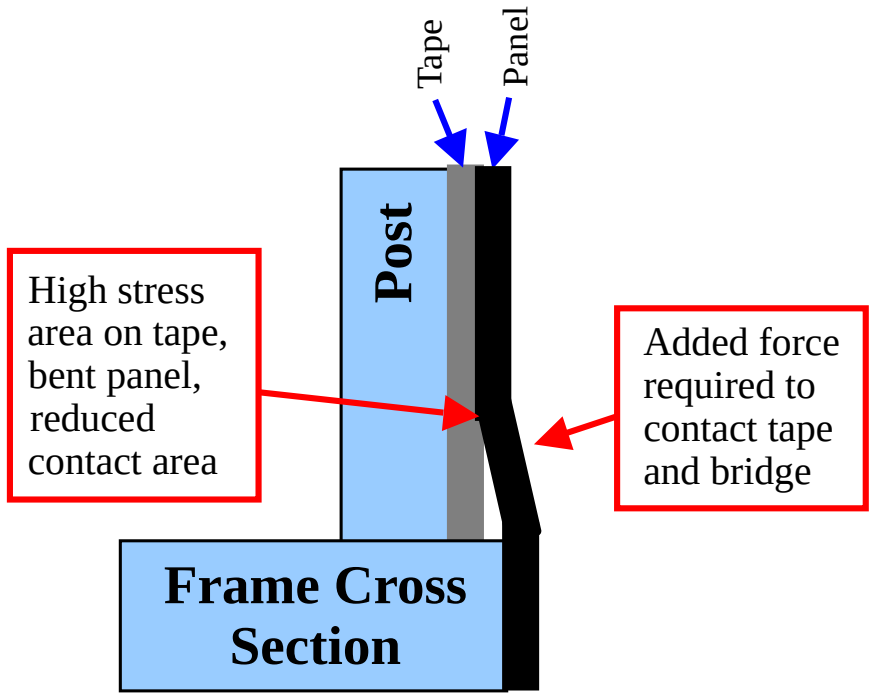
C. Panel Length

Cutting the panel to the appropriate length is important to ensure that thermal stresses are minimized in the sidewall attachment. Design for a 1/4" gap between the top and bottom end of the sidewall panel and the standoffs or spacer in the corner rail extrusions.

III. Frame Considerations

A. Design frame face to be as flat as possible.

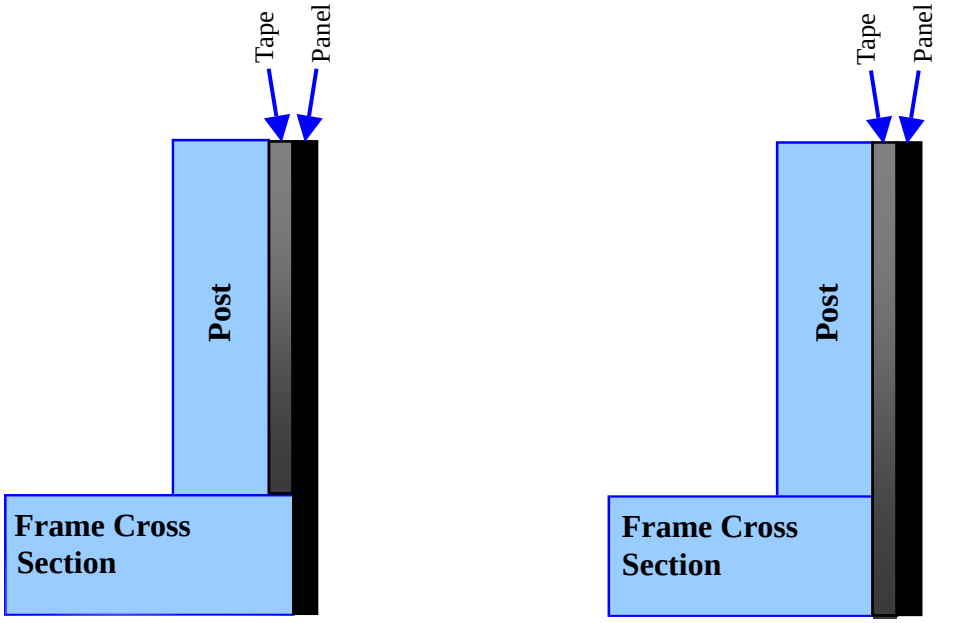
One important design consideration for smooth sided trailers is the flatness of the frame or the plane on which the panels will be attached. The goal is to create the flattest sidewall possible and minimize static stresses on the tape. One very common area for consideration is where the upper and lower horizontal frame rails connect to the vertical posts as shown in illustration below.



Undesired frame post to frame rail alignment.

III. Frame Considerations *(continued)*

A post to panel misalignment creates a potential initiation point for tape delaminations and can be corrected through a modification in the frame design. The preferred ways to accomplish this are shown in the illustrations below



Offset in post accommodates tape thickness

Post flush with frame rail provides a flat plane for tape

B. Other Frame Considerations

Other frame considerations include managing constraints associated with other areas on the wall that typically involve mechanical fasteners. This may include door and window frames, vents, horse tie downs and fenders. As with the side wall posts, the areas around these openings, where the sidewall will be attached with tape, should be built on the same plane as the posts. This will minimize sidewall distortion and static loads on the tape. Items such as horse tie downs and fenders should be studied to determine if it is necessary to provide an unconstrained design that provides for thermal expansion. The greater the length of the panel between constraints, the larger the affects of thermal expansion and the more prone a panel is to buckling.

C. Structural Strength of the Frame

Although extremely strong, durable, and time proven, the 3M™ VHB™ Commercial Vehicle Tape is not considered to be a structural adhesive. The trailer frame must provide virtually all of the structural strength for the trailer. If a fully loaded trailer, with no sidewall panels attached, would be fully functional, then 3M™ VHB™ Commercial Vehicle Tapes would be an excellent option for further consideration and evaluation as the sidewall panel attachment system.

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Industrial Adhesives and Tapes Division
3M Center, Building 225-3S-06
St. Paul, MN 55144-1000
800-362-3550 • 877-369-2923 (Fax)
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