THE COMPLETE SALESMAN'S GUIDE TO

Vinyl Windows

There are four key elements involved in the production of high quality vinyl extrusions manufactured by VEKA Inc. These elements are:

Compounding:

The science of combining PVC (Polyvinyl Chloride) with specific measurements of micro ingredients in a formulation that meets the needs of material performance requirements.

Blending:

The weighing, measuring, and mixing of all "compound" ingredients into a homogeneous, uniform state.

Extrusion:

The creation of a finished workable form through a process that includes the plasticization of dry compound, the shaping of this plastic through specified die shapes, the cooling of the final shape through specified die calibration, and utilizing water baths and calibration tables.

Design:

The utilization of modern extrusion and fabrication technology to create an operational window unit with specific attributes that maximize specific market criteria.

VEKA

Section 1.0

Compound and Micro Ingredients

The vinyl used in VEKA's window and door systems is comprised of many different ingredients. Approximately 85% of this mixture, commonly referred to as "compound," is PVC (Poly Vinyl Chloride). (See Figure 1)

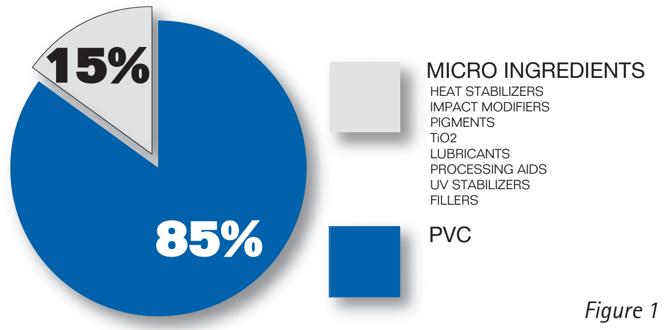

Figure 1

PVC is created from ethylene, a gaseous by-product of petroleum, and chlorine, an element derived from salt. In its pure state, PVC lacks the properties required to satisfy durability and weatherability parameters necessary to fabricate a vinyl window/door system. To increase the performance of the final product, micro-ingredients that possess specific performance properties are added to the PVC. (See Figure 2)

Features and Benefits of Micro Ingredients

INGREDIENT	FUNCTION	PREVENTION
Heat Stabilizers	Prevents compound degradation during the extrusion process	Minimizes the effects of solar radiation on vinyl frame and sash
Impact Modifiers	Adds ductile properties to PVC which is basically brittle	Inhibits damage during fabrication, shipping and operation
UV Stabilizers	Minimizes effects of UV light on the window profiles	Prevents color fading and degradation from UV light
TiO2	Imparts white color to profile and reflects the sun's rays	Aids to prevent heat build up on vinyl surface
Lubricants	Counteracts frictional forces between vinyl and extrusion dies	Maintains a smooth finish on vinyl sashes and frames
Processing Aids	Affects morphology of PVC compound	Prevents inconsistency in quality and unpredictably during fabrication
Pigments	Imparts color to profile	Allows product variety

Figure 2

Section 1.1

Heat Stabilizers

PVC would burn and char through the intense temperatures induced in the twin screw extruders if it were not for heat stabilizers. VEKA uses adequate amounts of expensive heat stabilizers to prevent the degradation of the compound throughout the extrusion process. This ensures that the performance properties of this mixture will not be affected by the severe thermal changes that occur during plasticization.

A finished window system that used inferior or limited quantities of the heat stabilizers would be affected by solar radiation. Intense heat can build up on the external surfaces and within the internal profile chambers (especially on south facing walls in North America).

Without proper stabilizers, the vinyl will want to revert from a solid, rigid form to a soft, structurally inferior state. The result can be warped or deformed sashes, frames and mullions that can lead to performance and operational failure.

These failures can arise in the form of "crashing" or misaligned interlocks, sticking or non-operational sash movements, failing support of glazing beads or glass packages and expanding infiltration gaps between sash and frame units.

These failures may lead to service calls, failed units or severely decreased performance characteristics (i.e., increased air and water infiltration, decreased U-values, etc.).

Some extrusion companies cut costs by adding additional amounts of the less expensive TiO2 (see Section 1D) to their compound in order to ref ect more of the sun's rays away from the window. This scenario, however, can lead to "chalking." Chalking occurs when TiO2 leaches out of the vinyl forming as a white powdery residue on the frame and sash surfaces.

Rain and wind can wash this powder across other building materials creating unsightly stains and discoloration.

VEKA's utilization of expensive heat stabilizers ref ects their corporate position that the additional cost of these elements is greatly outweighed by possible field service calls, window failures, and product returns that would occur with other formulations.

Section 1.2

Impact Modifiers

Without impact modifiers, the final window product would be very brittle. Great care would be required in handling the window during fabrication, shipping, and installation to prevent serious breaks or cracks from occurring in the vinyl. VEKA uses impact modifiers in the compound to counteract the intrinsic brittleness of PVC and add a certain ductility (surface forgiveness) to the final product. Windows without sufficient impact modifiers could be damaged by errant blows from installation tools, would show cracks or breaks from environmental hazards as hail or sleet, and may even show damage caused by the contact of tilt latches when the operable sashes are returned into the frame. The impact modifiers are extremely important when it comes to new construction windows. The nailing fin, a single wall of vinyl that protrudes from the window frame with only one end of support, may be exposed to various forces during the fabrication process. Many times these windows are stored with the entire weight of the window supported by the nailing fin. Also, framers and carpenters installing these windows in all types of weather, will find that errant blows from hammers or nailing guns may damage the nailing fins in windows that use a lower quality vinyl.

Section 1.3

UV Stabilizers

Ultra-violet light (UV) is a natural component of sunlight (see Figure 3). This wavelength of light has been connected to sunburn and melanoma (a form of skin cancer). These rays also cause fading and discoloring of various fabrics and fibers used in furniture, draperies, and other building and home materials. These same rays will also cause a discoloring of the material used in vinyl window and door systems. To minimize the effects of the sun, VEKA adds UV stabilizers to their proprietary compound. This ingredient acts to prevent the compound from changing colors after long exposures to the sun.

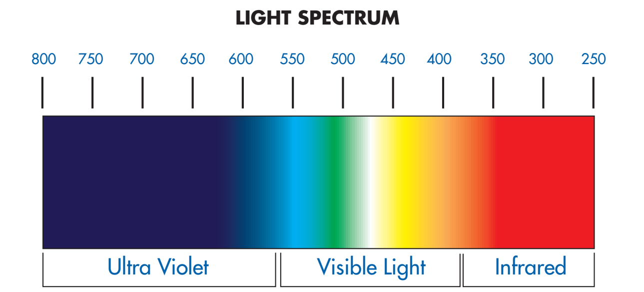

Figure 3

A window system that did not utilize the added performance of UV stabilizers would show drastic color changes in only a short period of exposure. White windows would look dull, they may turn yellow and sometimes even dark brown. Dark brown profiles would show a dull surface and actually lighten to a uneven color that is very unsightly. Just like heat stabilizers, UV stabilizers are an expensive additive in the VEKA compound. However, the cost of adding this important component greatly outweighs the possible field problems that may occur. (See Section I-A, I-D and Figure 9)

Section 1.4

TiO2

Titanium Dioxide (TiO2) is a common chemical used in a variety of products where a brilliant white color is needed. TiO2 is added to VEKA's proprietary compound for this same reason. Because the TiO2 is mixed into the compound, the color is retained throughout the profile. For that reason, any surface marring or scratching from handling or weathering remains less evident than windows that are painted or cap stocked (a white lineal with a thin vinyl extrusion covering its exterior surface, usually in another color).

Besides just an aesthetic appeal, TiO2 provides important performance functions to the final window product. Because of its brilliant color, it ref ects the sun's rays away from the window unit preventing unwanted heat build up on the exterior surfaces and inside the internal chambers (see Figure 4).

This thermal build up could result in lowering the structural integrity of the window unit and hamper its insulating abilities (see Figure 15). Though this micro ingredient performs a valuable function within the vinyl window, improper amounts of TiO2 can create unwanted effects. (See "chalking," Section I-A)

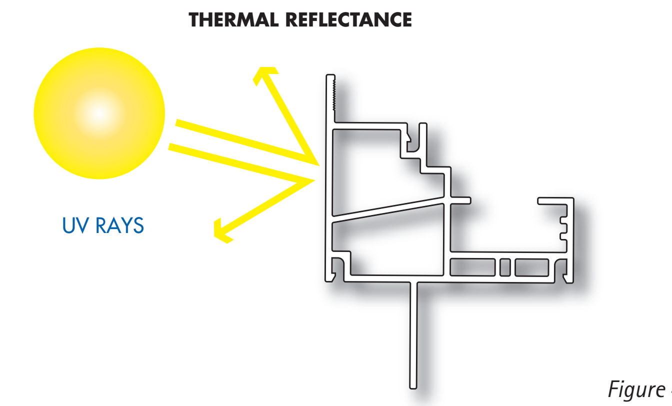

Figure 4

Varying levels of TiO2 can create various intensities of white (see Figure 5). Extruders not dedicated solely to vinyl window and door systems may formulate their compound to closely match that of their siding, soffit or fascia products. VEKA's TiO2 formulation results in a median color that can easy match the majority of building and paint products.

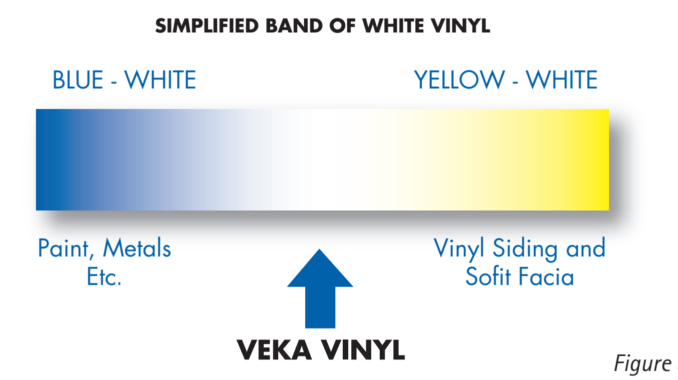

Figure 5

Section 1.5

Lubricants

Lubricants counter act the friction between the vinyl and the metal surfaces of the extrusion machinery, dies and calibrators. This micro ingredient allows the vinyl to travel smoothly and consistently throughout the extrusion process. The smooth shiny surface associated with a VEKA vinyl extrusion would not be possible without the addition of these lubricants.

Section 1.6

Processing Aids

These ingredients affect the melt morphology of the compound (i.e. the consistency of the compound as it changes into a plastic). Proper amounts of these elements are necessary to insure the plastic melts and cools at the same consistent rate. Without the processing aids, an extrusion would be inconsistent in quality and non-predictable in fabrication.

Section 1.7

100% Virgin Vinyl

VEKA uses only virgin vinyl compound to manufacture their high quality window and door systems. Virgin Vinyl (see Figure 6) refers to a compound material that does not have a melt history.

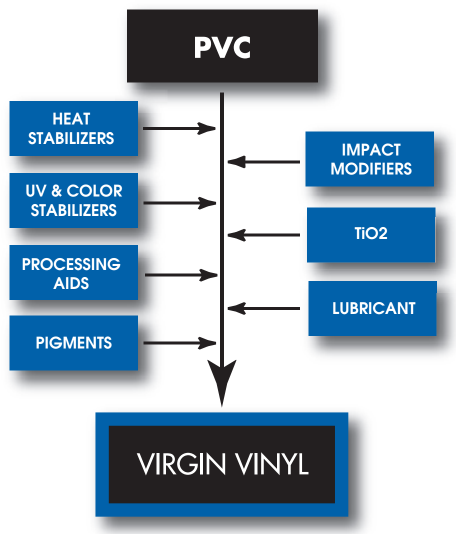

Figure 6

Materials with a "melt history," in essence, are vinyl compounds that have been recycled from other vinyl products. This material (commonly known as "regrind" because the components are ground into small pellets) adds a previously "recorded" molecular "memory" (see Section III-B) into the mixture. Some companies may use regrind or a mixture of regrind and virgin vinyl in the formula for their vinyl extrusions. These companies run the risk of producing vinyl products of lower quality and reduced performance in strength, surface texture, weatherability, shrinkage and durability. Also, as their regrind is introduced into the compound mixture time and time again, the actual ingredients of that blend will drastically change over time. Adding regrind material that consisted in part of previously recycled materials will lead to a mixture with unpredictable characteristics.

Section 2.0

Blending

A cake recipe will call for a variety of ingredients, in various amounts, mixed with a certain amount of "strokes." Straying from the recipe creates unexpected results and a dessert that is "too sweet," "too dry," or just "doesn't taste right." Vinyl compounding is a similar process. The many ingredients must be precisely measured to obtain the optimum performance characteristics and they must be properly blended to create a homogeneous mixture. If one does not follow the "recipe," the resulting vinyl windows will fall far short of VEKA's quality expectations.

Other extrusion companies rely on manpower to do much of the weighing, mixing and delivery of their compound to the extrusion machinery. These methods are inherently fraught with error.

"Eyeballing" the amount of an ingredient using a bin or scoop can vary from one batch to the next or from one day to another. To eliminate any human error within the compounding facility, VEKA incorporates the use of micro computers and computer controlled scales. (See Figure 7)

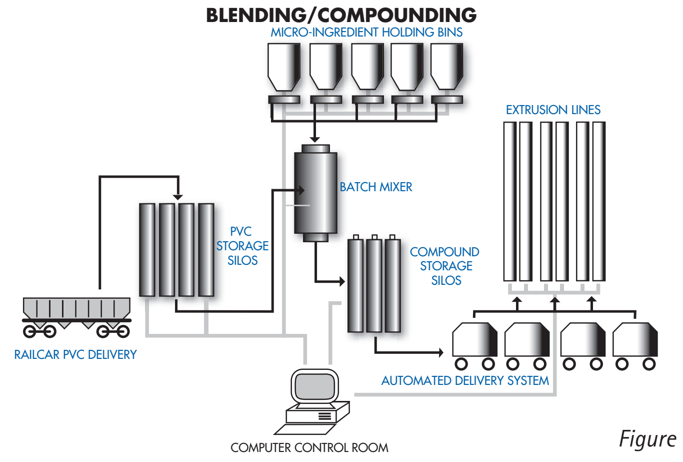

Figure 7

These scales measure each ingredient to 1/100th of pound before it reaches the mixing phase of the operation. There is no variation from one day to the next, thereby maintaining a constant and optimum mixture batch after batch. Once these ingredients are properly weighed, it is vital to mix the materials thoroughly into a uniform, homogeneous state. Without proper blending, a vinyl lineal would possess varying properties in different areas of the profile. This can greatly effect the joints of a window system manufactured with welded sashes or frames. When the vinyl is touched by the heater plates of a welder, the plastic might melt at a variable rate. (See Figure 8)

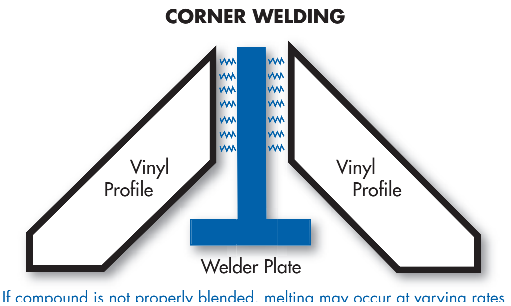

Figure 8

After the slightly melted lineals are pushed together, they may not bond properly, if at all. Also, improperly mixed batches of compound may discolor or fade at varying rates throughout the lineal due to poor distribution of color and UV stabilizers. This would cause a spotting or speckling effect. (See Figure 9).

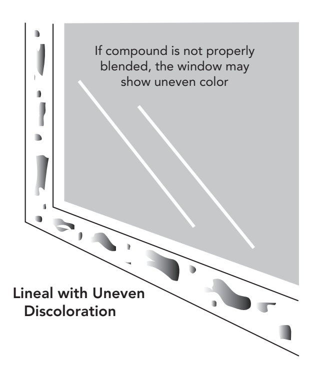

Figure 9

Likewise, an improper mix of impact modifiers may cause what is known as "spidering." Here, surface cracks appear to spread across the top of vinyl lineal while the interior portion of the vinyl wall remains in tact. This is caused mainly from variable ductile properties between the surface and underlying vinyl. These surface cracks resemble mud dried in an intense sun. (See Figure 10)

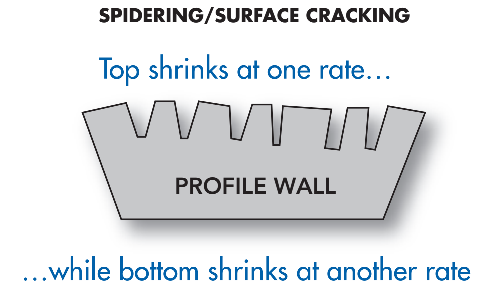

Figure 10

The use of computer control is vital in this phase as well. Computers not only measure the revolutions of the mixing blades, but also track the temperature created from the friction that occurs inside the blender. An extremely high temperature can sometimes cause the compound to lose some of its properties even before it enters the extrusion line. Once the compound is weighed and mixed, it is automatically transferred to storage bins to await yet another computer system controlling the f ow of the material to the extrusion lines (see Figure 11).

When an extrusion line becomes low on raw materials, it can automatically "ask" for more compound. At this point, an automated rail car system moves the raw material from storage to a gravity feed tube located above the extrusion line. The entire system guarantees an uninterrupted supply of materials for all extrusion lines.

The entire compounding and delivery system is closed. That means that there is no opportunity for impurities to enter into the compound and minimizes "down time" for any repairs or modifications. The only time the vinyl actually comes into contact with human hands is at the end of the line when the long 21-foot lineals are loaded onto shipping racks. VEKA's facility is safe, dependable, and has a long track record as the finest vinyl compounding facility in the world.

Section 3.0

Extrusion

VEKA utilizes the latest technology on all of its extrusion f oors with the implementation of twin screw extrusion systems.

Section 3.1

Twin Screw Extruder

The term twin screws describes the interior working parts that force the compound through an extrusion die and calibration system. Twin screw extruders are superior to single screw systems in many ways. Using our "cake mixing" analogy, imagine making a cake with an electric mixer that has only one blade. Rotating in one direction with limited material movement, the time needed to properly process the mixture would be greatly increased over a mixer with two blades. Twin, inter-meshed, opposite rotating screws inside an extruder can be compared to a two bladed electric mixer. Almost three times as much material can be pushed through the end of a f ume that carries the mixture downstream through the die heads. This means that VEKA can produce more finished material with less machinery and manpower, increasing the efficiency and output of each extrusion line.

Most companies that use single screw extruders are manufacturers that use "regrind" (see Section I-G) in their compound. Regrind in its raw form is made of much larger particles than virgin vinyl. Because of the close proximity and limited clearance that occurs between the screws of a twin screw extrusion system, only fine particle virgin vinyl can be processed.

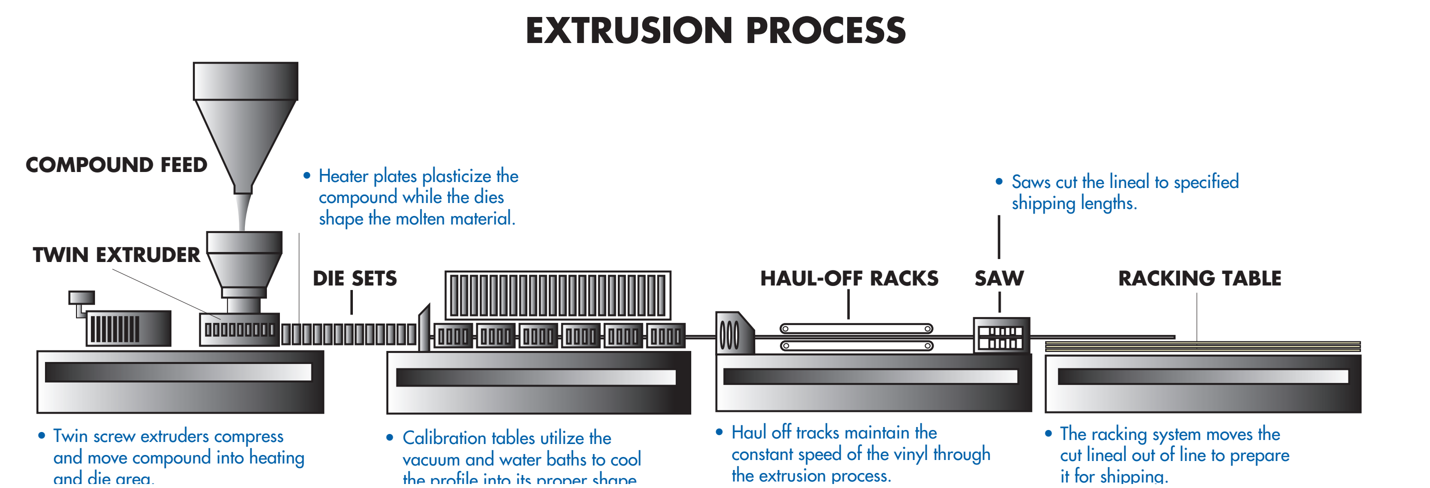

Figure 11

Section 3.2

Calibration

One of the most important aspects that differentiates VEKA from other extrusion companies is the amount of calibration used in VEKA vinyl profiles. Calibration is the act of cooling the vinyl from a plastic state into its final solid workable form. Once the plastic moves out of the die system, the outer surfaces and the inner chambers must be cooled sufficiently to retain their shape throughout the life of a window system. This shape retention is commonly called “memory.” If the vinyl lineal is not cooled properly, the exterior or interior walls may warp, buckle or bend as they try to cool to room temperature. These deformities will cause major fabrication problems as well as performance failures in the final product. (See Figure 12)

COMPARISON OF CALIBRATION

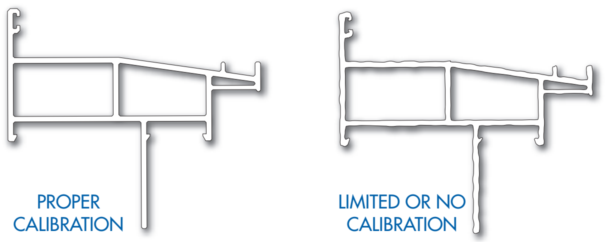

Figure 12

Calibrators (see Figure 13) are a series of metal dies that ref ect the exterior shape of the profile being extruded. As the heated plastic moves through these dies, tiny vacuum holes suck the exterior wall against the inner track of the calibrators. This guarantees that the walls will not warp or def ect from their desired dimensions.

CALIBRATOR CROSS SECTION

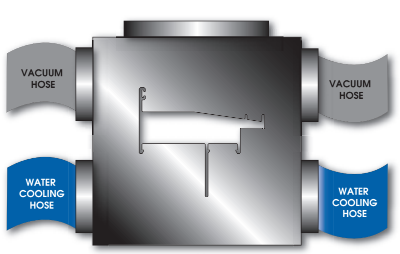

Figure 13

While the shape moves through these units, a water bath is injected through the metal of the calibrators. The heat from the vinyl is absorbed by the metal and then carried away by the constantly f owing water. VEKA typically uses between six to eight calibration systems for every profile it extrudes.

Though the cost may seem prohibitive to other extrusion companies, VEKA feels the higher quality profile produced by such a system far outweighs the additional cost of the added calibrators. To guarantee consistent cooling, VEKA recycles its water bath through a chiller system that constantly monitors the temperature of the 330,000 gallon reservoir located beneath the factory f oor. This reservoir circulates water through the calibration system and out to roof top chillers to retain a temperature of between 55-65 degrees Fahrenheit. Controlling this temperature allows the optimization of the cooling process. (See Figure 14)

Proper Calibration and Cooling	Insufficient Calibration and Cooling
• Will cool both external and internal surfaces of profile to room temperature (solid state). • Insures vinyl retains its shape when loaded and stored onto shipping racks. • Profiles extruded to “spec.” will minimize fabrication errors. • Window will perform within design parameters for performance, durability and weathering..	• May cool only external surfaces leaving the wall warm and supple. • Walls may deform from further cooling after leaving extrusion line. • Deformed material may cause fabrication difficulties leading to material returns. • Window may not perform properly.

Figure 14

Section 3.3

Push/Pull Extrusion

Once a profile has been cooled it enters into a “locked memory” state. This means that the stresses incurred during the extrusion process will be molecularly induced into the profile. If the lineal is cooled while in a stretched or compressed state, the vinyl would retain these inner forces in its “memory.” Once the lineal is introduced to external heating (from a hot summer sun, for example), the vinyl may revert to an undesired shape that would alleviate these inner forces.

PROBLEMS CAUSED BY POOR QUALITY EXTRUSIONS

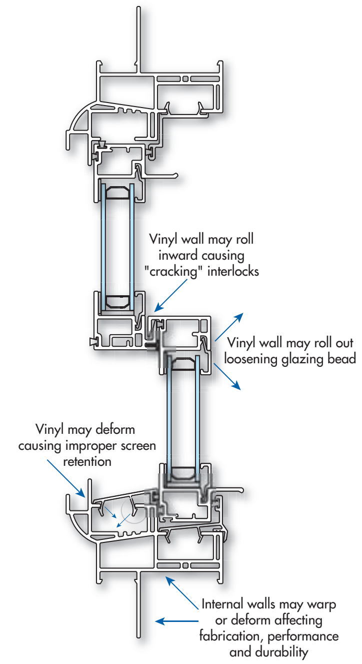

Figure 15

Visualizing a rubber band would create a good analogy. Imagine stretching a rubber band to twice its normal length. If you would freeze the rubber band in that position, it would retain its shape as long as it was left in a frozen condition. As the rubber band warmed to room temperature, however, it would slowly shrink back to its dormant length where the interior stress would be eliminated. This same phenomenon occurs in a vinyl lineal. Shrinking vinyl components in a window system can cause a myriad of problems including failed glazing beads, air and water infiltration, “crashing interlocks,” broken glass units and poor operation of the window (see Figure 15). The secret to producing the highest quality extrusions is to cool the lineal through proper calibration in a state that has the least amount of compression or tension. If the movement of the plastic would be left to the twin screw extruder, the plastic would be pushed through the entire system.

PUSH/PULL DIAGRAM

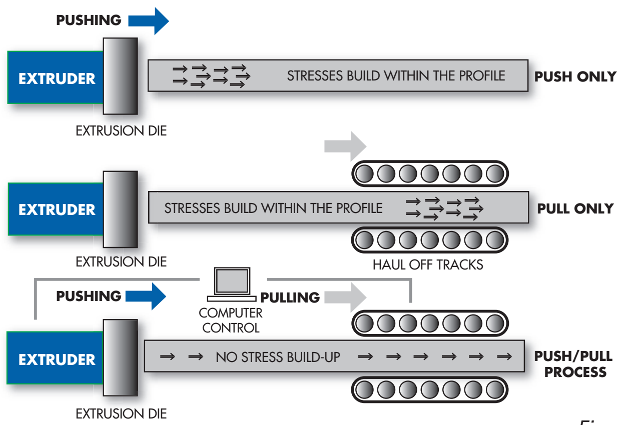

Figure 16

This constant push would naturally induce different compression rates throughout the length of the vinyl profile as it exits from the die face. If the lineal was merely pulled through the system, then a stretching force would occur in the length. By duplicating the pushing force of the extruder with an equal pulling force at the end of the extrusion line, VEKA virtually eliminates any stress build up inside the lineal (see Figure 16). The pulling force is provided by a haul off track located downstream from the calibration and die system. Linked by computer to the upstream extrusion screws, the haul off track allows the lineal to pass through the extrusion line at a constant rate of speed, eliminating internal stresses that may affect a window’s performance.

Section 4.0

Design

Using current extrusion and production techniques to develop window systems that conform to performance codes and to specific market and fabricator concerns.

Section 4.1

Chambered Profiles

Most of VEKA’s high quality extrusions are designed with internal spaces that are formed by interior and exterior vinyl walls. Exterior walls are designed to meet the performance and aesthetic parameters required by a particular window system. Interior walls are added for a variety of reasons including structural integrity to the window unit, weld strength at the corners of frames and sashes, screw bosses for the reception of mounting screws, and insulating performance. The air trapped inside the interior hollows is a major contributor to the thermal properties of vinyl window and door systems. Air is a good insulator and if used properly in a vinyl design it can greatly increase the insulating properties of the frame and sashes.

When a variance exists between the indoor and outdoor temperature of a home, the interior and exterior surfaces of the vinyl window will absorb various amounts of heat. In winter, the indoor surfaces will be warm and the outdoor surfaces will be cool. As the interior wall heats the air inside the chamber adjacent to it, the air will begin to rise to the top of the chamber. This air is replaced by the cooler air that exists along the opposing wall. This constant movement (commonly referred to as “convection”) will create a circulation of air inside each chamber throughout the profile and cause rapid heat transfer. This circulation in effect will lower the thermal performance of a frame. In a window frame or sash where multiple chambers exist, exterior temperatures are never permitted to come in direct contact with interior temperatures because of the internal wall that exists between the outside and inside hollows. This design feature plays a major role in the insulating properties of the frame and sash of a vinyl window system. If a window design were to have only one chamber, air that is cooled by the exterior wall moves to the interior wall causing rapid heat transfer. (See Figure 17)

CONVECTION CURRENTS WITHIN A CHAMBERED PROFILE

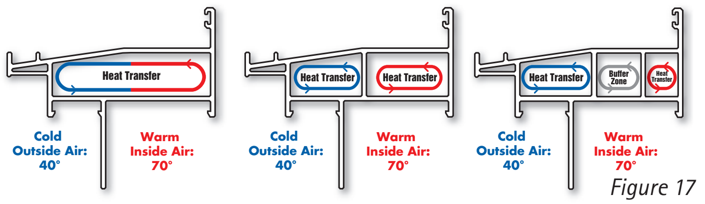

Figure 17

This would greatly lower the insulating capabilities of the vinyl frame or sash unit. The size of the interior chambers also plays a role in the heat transfer that occurs due to convection. A larger chamber will allow more air to circulate, thus lowering the insulating capability of the vinyl member. Smaller chambers and chambers with added vinyl legs will decrease the amount of air circulation leading to a higher performing window frame or sash unit.

CHAMBERED PROFILE WITH LITTLE OR NO CONVECTION (DEAD AIR)

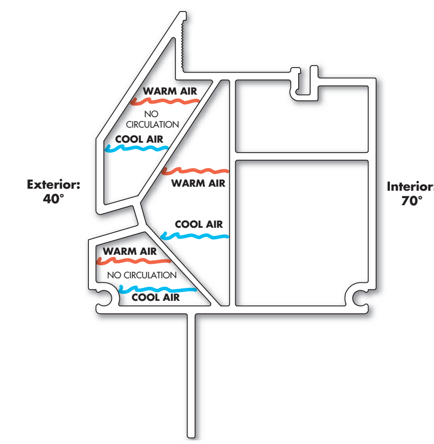

Figure 18

The ultimate chamber in a window system would be one that has “dead” air or no movement of air whatsoever. Properly designed chambers, where the interior is higher than the exterior, can actually hinder the convection currents within the profile and create a dead air space (see Figure 18). Some fabricators will fill the chambers of vinyl profiles with insulating foam. Used in the proper chambers, this foam can increase the thermal performance of the frame unit. Many times, fabricators will add the foam into areas that do not cause a thermal improvement in the design (i.e., a chamber with a large area exposed to interior heat). In these instances, the foam becomes a highly visible “sales tool” and will not directly affect the thermal characteristics of the window as a whole. (See Figure 19)

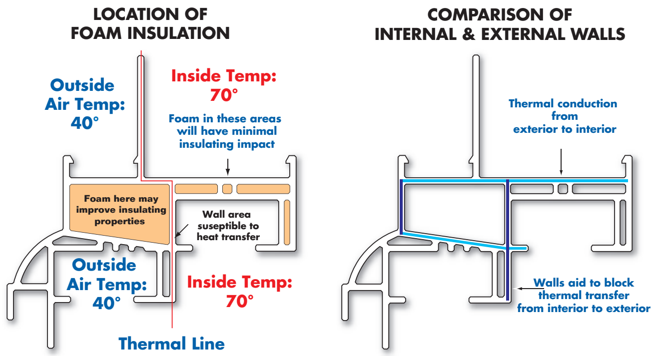

Figure 19

Section 4.2

Internal Walls or Webs

As mentioned earlier, internal walls are designed into a profile shape for various reasons (see Section IV-A). The amount and positioning of these walls can be crucial to the thermal and structural performance of a window system. However, there are trade-offs between performance and price. Adding more vinyl walls to a window system will result in higher raw material cost which leads to a higher priced end product. Therefore, design engineers must be diligent when adding walls to a design by concentrating on the benefit "pay back" of the added cost.

Vinyl is well known for its natural insulating properties (i.e., it does not easily transfer heat). Compared to other materials, aluminum and steel for instance, vinyl is far superior in thermal performance. However, it does not totally block all heat transfer and for this reason it is important to note the position of the walls in a window design. When looking at a particular frame or sash design, one can count the vinyl walls that directly connect the interior temperature zone to the exterior temperature zone. These walls can be considered direct pipelines for heat transfer (conduction) and can lower the thermal performance of a window. Vertical walls, however, that do not directly link the inside with the outside, will reduce the amount of heat transfer across a window unit and can actually add to the thermal performance of a window by trapping air inside internal hollows (see Section IV-A). Air has a higher insulating value than most solid materials used in most building products, therefore the trapped air can add to the insulating value of a window. (See Figures 17-18)

Wall thickness is of great importance when it comes to the structural integrity of the window system. Just like any other building material, (wood, steel, iron, etc.), Increased material thickness generally means increased strength. Again, there is a price trade off between the increased material costs and the added strength that a specific thickness will provide. Wall thickness is of vital importance in welded window designs. To optimize the strength of a welded corner in a frame or sash, the vinyl walls must be thick enough to provide an adequate surface for fusing. Thin walled designs provide a smaller surface area where machines melt and fuse the two vinyl components. This may lead to weaker weld joints and possible window failure. The thicker walls also provide for the vinyl material that is removed from the welded joint during corner cleaning. (See Figure 21)

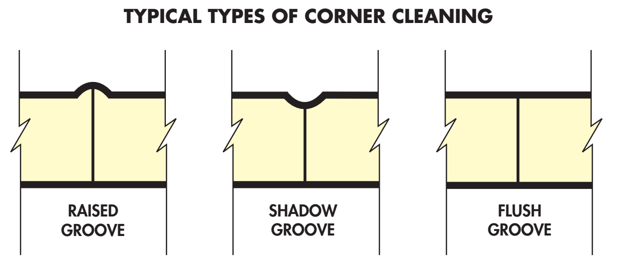

Figure 21

Thin walls may be cleaned to a point that little thickness remains in the walls to provide adequate integrity. Also, if two profiles are slightly out of spec or extruded beyond designed tolerances, thinner walled window systems have less margin for error than systems designed with greater wall thickness.

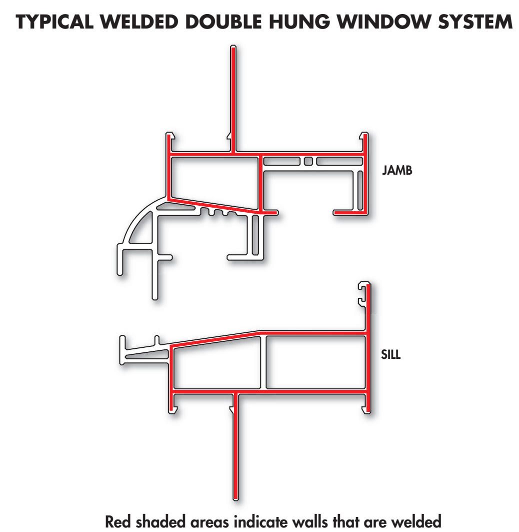

Figure 22

Comparing the wall positions between two vinyl profiles designed to be welded is important to the structural integrity of the corners. One of the keys to designing a strong weld joint is to maximize the number of walls in a jamb that will fuse to their counterparts. Walls that don't align will not aid in a strong corner weld (see Figure 22). Another key is to design the welded walls at a maximum distance from the center of mass of the profile. Consider the use of steel I-beams common in commercial architecture. An I-beam is used because a large part of its mass is located away from its center of mass. Because of certain laws of physics that deal with moments of inertia, the beam will not bend as much as a single bar of steel with the same mass. Likewise, in a welded vinyl corner, if the welded walls are designed away from the center of mass of the vinyl profile, the welded corner will be able to withstand the forces exerted on it during fabricating, shipping, handling, installation and operation. (See Figure 23)

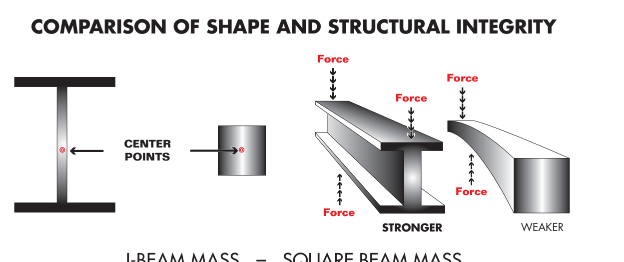

Figure 23

Section 4.3

Glazing and Glazing Beads

Two forms of glazing methods are utilized in vinyl window systems that incorporate glazing beads. Internal glazing describes a design that positions the snap-in bead on the interior of the house while external designs position the bead on the outside. Both designs have advantages and disadvantages as the method used is primarily determined by traditional building practices.

Internal glazing (see Figure 24), has an advantage when it comes to replacing damaged window units. If the insulating glass unit should ever break or fail, the glass package can be replaced easily from inside the home.

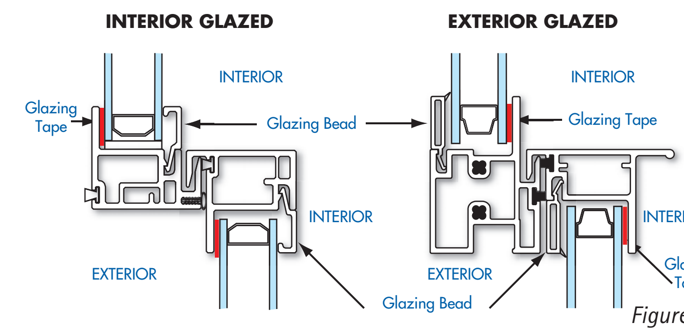

Figure 24

This is especially important on a second f oor where ladders or scaffolding may be needed to replace the window. Also, the internal glazing bead is not exposed to all of the weathering effects that occur on the exterior of the window. Intense heat from the sun over long periods of time may affect the integrity of the bead or the bead pocket. This is very important when co-extruded beads are used in a design. (Co-extruded beads use two types of vinyl - a rigid form of vinyl is used for the main structure of the bead while a softer, pliable vinyl is used to provide a cushion between the glass and bead itself). Part of the bead may be extruded in a darker color because the compound formulation used in co-extrusion is different than that of other vinyl components. In order to create this pliable plastic, certain micro ingredients are not used which may lead to rapid and uneven color changes or structural instability. The darker co-extrusion may absorb greater amounts of radiated heat from the sun. Internal glazing has its disadvantages, too. When using a tape glazed system, the two sided tape is located on the outside of the window. Though this can create an uninterrupted seal against water infiltration, the tape will absorb large amounts of heat and will be exposed to all of the elements in the environment. Pollution, heat, water and sunlight may deteriorate this tape over time causing the window to deglaze.

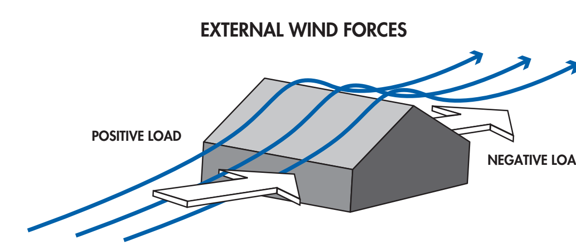

Figure 25

Some consider external glazing (see Figure 24) to be a safer alternative to the two methods. The statement has been made that "if the glass falls out, it is better to fall outside the house than inside." Though there isn't sufficient evidence to support this theory, many customers perceive external glazing a superior choice because of this "safety" factor. Another theory holds that external glazing is a superior weather performer because the forces created from a positive wind load will push directly on a solid interior vinyl wall.

This internal wall will be able to block any air and water infiltration that may occur around the glass package while it will structurally support the added pressures created by the external forces (see Figure 25). This may be true on one side of a house, but since a wind load is usually in one direction, the opposite side of the house will experience a negative load that will push the window away from the house. In either instance, the forces on a glazing bead are not solely directed from the outside toward the home interior. The same theory holds for air and water infiltration around the insulating glass units.

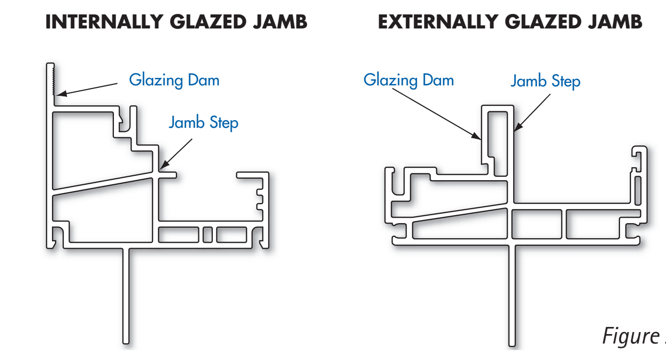

Figure 26

External glazing may have some additional problems controlling water infiltration in and around the insulated glass unit. Water may be able to penetrate the area where the bead touches the glass or the regions where the beads touch one another (this occurs at the corners of the frame or sashes). If water is allowed to enter through these areas, additional fabrication procedures may be needed to control this infiltration by using weep holes or channels (pathways to evacuate the water to the exterior of the window). If water is allowed to penetrate and stand in the glazing pocket, severe deterioration of the insulated glass unit may occur. Vinyl conservation is the main reason for using external glazing (see Figure 26). When designing an internally glazed jamb profile, engineers must add an external glazing dam to back the glazing tape and an internal step to hold the operating sash in place. On an externally glazed jamb, the glazing dam and step can be designed into a single chambered wall. This reduces the amount of vinyl needed in the jamb and creates a slimmer profile. A slimmer profile means the window has a larger daylight opening which may lead to an increase in thermal performance (depending on the insulating glass unit).

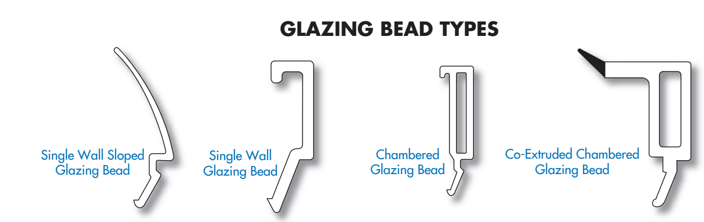

Figure 27

A window unit with a lower frame height may be aesthetically pleasing to some homeowners and may also allow the window to meet certain egress requirements. The actual shape of the glazing bead is also vital to many aspects of a window's performance (see Figure 27). Computer simulations have shown that a glazing bead designed with a thin, single vinyl wall is a better thermal performing bead (that is, it will increase the overall U-value of the vinyl frame) than some beads designed with small internal chambers.

Larger internal chambers, present on glazing beads used to accommodate slimmer glass packages, offer better thermal performance than the small internal chambered designs. But the single wall bead shows the most positive effect. Better yet, if the single wall vinyl bead is designed to slope in from the sash to window surface, the bead has even more effect on increasing the U-value (actual thermal performance of glazing bead designs may differ from computer simulations) of the frame. As with any design parameter, there are trade-offs between cost, ease of fabrication, and aesthetics.

Section 4.4

Vinyl's Role in a Window System

In a discussion about the added insulation provided from the vinyl used in fabricating a window system, one must realize the effect that the frame and sash material has on a U-value rating. Most window systems have an overall U-value that describes how much heat is transferred across a window unit. The higher the value, the more heat will be lost through the window (see VEKA publication titled: "What is a U-Value"). This number is a total of all of the heat that is lost through the glass, frames and sashes from conduction, convection, and radiation. By looking at a window unit of any size, one can readily see that the majority of the exposed surface is glass. The larger the window size, the higher the percentage of glass surface. Computer simulations show that in common sized windows used in modern construction, only 10-20% of the exposed surface of a window unit is comprised of the frame and sash structural components (see Figure 28). On very large window units, the numbers are even lower. The majority of the surface is glass. Therefore, the majority of the windows U-value rating is dependent on the insulating glass unit. That is not to say that the design and material make-up of the frames and sashes are of little importance. On the contrary, poor window designs that allow air and water infiltration around the glass unit will greatly effect the U-value. But the actual material make-up of a window unit is not as important to the thermal rating as the specified glass.

COMPARISON OF EXPOSED SURFACE WINDOW MATERIALS

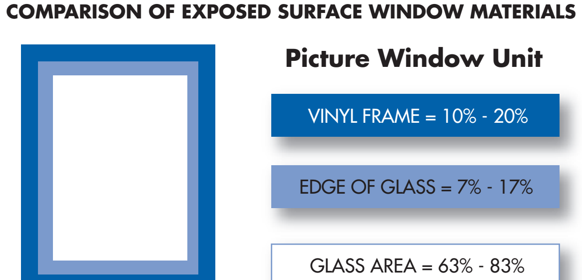

Figure 28

Vinyl is not the most important factor when it comes to the structural integrity of a window unit. At first glance one may think the strength of a window comes from the material used in the frame. First of all, the frame of a window does not provide the primary integrity of the overall unit. Granted, the frame provides structural support to the window but it is primarily due to the fact that it is attached to structural frame members in the rough opening. The sashes and/or mullions actually provide most of the structural integrity. Secondly, vinyl is not an inherently strong material and needs to be reinforced at times with steel or aluminum. So why is vinyl becoming a popular material in window and door units? (See Figure 29)

	ALUMINUM	WOOD	VINYL
DISADVANTAGES	Extremely poor insulator. Allows condensation to form. Pits, corrodes, dents and scratches. Most frames & sash are mechanically fastened, usually with screws that may eventually loosen. Painted aluminum windows may chip and scratch.	Absorbs moisture which can lead to possible rotting or warping resulting in air and water infiltration. Requires regular painting and maintenance. Paint chips and peels. Inferior milling for interlocks and weather-strip pockets.	Strength. Brittle if not correctly modified. Shrinkage if not correctly modified and extruded.
ADVANTAGES	Will not decay or warp. Strength.	Excellent insulator. Beauty and aesthetics.	Excellent insulator. Reduces air infiltration, will not shrink or warp. Easy to clean, low maintenance. Durable, no pitting, peeling, rotting, corroding. Ease of operation. Custom size opening. Solid color throughout, never needs painting.

Figure 29

Vinyl is a low maintenance material, easily cleaned, and is easy to fabricate. It is a low cost alternative to other materials and can be extruded into profiles with detailed, intricate shapes. These shapes make it possible to create weather stripping pockets, interlocks and accessory grooves that provide valuable features to the end user. Also, vinyl's weatherability is by far superior to wood and aluminum. It never needs painting or staining, won't rot, chip, f ake or peel, and will not rust or corrode. (See related VEKA publications titled: "Vinyl vs. Aluminum," "Vinyl vs. Wood," and "Vinyl is Safe.")

Section 4.5

Integral Features

Because of vinyl's ability to be extruded into specific intricate shapes, many features of a vinyl window are unique. These features are sometimes referred to as "integral" (see Figure 30).

EXTRUDED INTEGRAL FEATURES

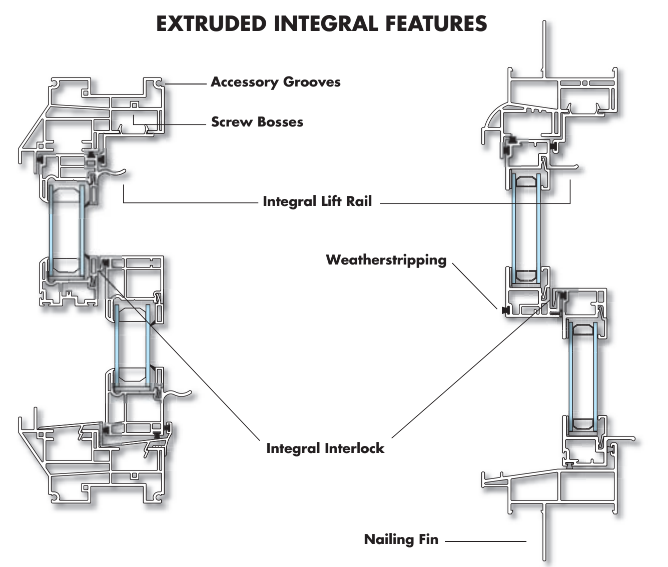

Figure 30

Features described with this nomenclature are included as part of the design of the sash or frame extrusion. There is no need for additional parts or hardware mounted on the profiles or attached with screws or rivets. By eliminating the need to mount auxiliary parts to the window you eliminate many of the problems that may arise. Primarily, if the additional parts are made of a dissimilar material, they will have a different shrinkage rate than the vinyl. Over a period of time, the vinyl and the attached parts will shrink and expand at varying rates. This may lead to improper operation, increased air or water infiltration, or a window failure. Secondly, the chambered profiles do not need to be designed with additional vinyl or aluminum to accommodate screws or rivets and the vinyl members will not be violated from these fasteners which may lead to air or water infiltration problems. Integral interlocks (see Figure 31) refer to the areas of hung or sliding window and door units where the moving sash or sashes meet one another. Interlocks are usually extruded in the meeting rail and mullion profiles. As the window or door unit is closed, they lock together forming a barrier to air and water infiltration. Some interlocks are extruded into the glazing beads of either operable or fixed glass units. Though many successful window systems sport this design, there is a risk for the introduction of unwanted external pressure on the bead during opening and closing. This may cause a deformity or loosening of the bead and may lead to some additional problems with the integrity of the glass installation.

WEATHERSTRIPPING

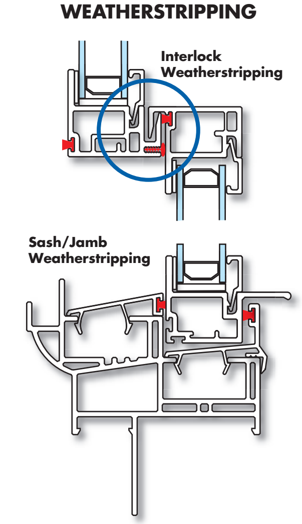

Figure 31

Integral lift/pull rails are used to lift or slide the operable sashes on hung and sliding windows. Again, the fact that these are extruded into the sash profiles creates a long lasting and durable surface that arguably sustains the most operational abuse. As with interlocks, some designs feature a lift rail extruded into a glazing bead. This is not a recommended design as the pressures involved in lifting or moving a sash may cause the bead to fail. Weather stripping pockets are provided in vinyl windows at many locations. Sometimes they are designed to work in and around an interlock. These provide additional barriers to air and water infiltration through the area where the operating sash or sashes meet (see Figure 31). Weather stripping pockets can also be designed around the exterior of the operating sash units. Likewise, these weather stripping areas provide additional barriers to air and water infiltration. The type of weather strip inserted in these pockets can vary greatly and should be an issue directed to your particular weather stripping supplier. One must be careful, however, when determining whether the weather strip location actually performs the proper thermal function. At first glance, many designs may look as if the weather stripping performs its advertised role. However, on close scrutiny, one can find paths around the weather strip through which air can freely f ow. In these cases, the weather stripping is merely a visual feature that does little to aid the performance of the window.

Integral vinyl nailing fins, on windows designed for new construction, are an important feature of many window and door units. Usually they are 1½" inches in length. The extra half inch is an added margin to alleviate "out of square" openings, improper measurement of the rough opening and damage that may occur from an overzealous installer. Most are pre-punched, with holes provided in the extrusion to accommodate the nails used to install the window. In a welded window system design, integral nailing fins play a vital role in protecting the interior of the home from the incursion of water or air. The welded corners and the fact that the nailing fin is extruded into the frame profile, create an uninterrupted barrier between the exterior and interior of the home.

Many fabricators and installers require integral accessory grooves around the perimeter of the frame. These grooves accommodate auxiliary vinyl profiles (see Figure 32), that are used to finish the window after installation. These profiles include brick returns, siding returns, stucco returns, drywall returns, sill extenders, and panning profiles. The accessory grooves are also used to mull two window units together either in the construction of a "window wall" or when making bay or bow window units. Some accessory grooves allow the use of snap on nail fins or nail fins with varying set backs. This allows a fabricator the use of replacement windows in new construction installations or allows the window to accommodate various types of building construction.

Section 4.6

Other Design Criteria

There are numerous design criteria involved in a successful vinyl window system. These criteria can vary from country to country, region to region, and even customer to customer. The actual width of the window (commonly know as the "depth of frame"), the type and size of the glass units, and the hundreds of other features that can be incorporated into a window unit to provide aesthetic appeal or functional performance, are all driven by various markets.

SAMPLES OF ACCESSORY PROFILES

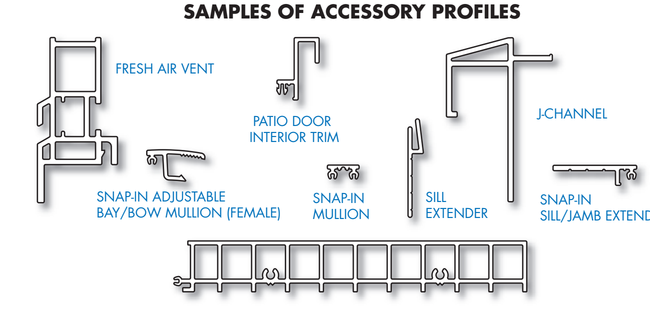

Figure 32

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