# Recommended Techniques for Washing Glass

### *Prologue*

The original PPG Industries, Inc. publication of *TD-144 Recommended Techniques for Washing Glass* was introduced in the 1980's and continues to be one of the most requested and helpful resources by Vitro's customers today. The principles and recommendations for the machine washing of glass by vertical and horizontal washers remain applicable. The current version of this document removes outdated cleaning product information and includes several recommendations specific to the machine washing of performance enhancing MSVD low-e coatings, such as Vitro Sungate® and Solarban® Solar Control Low-E Glasses.

### *Introduction*

The durability and beauty of glass, coupled with its transparency, make it one of the world's most utilized building materials. Glass allows light to enter the building while providing protection from the elements and it allows occupants the connection to the outside environment that has been proven to improve morale and productivity.

Glass is available in a wide variety of tints that provide aesthetic variety as well as improved energy efficiency and occupant comfort. In addition, aesthetics, comfort, and energy efficiency can be further enhanced using the many types of coatings that have been developed for application to the glass.

Whatever the job and whichever glass product is chosen, the attractive and efficient use of glass requires a clean glass surface. Based on more than 130 years in glass manufacturing and fabrication, Vitro offers the recommendations in this document to assist glass fabricators in successfully washing the variety of glass products that Vitro offers. The included recommendations are based on detailed research, years of first-hand production experience, and work in solving actual glass-cleaning problems during product fabrication.

Included in this document is a detailed review of:

- Dirt types that affect glass
- Glass surface protection
- Water and detergent requirements
- Mechanical washers
- Prewashing
- Requirements for Low-E glass
- Washing system maintenance
- Troubleshooting

### *Executive Summary*

The overall objective of washing glass is to provide glass that is both "clean" and "dry" to the downstream fabrication process. Achieving this requires the right equipment that is properly maintained, trained personnel to properly setup the washer, and daily diligence to properly operate the washer. The key factors to consider for achieving washed glass quality are:

- Amount of flow & direction of water spray
- Water quality
- Properly setup of pre-wash section
- Brush type and setup
- Air knife and pinch roll setup

# Recommended Techniques for Washing Glass

- Clean filtered air used in blow-off drying
- Dwell time in the washer
- Proper inspection lighting to verify glass is clean and dry
- Cleanliness & maintenance of the washer

When you do a Gemba walk of the production floor, is your glass washer clean? It is more realistic to expect clean glass from a clean, well maintained washer; conversely, it is more difficult to get clean glass from a dirty, poorly maintained washer. The importance of an excellent functioning and efficient washer cannot be overstated.

***Glass Surfaces: Cleanliness & Protection***

Because dirt can have negative effects on glass undergoing any type of processing, glass surfaces must be cleaned. This requires that the glass surfaces must be washed effectively.

When glass is "dirty", both its aesthetic and performance may be diminished. If dirt is not removed effectively, it will inhibit the adhesion of other materials to the glass. For example, when glass is used for mirror and architectural coating applications, the surface must be clean to permit the metals or metal oxides used in mirror coatings to bond to the glass. Insulating glass fabrication processes require clean glass for the sealants to adhere properly to the glass, since this bond provides the required long-term performance of the hermetically sealed unit. Glass processes such as heat-strengthening, tempering, and bending require clean glass to minimize localized distortion, burn-in blemishes, and other "dirt" related effects.

***What Makes Glass Dirty***

"Dirt" on glass can best be defined as "any unwanted material on the glass surface". Consider glass interleaving powder, for example. Interleaving materials are essential for the protection of glass surfaces and coatings during transport and storage. However, when glass is prepared for any fabricating process, the interleaving becomes an unwanted material, or "dirt", that must be removed from the glass surface.

The degree of glass cleanliness which is deemed acceptable is dependent on the end-use of the glass. For example, glass cleanliness that is sufficient for picture frame applications (in which the glass surfaces remain accessible for repeated future cleaning) would not be acceptable to the insulating glass fabricator where two or more glass surfaces are permanently bonded together within the insulating glass unit. Fabricators who spandrel coat, temper, or etch glass, require an even more critical level of glass cleanliness.

Dirt on glass surfaces can be grouped into four general categories:

- particulates
- surface residues
- reaction contaminants
- surface corrosion

# Recommended Techniques for Washing Glass

**Particulates** are solid materials, loosely deposited on the glass surface, which can best be removed with non-abrasive mechanical methods such as a high-pressure water spray. Typical surface particulates include paper interleaving fibers, acrylic beads, wood flour interleaving, powder interleaving materials, glass handling chips, wood splinters, cardboard fibers, and shavings of packaging materials. See fig. 1 for an example of typical particulates residing on the glass surface.

**Surface residues** are contaminants that adhere to the glass surface that may require using detergent washing solutions to remove them. Examples of such residues are fingerprints, paper scum, and cutting fluids. An example of paper scum is shown in fig. 2.

**Reaction contaminates** are more tenacious than surface residues and may physically or chemically bond or interact with the glass surface. For this reason, their removal may require chemical "undercutting" with a cleaning solution tailored for specific dissolution or bond breaking.

Hard-water salts are an example of a commonly encountered reaction contaminant. In some parts of the country, water supplies contain large quantities of inorganic compounds. If glass is washed with this "hard" water, care must be taken to rinse the glass surfaces thoroughly with demineralized (DI) water before drying or further processing (coating, tempering, etc.). If hard water dries on glass surfaces, the chemical nature of these salts may require the use of off-line cleaning with acid solutions for their effective removal. This type of aggressive cleaning may not be environmentally friendly, or economically feasible in a production environment. In addition, with coated glasses, such cleaning procedures will most likely lead to coating damage.

**Surface corrosion** is not really a type of "dirt", although a corroded glass surface will exhibit a semi-opaque appearance that can be and often is mistaken for deposited dirt. Surface corrosion is an irreparable physical degradation of the glass, usually resulting from inappropriate storage conditions involving high temperature and humidity. To prevent surface corrosion, it is recommended that customers store glass properly, maintain a detailed inventory, and practice FIFO stock rotation. With the increased use of MSVD low-e products, such as *SUNGATE* and *SOLARBAN* low-e coated glass, the proper storage of glass inventory becomes even more important, as these types of glass are more sensitive to moisture.

In its initial stage, glass surface corrosion is visible only under critical light (or occasionally after coating application) and cannot be observed by the naked eye. At this stage, with uncoated glass, it may be possible to remove the corroded glass layer(s) with an abrasive polish such as cerium oxide. Note: Care must be taken not to locally over polish the glass which can lead to optical distortion.

# Recommended Techniques for Washing Glass

Figures 1 – 4 are examples of the different types of "dirt" on the glass surface.

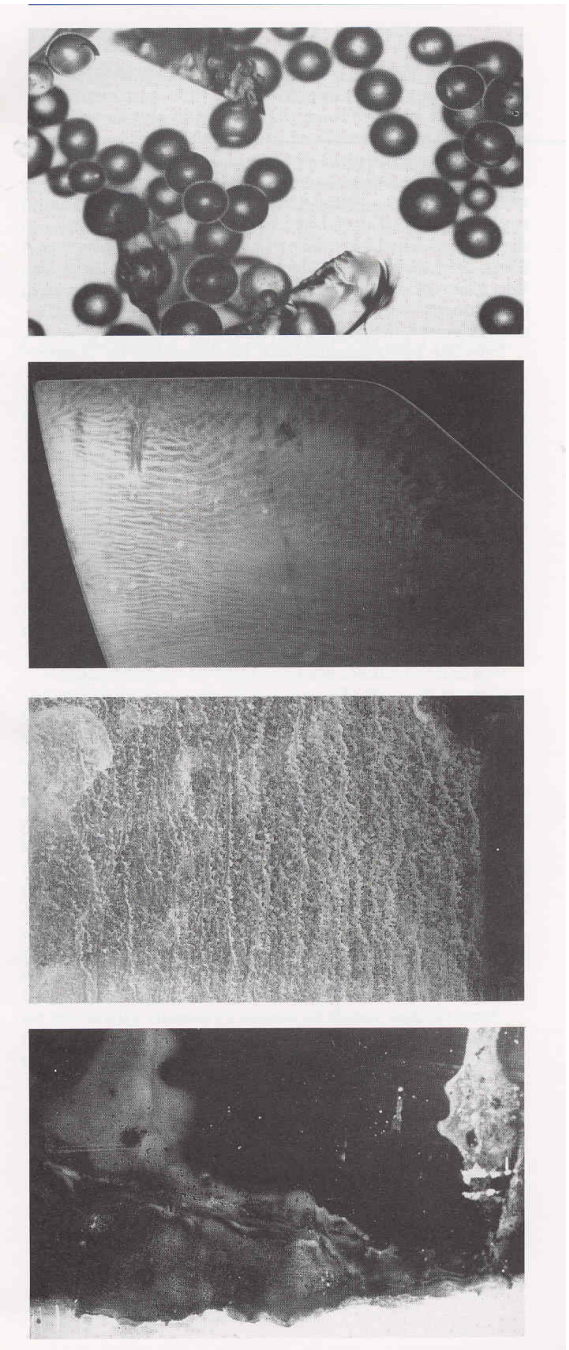


**Figure 1 – Particulates**

**A magnified (40x) view of particulates which should be removed from incoming flat glass by a prewash system. Interleaving beads and glass chips are seen here.**

**Figure 2 – Surface Residue**

**Typical paper scum on glass (note the duplication of the paper ridges and wrinkles in the scum pattern.) This residue can be removed using a 50/50 isopropanol alcohol and DI water mixture, or a mild detergent solution and DI water rinse.**

**Figure 3 – Reaction Contaminant**

**Acid rain / masonry / glazing material run-down on the glass surface. Removal requires an acidic solution which may not be practical and should be done only by a professional glass cleaner.**

**Figure 4 – Surface Corrosion**

**Glass corrosion is typically caused by prolonged exposure to high humidity and temperature and is often not removable in its advanced stages.**

# Recommended Techniques for Washing Glass

Once glass corrosion becomes more severe, a heavy blue or white stain is visible on the glass surface with the naked eye. Glass with this degree of stain has undergone degradation, and glass transparency cannot be restored. The only practical remedy at this stage of surface damage is to replace the glass.

### *Protecting Glass*

To protect glass surfaces from corrosion and scratching, a chemical and physical barrier must be maintained between adjacent lites of glass when stacked for shipment and storage. This dual function is performed by an interleaving material. While other types of interleaving (such as paper) are still occasionally used, the major form of interleaving currently used in the flat glass industry for uncoated glass consists of plastic beads to provide the physical separation, combined with acidic corrosion inhibitors mixed into a powder and applied to the glass surface.

***With Vitro MSVD low-e coated glass, corrosion inhibitors are not applied to the glass. Interleaving consists of only the plastic separator beads. However, the appearances of the interleaving powders are very similar.***

Vitro's powder interleaving (with or without the corrosion inhibitors) is compatible with mechanical packing, which reduces packaging related glass surface issues such as scratches, handling chips and packing rubs encountered with manual packing procedures. The powder interleaving is also compatible with automated "pick" equipment used by many glass optimizer lines. Care must be taken to clean vacuum cups occasionally with a clean cloth and 50/50 IPA & DI water to prevent excessive interleaving build-up on the cups and in the vacuum lines. Also, dirty cups can leave marks and even damage the low-e coating. Therefore, it is recommended to apply the vacuum cups to the glass or non-coated side.

At some point in the glass fabrication process, any interleaving becomes an undesirable surface contaminate that must be fully removed. Powder interleaving can be removed by utilizing cleaning procedures previously recommended for particulate contaminants: non-abrasive mechanical action (e.g. high-pressure water spray). The water-soluble corrosion inhibitors will dissolve and be carried away, along with the separator beads. For this reason, a prewash system is especially suitable for removal of powder interleaving. See later section on **Prewash System** for additional information.

### *Mechanical Glass Washing*

The key elements involved in mechanically cleaning glass are:

- Water Quality and Flow
- Detergent (optional)
- The Washer System Components
    - Prewash
    - Wash section w/ brushes & water heater
    - Rinse spray section
    - Water tanks & recirculating system
    - Drying air knives & pinch rolls

# Recommended Techniques for Washing Glass

- Entrance, washer and exit conveyor
- Drying air filtration & supply system

All these critical elements must be carefully selected and maintained so that they will work together effectively to clean and dry the glass.

***Water Quality & TDS***

Water is the foundation of the washer system. Used at high pressures with appropriate flow, it physically removes particulates and residues. Water also acts as a "lubricant" between the washer brushes and the low-e coating surface, and ultimately carries away dirt and debris.

Because water plays many important roles in the cleaning system, ***water quality*** is critical. Water used in glass cleaning should have minimal turbidity (solid material content), and a suitable hardness or softness for two reasons:

- To allow detergent dissolution (if used) and easy rinsing
- To prevent build-up of excessive scale deposits

Good quality municipal water (<500 ppm) can be used in the pre-wash and wash sections. However, high quality water provided by a RO or DI water treatment system is necessary for the final rinse section of the washer.

Appropriate filters installed on the main water supply lines and within the wash system flow lines will remove inherent water turbidity and internally generated washer debris (broken brush bristles, scale, glass chips, pieces of conveyor rolls, etc.). Based on Vitro's production experience, a (25) micron replaceable cartridge filter is recommended. These filters will reduce glass surface scratches by greatly reducing recontamination of particulates back into the washer and lower the incidence of nozzle blockage from water borne particulates.

***The pH*** (acidity/basicity) of the water used in the wash section of glass washers will be altered by any detergent that is used. Therefore, the pH range of the incoming wash water cannot be practically specified. However, if detergents are being used, Vitro recommends maintaining a wash solution pH that is slightly acidic to achieve the best glass cleaning. While this recommendation remains valid, there are detergents that yield slightly basic solutions that are also successfully used. Detergents that yield a pH of (11) or higher should be used with care, as they can lead to scale and deposits in the washer, as well as on the glass.

***Warm water*** dissolves residues more readily and enhances cleaning efficiency. Wash water temperature for various washer equipment is typically in the 110 to 140°F (43-60˚C) range with hotter water working better. However, water should not be heated much past 140˚F to help eliminate the risk of potentially melting the interleaving beads, aprox. Melting [point of 150F (65˚C) that may have entered the washer.

***The rinse section water quality*** is extremely important because it is the last liquid to contact the glass before the drying process. The use of water treatment systems such as reverse osmosis (RO) or mixed bed deionizer (DI) is recommended to provide high quality,

# Recommended Techniques for Washing Glass

low mineral content water to the rinse section of the washer. Vitro requires the final rinse water to have a TDS of maximum (20) ppm. Such water minimizes or eliminates the possible streaking/spotting that occurs with untreated water from mineral residue deposits.

Generally, heated rinse water provides a more effective rinse and facilitates drying, but room temperature rinse water can also work effectively provided there is a properly setup and functioning air knife section and pinch roll.

### *Water Flow*

Equally important as water quality is the flow rate. Removal of particulates and residues from the glass primarily depends on water pressure. But to efficiently flush away the loose particulate and residue, good water flow is also needed. Vitro recommends ¾ US gallons per minute (2.8L/min) per foot of pipe for each spray header within the washer. For example, in one brush section of the washer, for an (8) foot long top & bottom spray headers, the water flow should be ¾ x 8ft x 2 = 12 gal / min. Inline water flow meters (example shown below) provide an indication of flow rate and can be easily checked since they are located outside the washer enclosure.

A water flow meter can also help detect if there are clogged nozzles within the spray header as the flow rate drops provided that the pressure remains relatively constant.


Inline water flow meter w/min/max indicators

### *Detergents & Other Water Additives*

While we continue to suggest the use of detergents with non-coated glass, the increased use of MSVD low-e coated glass products (*SUNGATE* and *SOLARBAN* products) has prompted many fabricators to be able to successfully clean all types of glass without the use of detergents. As previously mentioned, MSVD low-e coated glass products are shipped with only the separator beads as interleaving. This glass is typically very clean when it is shipped especially with the recent additional application of a temporary protective film (TPF). For these reasons, a detergent free wash can be successful, provided that the washer is well maintained, setup properly and adequate water quality and flow are used. The use of high quality, low mineral content (TDS ≤20ppm or ≤40µS) water in the final rinse section is recommended for all glass, but it is critical when processing MSVD low-e coated glass products. Rinse water with higher TDS can result in spots and/or streaks which are readily visible on the coating in the finished IGU especially when sunlight shines on the glass at just the right angle.

# Recommended Techniques for Washing Glass

For a given water type and operating temperature, the selection of a suitable detergent requires answering the following questions:

- **Solubility:** Does the recommended amount of detergent dissolve in your water resulting in a clear, uniform solution?
- **Foaming Characteristics:** Will the detergent foam excessively in your washer? A quick, easy method to screen detergents for foaming characteristics involves pouring 50cc of a one-percent (by weight for solid detergent, by volume for liquid) detergent to water solution into a 250cc graduated cylinder, agitating vigorously, and observing the resulting foam volume. For a low-foaming detergent, the total foam volume should not exceed 80cc. The use of anti-foaming agents as an additive to the water in any section of the washer (including the prewash) is not recommended. The chemical make-up of such solutions has been found to be incompatible with coated glass.
- **Rinsing Characteristics:** If a small (12" x 12" is suitable) glass sample is hand washed with a one-percent detergent solution, is excessive rinsing necessary to remove all traces of the detergent? Use a high intensity light (~300 lumens) to perform this inspection.
- **Environmental/Safety Considerations:** Does the chemical composition of the detergent meet the specific environmental requirements for your water treatment area (e.g., phosphates, acidity)? Does the resulting discharge comply with local, state, and federal EPA requirements? Will it be necessary for personnel to wear protective equipment (gloves, face shield, etc.)? Consult the detergent supplier's Safety Data Sheet.
- **Local Availability:** Is the detergent locally or readily available, or is a large inventory required?
- **Supplier Reliability:** Will the supplier go out of business or change the detergent formulation without notifying customers?

***Note:*** **These detergent considerations are for non-coated glass products. Some coated glass products such as *SUNGATE* and *SOLARBAN* low-e glasses are acid and base sensitive and require special consideration including processing without a detergent if it has negative effects on the coating.** See later section *Precautions for Washing Coated Glass Products* for more information.

In general, acidic detergents rinse from glass surfaces more readily than those that are basic (or alkaline). However, acidic detergents may cause etching of some metal components of the washer, and perhaps an all-stainless-steel construction would be required. Vitro recommends that the washer manufacturer be consulted to determine if this acid condition will have an adverse effect on the washer equipment.

**Some coated glass products may be acid (or base) sensitive and require special detergent consideration. See Precautions for Coated Glass on p. 17.**

# Recommended Techniques for Washing Glass

After a detergent has been selected, it is recommended to perform trial runs in the washer. Full scale production should not be attempted until the user is satisfied from these trials that the detergent will perform satisfactorily, and rinse completely away and not result in any damage to the low-e coating.

Please consult TD-149, *Acceptable Cutting Fluids and Detergents for use with Vitro's MSVD Sungate® and Solarban® Coated Glass Products* available on the Vitro website at https://www.vitroglazings.com/technical-information/technical-documents/ for the latest copy of the approved materials list. Although the detergents on this list have been lab tested and found them to be compatible with MSVD coated glass products, it is the fabricator's responsibility to perform their own detergent trial in their production process and environment to make the final determination that the detergent will perform satisfactory with no negative effects on the coating or quality of the fabricated glazing unit.

### *Dwell Time*

All aspects of the washing process are tied to this one variable. The line speed setting controls the dwell time of the glass as it progresses through each section of the washer. Consult the washer manufacturer's operational manual for the recommended line speed settings to achieve the optimal dwell time. However, this setting may need minor adjustments depending on the individual washer's performance and results of achieving clean and dry glass at the exit.

Considerations to run the washer faster than recommended or with glass spacing closer together should be done with extreme caution and with scrutiny of the washed glass quality.

**Note: At no time should any portion of the glass (coated or un-coated) be allowed to stop inside any part of the washer enclosure.** Even if water, brush rotation, and air blower are programmed to stop, there is the risk of residue remaining on the glass and/or the glass not getting completely dry. Also, even a low-e type brush can scratch the coating if there is not enough water flow which is typically the case once the washer starts back up again until the water line is up to full pressure.

### *Washer System Components*

The diagram shown in fig 5 shows a simplified cross section of a typical horizontal flat glass washer consisting of the following basic components:

- Glass entrance conveyor
- Prewash section with top & bottom spray headers
- Pinch rollers that drive glass through the washer and squeegee off excess water; note: the last pinch roll before first air knife is most critical and should be the newest roll and in good condition
- Wash-brush section with regular or low-e type bristles; can be rotating cylinder and/or oscillating cup style brushes
- Additional water spray headers directed at the brush

# Recommended Techniques for Washing Glass

- Rinse section with more top & bottom water spray headers (not shown)
- Air knife drying section with air intake filters and high velocity blower system and supply hoses (not shown)
- Glass exit conveyor and lighted inspection area

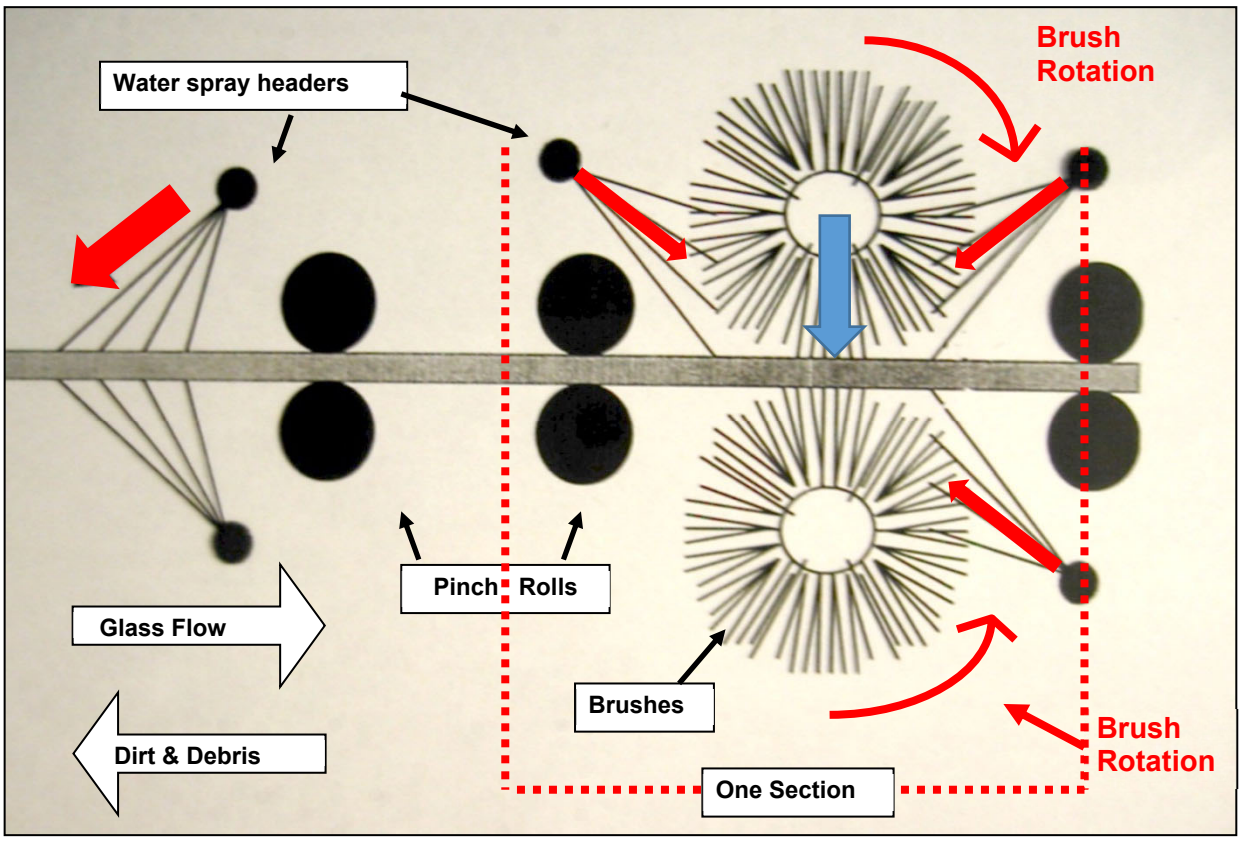



**Figure 5 - Simplified cross section of typical flat glass washer**

The actual design of the washer may have multiple wash and rinse sections depending on the glass size, line speed (dwell time), and performance requirements of the washer (i.e. how dirty the glass is to be washed). Also, there are different designs of water collection and recirculating systems.

# Recommended Techniques for Washing Glass

### *Typical Mechanical Glass Washing System*

Typical mechanical glass washers are designed to remove water soluble surface residues. These washers consist of a detergent application (optional) and washing section, one or more rinse sections, and a drying section (e.g., air knives). In the washing section, cylindrical and/or oscillating cup brushes provide mechanical action that operates with the water pressure action to clean the glass.

Optimum washer performance requires proper glass loading (i.e. place coated surfaces away from conveyor rolls). Glass spacing should be greater than the roll circumference. Conveyer speeds should provide suitable washer dwell time. Conveyors should not be stopped while glass is under the brushes, the air knives, or in any other section of the washer.

Glass washers are not always successful in removing water insoluble surface residues. Identification of a residue's chemical nature can save production time wasted by repeatedly washing glass in attempts to remove such residues. For example, deposition of an adhesive from tape or a label on glass surfaces may require special off-line pre-cleaning with organic solvents to remove this water insoluble tacky residue prior to on-line washer entry. **It is not recommended to add such solvents to the washer as they may harm internal components. Also, exercise caution with coated glass which may not be compatible with certain solvents.** See later section *Precautions for Washing Coated Glass Products* for more information.

While a typical glass washer is appropriate for cleaning surface residues from glass, particulate "dirt" can cause significant system problems, especially in re-circulating washers that are not equipped with appropriate inline water filters. Glass handling chips or other gritty particulates that enter the washing section may be mobilized on the glass surface by the washer brushes causing scratches. Even non-abrasive particulates pose a problem as they can clog spray nozzles, accumulate on washer brushes and in recirculating tanks, decreasing cleaning efficiency and increasing the need for washer maintenance.

### *PREWASH SYSTEM*

Recognizing the need to optimize washer performance by preventing particulate entry, research in glass cleaning was conducted that led to the development of a simple, compact, economical washer add-on that is called the "prewash" section.

Just as optimum performance is obtained from automatic dishwashers by rinsing solid foods from dishes prior to loading, the prewash system provides optimum glass washer performance by effectively removing particulates from the glass surface prior to entry into a typical glass washer.

If water is recirculated in the production washer that follows the pre-wash, it may be necessary to place a high pressure pipe below the conveyor to remove the few particulates that transfer to the bottom surface of the glass during stacking. This prevents the potential accumulation of these particulates in a re-circulated system. Otherwise, one or

# Recommended Techniques for Washing Glass

two high pressure pipes spraying only on the glass top surface will suffice for the pre-wash on a line with a non-re-circulating washer.

The high-pressure prewash usually contains a metal sheeting enclosure fitted with spray-pipes delivering filtered water at a pressure of around 100 - 150 psi. ***Note: Water pressure may need to be lowered if excess spray from the contact with the glass is causing skewing or breakage of the glass or excessive overflow causing a slipping hazard.*** Water used in the high-pressure spray may be from any convenient source (well, tap, washer rinse overflow), as long as it is filtered through at least a 25-micron replaceable cartridge filter before being pumped through the delivery pipes. This room temperature water must be particulate-free to prevent potential glass surface scratching and nozzle blockage. If the water source is acidic (e.g., some demineralized water), stainless steel pipes, nozzles, and pumps are recommended to prevent corrosion of these system components.

The top and bottom spray pipes shown in figure 6 in the high-pressure enclosure are mounted 3 to 4 inches* from the glass surface in an orientation to provide the spray with a 45-degree angle of incidence with the incoming glass surface. **Note that the nozzles are angled toward the prewash entrance so that dirt and debris are flushed away from the washer. Also, the pressure and volume of water should be higher on the top spray compared to the bottom spray.** Stainless steel nozzles (fan type 65 to 110 degrees, orifice diameter 0.026 inch) are suitable for use in these high-pressure spray pipes.

*Prewash parameters relating to pipe position/alignment, nozzle spray pattern, orifice size and spacing, etc. are given as guidelines based on our experience. Since all line configurations vary for a given production facility, experimentation with these parameters must be conducted to devise the most effective system for a specific installation.

When the prewash water is discarded, it can be included with all other plant discharge for normal sewage disposal. The particulates suspended in the water will require normal solid-waste treatment. If there is a concern with particulates in the discharge, a screen (or tandem series of screens) can be placed beneath the high-pressure enclosure to retain solid matter rinsed from the glass surfaces. Based on the particle size distribution of typical powder interleaving, a 120-mesh screen will retain approximately 99 percent of this material for alternative disposal. These screens should be installed so that they can be easily removed for cleaning, as necessary. These discharge collection methods are not necessarily complete or comprehensive. EPA, state, and local requirements should be considered before dumping any waste system.

***Removal of TPO –***

Use of a prewash system provides a debris-free glass surface for subsequent cleaning. The prewash is also critical to the complete removal of a Temporary Protective Overcoat (TPO) which may be applied to MSVD low-e coated glass that will be heat treated. **Caution should be taken to ensure that the prewash solution, which includes dissolved TPO, does not dry on any portion of the glass since the dried residue may be harder for the washer to remove. This is also the case where a wet seaming process is used prior to the washer.**

# Recommended Techniques for Washing Glass

As TPO is dissolved and flushed away in the prewash, it is common to observe foaming in the catch tank. If the water in this tank is recirculated, after 30min or so of run time the water can become super-saturated with TPO and it will no longer be dissolved. As a result, the TPO will be sprayed back onto the glass and then carried into the washer and potentially even into the final rinse. If foaming is seen in the wash water catch tank and no detergent is used or in the final rinse tank, the prewash tank should be run to drain and fresh water allowed to enter the prewash tank to flush away the excess foam. If the level of foam does not subside, the washer may need to be shut down and entirely cleaned and tanks dumped & refilled. A best practice is to keep the TPO foaming to a minimum by continuously introducing a percentage of fresh water into the prewash and draining off the foam, so it does not build up.

The prewash system description given here is tailored for a horizontal washer. The same requirement for a prewash section in vertical washers holds true when the vertical washer is used to clean glass prior to heat treating or the glass processed through the vertical washer is quite dirty and is not coming out of the vertical washer clean.

### *Recommendations for Pre-Wash and Washer System Maintenance*

Routine maintenance of all washing system components is essential for providing optimum glass cleanliness. While some maintenance functions will be performed on a demand basis, others should be scheduled periodically or in response to production volume.

#### *Pre-wash*

The recommended prewash system requires only three basic maintenance procedures:

1. Filter cartridges on high-pressure water lines must be changed whenever exhausted. Filter replacement frequency is based on several parameters, including supplier recommended pressure differential across filter sumps, visual filter inspection, or as dictated by production experience.
2. Occasional cleaning or replacement of blocked or corroded nozzles may be required. A visual system inspection will generally reveal the need. **There should always be a pooling of water on the glass surface as it enters the prewash. Also pay attention to the spray pressure and amount of water flow which are indicators of clogged nozzles and/or filters, or corrosion/ enlargement of the nozzle aperture.**
3. For a prewash system using re-circulating high pressure rinse water, the holding tanks must be drained and rinsed at least every 24 hours depending on overall run time.

# Recommended Techniques for Washing Glass

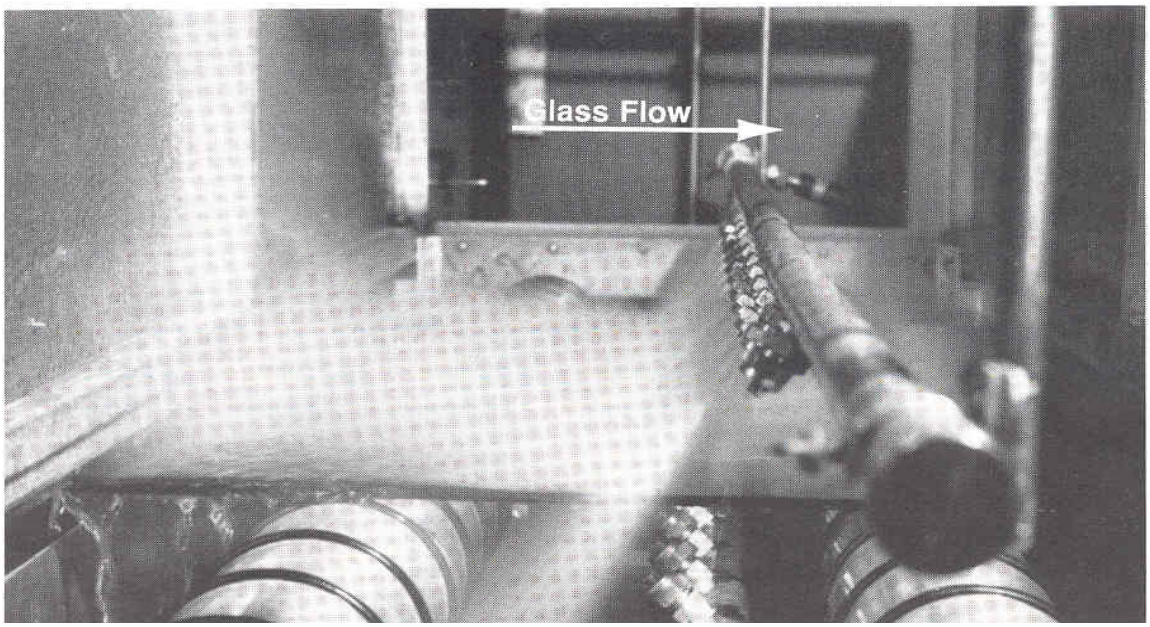



**Figure 6 - High Pressure Spray of the Pre-Wash System; Uncovered to show internal components.**

### *Main Line Washer*

**Note:**
**The best source for maintenance requirements and procedures is from your equipment manufacturer. Vitro offers the following recommendations in good faith and to provide some useful information, NOT as a replacement for the equipment manufacturer's recommendations.**

**Daily**

- Dump and replace the prewash, wash, and rinse tanks with fresh cleaning solution (if detergent is used) and demineralized water. Verify TDS at the start of the shift and throughout the day. Record TDS values on the washer check sheet.
- Rinse out inline filters (replace as necessary). Check for pressure drops across filters throughout the day.
- Check pinch rollers and conveyor rolls to ensure that they are free of dirt, grease, and mold and not damaged (especially the last pinch roll before the air knife section).
- Check spray pipes and nozzles to ensure that they are not clogged. Check for proper water flow in each washer section both visually and with inline flow meters (if installed).
- Perform "Washer Quality Marker Test" to ensure proper washer setup and performance. See Appendix 1.

# Recommended Techniques for Washing Glass

**Weekly**

- Replace air filters in the air-knife blower unit (may require more frequent change if filters look dirty).
- Clean the spray pipe nozzles and air knife slots.
- Clean exit conveyor rolls.
- Lubricate components per manufacturer's guidelines. Avoid lubricant contact with all interior components.

**Monthly**

- Clean all water pipes with a wire brush and inside the air-drying system (plenum, supply hoses, etc.).
- Thoroughly inspect all moving parts. Looking for uneven wear and damaged pinch rolls and brushes. Measure bristle length and replace brush per mfg. recommendations.
- Completely steam clean the washer, inside and out, with a high-pressure sprayer. Remediate any mold or other contaminants from every part of the washer.

If production problems occur that seem related to glass cleanliness, a check of some or all these washer system parameters may indicate that unscheduled maintenance and /or setup changes are needed. In addition, a quick reference to the following troubleshooting guide may prove helpful.

**TROUBLESHOOTING GUIDE**

There are a variety of washer associated defects on the glass that can be readily resolved by taking appropriate corrective action.

The following guide based on our experience, is provided as a convenient reference for locating potential causes of observed washer system related issues. We cannot accept any responsibility for its effectiveness in solving specific glass washer problems. We recommend this guide be used to supplement the manufacturer's instructions for washer operation, maintenance, and troubleshooting.

When production rejects occur, an effort should be made to examine glass that has passed through the washer but has not yet experienced further processing. If this examination reveals any of the glass conditions listed in the troubleshooting guide, the corresponding potential causes should be investigated. This procedure should identify those production problems originating in the washing section of the fabrication line. Since abnormal surface conditions on incoming glass (i.e., stain or corrosion) will also be discerned in this examination, these have been included in the list of potential causes.

# Recommended Techniques for Washing Glass

## General Troubleshooting Guide

| Observed Glass Condition | Primary Potential Causes |
|---|---|
| Washing has failed to remove spots/streaks/residue of dirt visible on glass as received | **d, g, j, k, o, p, r, w** |
| Surface scratches (washer related) | **e, k, n, o, q** |
| Washing has deposited particulate contaminants on the glass surfaces | **b, d, e, h, l, m, n, o q, s, t, u** |
| Water droplets on surface(s) | **a, f, g, t** |
| Spot defects on surface(s) | **a, b, e, f, g, h, l k, l, m, n, o, p, r, s, t, u, v, w, x, z** |
| Surface streaks that are random in occurrence and orientation | **a, b, c, h, i, k, l, m, n, o, p, r, s, t, u, v, w, x** |
| Relatively uniform surface streaks oriented parallel to direction of glass travel | **b, d, e, o, s, u** |
| Surface streaks oriented perpendicular to direction of glass travel | **c, e, f** |
| Visible film or haze over glass surface(s) or subsurface(s) may exhibit poor wetting/ adhesion indicative of thin hard to see surface film | **b, d, h, l, j, k, l, m, n, o, s, t, u, v, w, x, z** |

**Key**

- **a - Air Knife: poor alignment insufficient air velocity**
- **b - Air Knife: dirty filters and/or ductwork**
- **c - Air Knife: conveyors stopped while glass under blowers**
- **d - Brushes: dirty, poor contact, non-uniformly worn, losing bristles**
- **e - Conveyor Rolls: dirty**
- **f - Conveyor Loading: glass too close together**
- **g - Conveyor Speed: too fast**
- **h - Detergent: too much being used**
- **i - Detergent: solubility/rinsing inappropriate for water conditions**
- **j - Detergent: substandard cleaning capability**
- **k - Detergent – none in use**
- **l - Detergent contains de-foaming agent**
- **m - Detergent: recent change to new detergent causing release of accumulated dirt (scale)**
- **n - Filters (Prewash, Washer, Air Knife): expended, wrong size, or not in place**
- **o - Nozzles (Prewash, Washer, Rinse): blocked or corroded Resulting in insufficient water Volume or velocity**
- **p - Organic solvent pre-cleaning necessary to remove water insoluble contaminants**
- **q - Particulate contamination of washer system**
- **r - Reaction contaminant dirt on glass requiring alternative cleaning procedures**
- **s - Rinse Water Quality: high turbidity or hard water salts content**
- **t - Rinse Water Temperature: too cold**
- **u - Rinse Water Volume: insufficient**
- **v - Solution Hold Tanks (Prewash or Washer): dirty, scrubbing and/or steam cleaning needed**
- **w - Stained (corroded) glass**
- **x - Water in Pre-wash: dirty from prolonged circulation; TPO not removed or re-deposited**
- **y - Misaligned or bad pinch roll**
- **z- Improperly cleaned substrate beneath coating**

# Recommended Techniques for Washing Glass

***Precautions for Washing Coated Glass Products***

Coated glass can act differently from uncoated glass in a washing system. Precautions will be necessary when washing coated glass products.

***Pyrolytic coated glass***, such as Solarcool® or Vistacool® coated glass incorporate coatings that are "fired" onto the glass surface by a pyrolytic method at elevated temperatures. These products, when cleaned in a washer system as outlined in this document, can be treated the same as uncoated glass since the coating is relatively durable. Possible exceptions are the selection of detergent (if used) and use of any solvents prior to washing. These should be tested prior to use in production.

***Magnetron Sputtered Vacuum Deposition (MSVD) coatings*** such as *SUNGATE and SOLARBAN coated* glass are not as durable as pyrolytic coatings. In addition, these coatings contain materials that are more chemically reactive than those in pyrolytic coatings.

The following recommendations are offered to aid in the successful washing of MSVD low-e coated glass and while all are important, those that are in **bold** print are considered critical. Implementing these best practices & recommendations will also improve the efficiency and quality of with all types of washed glass.

***Recommendations for Washing Vitro MSVD Coated Glass –***

- **A properly setup and functioning prewash** to dissolve & remove particulates, residues, TPO, and other dirt & debris or at a minimum loosen them.
- **Install brushes that have a bristle diameter between 0.006 and 0.009" (0.15 – 0.23mm).** Specify the actual bristle diameter size instead of just ordering "low-e brushes". Measure the actual bristle diameter of all brushes received and report any discrepancies to the brush mfg. and do not use brush in contact with the low-e coating.
- **Keep washer brushes clean and free of grit and abrasives** (such as glass fines and chips).
- **Use minimum brush pressure required to provide effective cleaning. Use a marker test to confirm proper setup and performance.**
- **Never allow glass to be stopped in a fixed position beneath the washer brushes or elsewhere in the washer.**
- All brushes must have sufficient water flow to prevent the brush, even if low-e type, from scratching the coating. A "rule of thumb" is to have ¾ GPM per foot of pipe for each pipe within the washer. Flow meters on each header should be installed to monitor the water flow.
- **Nozzles in the brush section should be pointed at the brush and not the glass.**

# Recommended Techniques for Washing Glass

- **The total dissolved solids (TDS) in the final rinse water must be no more the 20ppm.** Water measuring over this level should be replenished or replaced. Use of a full time in tank sensor is the best way to monitor TDS as these devices can have an auto alarm to alert the operator when the water quality is no longer acceptable.
- The pH of the wash water should be monitored to ensure that it is not excessively low or high. This is more important when a detergent is used. Ideally maintain a pH of 6-7 for coated glass.
- If remedial hand-cleaning is necessary, use a solution of 50 -50 demineralized water and isopropyl alcohol and a clean microfiber cotton cloth (or similar). Patting, rather than rubbing, is recommended to avoid coating damage. Avoid use of household glass cleaners such as Windex, dish soap or other like products.
- **Implement a regular comprehensive preventive maintenance program for the washer and include a daily operational checklist.**
- **Avoid the use of detergent, if possible, with MSVD coated glass. This avoids potential streaks & spots from improperly rinsed detergent.**
- **Properly setup final pinch roll and air knife section to achieve good sheeting action of water and residue free drying without spots or streaks.** Such residues remaining on coated glass are significantly more visible than on uncoated glass especially after heat treatment and longer term could result in coating corrosion.

# Recommended Techniques for Washing Glass

## *GLOSSARY*

These definitions pertain to the words as they are used in this document.

**Adhesion Chips –** chips of glass bonded to the glass surface

**Alkaline –** having the properties of an alkali: capable of neutralizing an acid. Having a pH greater than7; also referred to as basic.

**Deionize –** the process by which ion exchange resins are used to remove hard water salts.

**Demineralize –** the removal of mineral constituents from water

**Hardness –** the amount of calcium carbonate dissolved in water.

**Hermetic Seal –** an airtight seal which resists the penetration (or escape) of gases and moisture vapor.

**Interleaving -** a packaging material that is placed between adjacent lites of glass to keep from sticking together.

**pH –** a scale of 1 through 14 that designates relative acidity or alkalinity of liquids. 7 is neutral, 1 is the acidic extreme, and 14 is the alkaline extreme.

**Particulates –** solid material loosely deposited on a surface. They can be removed by using non-abrasive, mechanical methods such as high-pressure water.

**Powder Interleaving –** granular particles purposely placed on the glass to act as a mechanical separator and to prevent corrosion between lites of glass. Acrylic beads and wood flour are examples.

**Reaction Contaminants –** residues that have some degree of physical or chemical bonding or interaction with the glass surface. These cannot be removed with practical, standard washing procedures.

**Scale -** a deposit of mineral compounds in water.

**Softness (water) –** the degree to which magnesium and calcium ions have been removed from water.

**Solubility –** the ability of a substance such as detergent, to dissolve in water.

**Surface Corrosion –** irreparable, moisture initiated, chemical erosion of a glass surface.

**Turbidity –** Opaqueness or cloudiness of a liquid caused by suspended particles.

# Recommended Techniques for Washing Glass

## Appendix 1: Washer Quality Marker Test

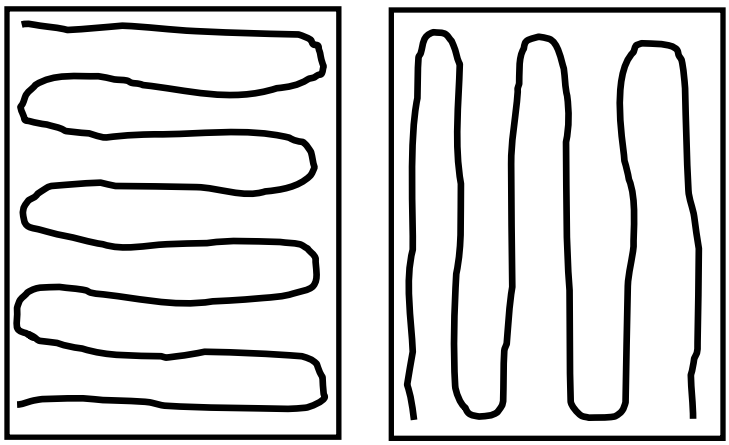
### Recommended Procedure for Performing "marker test" on Glass Washers

The following procedure applies to all glass fabricators who wash Vitro Flat Glass products, both uncoated and coated, for use in architectural glazing and specialty glass applications. The purpose of this test is to verify the proper setup and functioning of a glass washer, both horizontal and vertical designs, to effectively clean the glass while minimizing the potential for damaging low-e coatings. This marker test shall be performed at a minimum after washer maintenance and should be considered on a frequent basis to ensure ongoing washed glass quality (i.e. the start of each shift, change in glass thickness, and after a washer adjustment has been made).

Following these simple steps will indicate how well the washer is performing and if any additional setup changes or maintenance is required:

1. Start with a piece of Clear glass. The size can vary but suggest using a larger size to cover most of the washer's width/height. The glass thickness should be the same as what the washer is setup to process. Keeping a few pieces of sample glass of desired size and thickness near the washer allows for easy access to perform this test.
2. Prior to loading glass on the washer entrance conveyor, use a permanent marker (Sharpie® or equivalent with wide chisel tip; preferably black) to put "S" pattern mark on both sides of the glass (see diagram-1) using a consistent speed for uniform ink application. Important to use the same marker for both sides. Also note that other color markers may perform differently due to the die used. Alternate the orientation of the pattern so it is easy to determine which side of the glass the mark is on. Allow mark to dry (~1min).

Diagram-1: marker "S" pattern on front and back glass surfaces



*Note: Do not use a wax pencil for marking the glass since this type of material may melt with heated wash water and contaminate the washer.*

# Recommended Techniques for Washing Glass

Washer should be setup and functioning normally (i.e. normal conveyor speed, pre-rinse on, good water flow, brushes engaged - based on the type of brush and glass being washed, heated wash water, pinch rolls in position based on glass thickness, drying section on). If detergent is normally used in the washer, it is suggested to run this marker test without the detergent since the main interest is to test for proper water flow and brush setup. If testing coated glass washer setup and there is a sensor for detecting coated glass and adjusting brush position automatically, the operator will need to somehow bypass or trick this sensor when running the clear glass with the "S" pattern marked on it through the washer.

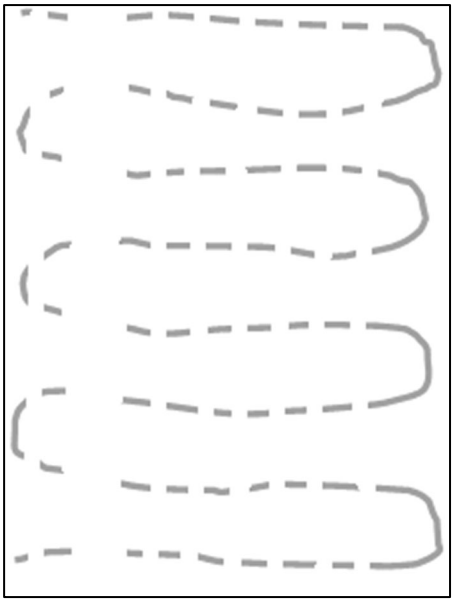
3. Place the marked glass on the entrance conveyor in the typical position and orientation which glass passes through the washer. Note: It is desirable to test the entire usable width/height of the washer.

4. Allow glass to pass all the way through the washer without stopping (note: glass should never stop part way through the washer even if the washer is designed to auto shut-off). As the glass exits the washer, visually verify the dryness of the glass. There should not be water droplets on the glass edges including the trailing edge. Also, there should not be any streaks, spots, or other dried water marks on the glass surface (suggest inspecting glass with a bright flashlight ~300 lumens). If streaks, spots or dried water marks are seen, check that the final rinse water quality is good (TDS ≤20ppm or ≤40µs), the pinch roll just prior to the air knife section is setup properly and in good condition, the blower air intake filters are clean and taped at the seams, the air knives (including supply hoses) are clean and properly positioned, conveyor rolls are clean, and sources of dust/debris are minimized to keep dust from settling on the clean glass. Remember the definition of washed glass quality is "clean" and "dry".

5. Pull the test piece of glass off the line (be sure to use clean gloves) and inspect with adequate bright lighting. Note: The use of a bright flashlight or light table/box is recommended. For a washer setup to run coated glass, the "S" pattern mark **should not** be completely removed on the top/front surface but **should** be completely removed on the bottom/back surface. If the mark on the top/front surface is mostly or completely removed, this indicates that the brushes may be engaged too far and there is a greater potential for coating scratches. Ideally the top/front mark **should** be about 50% to 75% removed as shown in Diagram 2. Some fading of the mark is typical and should be expected.

# Recommended Techniques for Washing Glass

Diagram-2 (top/front/low-e side): “S” mark after washing should be partially removed & faded



Note: Actual gaps in the partially removed “S” mark are typically much smaller than shown (i.e. width of the brush bristles).

6. (continued) – If the top/front “S” mark is barely removed or looks like it was not touched at all, this indicates that the brushes are not adequately engaged and the glass in general may not be getting properly cleaned. Note: This is especially important for achieving complete removal of the temporary protective overcoat (TPO) used on some coated glass products supplied by Vitro. If the washer is setup to run non-coated glass, then the “S” mark should be completely removed from both sides of the glass.
7. Look for consistency in the removal of the mark side to side and lead vs trailing. As shown in Diagram 2, there is an area down the left side where the removal is not consistent. This indicates an issue with an unevenly worn brush or could also be caused by a clogged nozzle as a dry brush performs differently than a wet brush. *Note: Even a low-e brush can scratch the coating if it is dry since water acts as a lubricant.* Also, the mark on the right side is not removed consistently which indicates a misaligned brush or heavily worn brush (especially if glass is repeatedly loaded to this side of the washer with the glass edge wearing out the brush).

# Recommended Techniques for Washing Glass

### Washer Setup & Operation Troubleshooting Guide –

| Symptom | Possible Action |
|---|---|
| "S" mark is completely removed from both sides | • For uncoated glass, this is the proper test result.<br>• For coated glass, adjust brush(es) position – back off brushes on coated side until the mark is only partially removed about 50% to 75%. Also inspect for coating scratches in glass washed since last good marker test.<br>*Note: On a vertical washer, the brush positioning between front and back sides may require a fine balance so that the glass still conveys through the washer properly. Consult washer manufactures instructions.* |
| "S" mark is not consistently removed/faded from side to side and/or lead to trail | • Check brush(es) for uneven wear especially if glass is always loaded to one side of the washer. To achieve the best brush wear, stagger the glass position and/or angle it through the washer.<br>• Check brush(es) for levelness across the washer. Adjust as necessary to achieve a level brush surface contacting the glass. |
| Brush scratches in the coating (not easily seen w/o bright flashlight looking in reflection) | • First rotate a piece of coated glass through the washer to confirm that the scratch orientation follows.<br>• Ensure there are no clogged or misdirected nozzles (in the brush section, nozzles should spray on the brush not the glass).<br>• Ensure there is proper water flow - Vitro recommends 3/4 GPM per foot of pipe for each header within the washer.<br>• Verify low-e type brushes are used (bristle diameter: 0.006" – 0.009"). |
| Dried water streaks/spots (may not be visible w/o bright flashlight) | • Check that the water quality is good (final rinse TDS should be ≤ 20ppm).<br>• The pinch rolls are setup properly and are free of cuts & gouges and foreign residue. Always put the newest pinch roll in the last top position to have the best squeegee action prior to the air knives.<br>• The blower air intake filters are clean and taped at the seams. Air supply hoses and air knife section are clean (requires periodic maintenance to keep them clean).<br>• Sufficient volume of air is coming out of the air knives and consistently across them (requires periodic cleaning of the air knife slots). |

# Recommended Techniques for Washing Glass

| Symptom | Possible Action |
|---|---|
| Dried water streaks/spots (cont'd) | • Air knives are properly set-up so that the slots in the top and bottom air knives are parallel to each other in all planes and the top air knife slot is positioned slightly closer to the exit end than the bottom air knife slot in the vertical plane so the top air knife is the last to blow on the glass.<br>• Conveyor rolls are clean, and sources of dust/debris are minimized to keep dust from settling on the clean glass. |
| Residue (could be from TPO) remains on the glass after washing; usually appears as purple spots and/or streaks | • Pre-rinse system has poor water flow and pressure, or nozzles are angled improperly (point nozzles towards entrance).<br>• Brushes are not touching the glass surface – run marker test to confirm proper setup.<br>• Check for proper water flow especially in pre-rinse section.<br>• Check for proper washer section water temperature 110-140˚F or 43-60˚C (ideally as close to 140˚F or 60˚C as the manufacturer allows).<br>• Check for water quality and excessive foam build up in any of the recirculating water tanks. Do not use chemicals to reduce the foaming but instead clean out buildup of TPO, grease, mold, or other foreign residue inside the washer (requires periodic maintenance of the entire washer to keep it clean).<br>• Glass sat too long (>2hrs) after cutting or got wet then dried again. |
| Water quality (TDS) deteriorates rapidly within a few hours | • Water treatment system is malfunctioning or need to replace filters.<br>• Brush rotation is not opposite glass flow, so dirt/debris is pushed into the washer instead of towards the entrance.<br>• Brushes are not in contact with glass, so all debris is carried farther downstream in the washer.<br>• Pre-rinse system is not setup/working properly to remove most of the dirt/debris or TPO prior to entering the washer.<br>• Water in each section is not isolated or cascading properly inside the washer; Look for rusted, leaking, or mis-installed interior components. |
| Excessive foaming in any of the recirculating water tanks | • If detergent is used, check/adjust the amount added to the wash water.<br>• After washing a large volume of coated glass containing TPO, make sure the TPO is not building up inside the pre-rinse, washer, or recirculating tanks. If there is visible foam, run pre-rinse recirculating tank to drain and purge with fresh water until foaming subsides. May require high pressure spray down of the pre-rinse section and of the recirculating tank(s) to remove TPO build up. |

# Recommended Techniques for Washing Glass

| | |
|---|---|
| Excessive foaming (cont'd) | • Pre-rinse system is not setup/working properly to remove a majority of the TPO prior to entering the washer and flush it down the drain. In worst case, the water becomes supersaturated with TPO and it is sprayed back onto the glass and carried downstream into the washer. |

Consult washer manufacturer's manual for additional setup, operational, and troubleshooting information.

| HISTORY TABLE | | |
|---|---|---|
| ITEM | DATE | DESCRIPTION |
| TD-144 | 8/7/2006 | Electronic version of "Recommended Techniques for Washing Glass" with minor modifications and additions. |
| Revision #1 | 8/28/2015 | Editorial changes, comment about bead melting temperature, link to TD-149, update of coatings listed. |
| Revision #2 | 10/4/2016 | Updated to Vitro logo and format |
| Revision #3 | 1/28/2019 | Updated the Vitro logo and format |
| Revision #4 | 8/22/2019 | Removed duplicate paragraph and changed Solarban 70XL to Solarban 70. |
| Revision #5 | 7/17/2020 | Updated information, formatting, and editorial changes: removed language and pictures related to pre-wash detergent application. Added section on water flow and added Appendix 1, Washer Quality Marker Test procedure |
| | | |
| | | |
| | | |
| | | |
| | | |