3 Distribution Line Washing Requirements and Techniques

3.1. General

This section provides guidance, practices, and procedures to safely and effectively clean energized and de-energized insulators on distribution lines. The information is compliant with the Company's requirements for cleaning electric distribution facilities that are between 5 kilovolts (kV) and 44 kV.

Distribution facilities that are washed using the procedures outlined in this manual may be considered as having been patrolled in accordance with the requirements of Utility Operations (UO) Standard S2425, "Electric Distribution Overhead and Underground System Patrol." To meet the inspection requirements, a qualified Company representative must look for any abnormal conditions as specified in the standard. Retain any records and documentation of facilities washed and/or patrolled and any abnormal conditions in accordance with UO Standard S2425.

Transmission structures with both transmission and distribution facilities should be washed at the same time. The respective transmission and distribution representatives need to establish responsibility for washing distribution facilities on these structures.

CAUTION

Do not wash nonceramic transmission insulators.

3.2. Tailboard Requirements

Before cleaning insulators, employees must:

A. Be trained and completely familiar with the applicable sections of this manual.

B. Perform the daily vehicle, wash trailer, and equipment inspections.

C. Check the level and resistance of the wash water.

D. Have mechanical problems repaired.

E. Report any problems or concerns to the supervisor.

F. Attend a tailboard with the cleaning employees to discuss all of the following topics.

- Section 2, "Safety," of this manual, stressing the importance of maintaining the minimum approach and working distance. (See Table 2-1 on Page 2-3.)
- Traffic control and public safety, especially when maneuvering the truck and equipment, notifying the public to close vehicle windows, etc.
- Maintaining the stream-length distances as outlined in Table 3-1 on Page 3-2.
- Positioning of the aerial lift truck and employees.

- Safety tips to use while moving or washing with a boom.
- Washing techniques to use.
- The height of the structure or pole.
- The route of the distribution line; e.g., which side of the road the line is on, the traffic direction, etc.
- The wind speed and direction.
- The types of insulators and their configuration.
- **Degree** of contamination.
- Maintaining communications between the equipment operator and the employees in the lift.

3.3. Water

A. Use **only** water that is clean and as free of salts and minerals as possible.

B. Use water with a resistance greater than or equal to 550 ohms-per-inch-cubed when washing distribution insulators on energized lines. When washing distribution insulators on de-energized lines, water as low as 100 ohms-per-inch-cubed may be used.

C. Maintain the minimum nozzle pressure, ohmic resistance of the water, and minimum stream-length distance listed in Table 3-1 below when washing insulators on energized distribution lines.

Table 3-1 Minimum Stream-Length Distance and Nozzle Pressure for Distribution Lines

Voltage (phase-to-phase)	Minimum Nozzle Pressure (psig)	Minimum Resistance (ohms-per-inch-cubed)	Nozzle Orifice Diameter (inches)	Minimum Stream-Length Distance (feet)
4 kV – 21 kV	400	550	1/4	8

D. Maintain the minimum stream-length between the nozzle and the insulator as shown in Table 3-1 above. This applies to washing any energized parts and supporting insulators.

⚠ **WARNING**

Never allow the distance between the nozzle and the insulator to be less than the specified minimum stream-length.

E. To achieve maximum cleaning effect, position the nozzle to wash at the most effective distance. If the distance is too great, the washing action becomes less effective.

3.4. Washing Precautions

A. Whenever practical, first wash the insulator side with the greatest amount of contamination. Apply a sufficient water stream (either directly or indirectly) to the insulator surface to clean off all contaminants. The bottom or inside skirt surfaces are the most difficult to wash.

NOTE

Contamination is usually heavier on the prevailing downwind side.

B. Preferred Method

Position the nozzle operator to wash into the wind or **upwind** (wind blowing at the nozzle operator). Wash the insulator or insulator string closest to the nozzle first. Move the wash stream as shown in Figure 3-1 below to wash the other insulators in sequence.

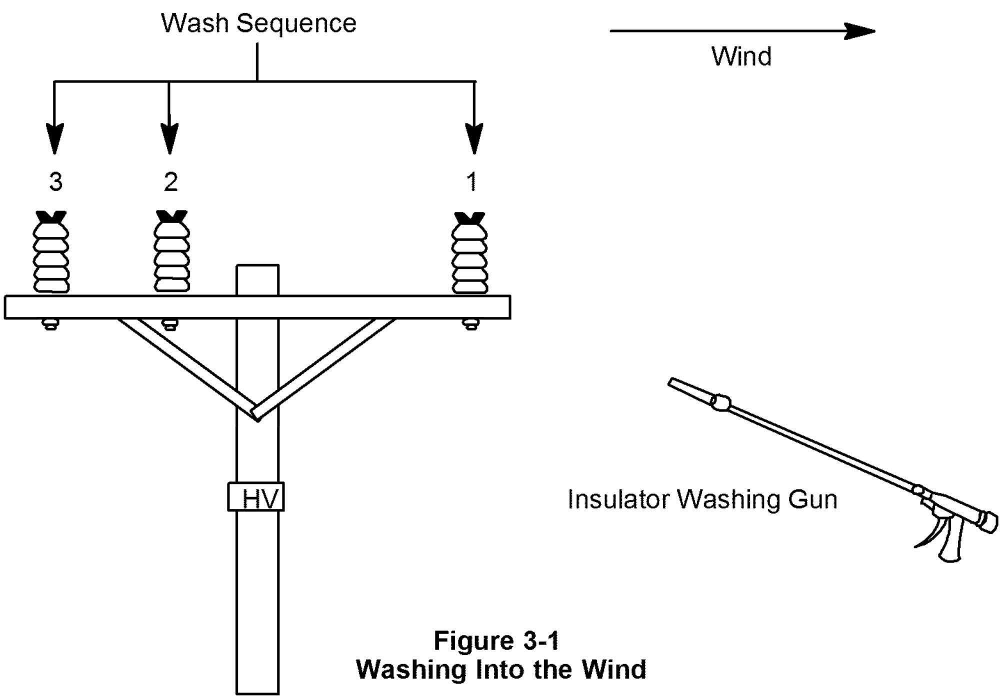

Figure 3-1
Washing Into the Wind

C. Alternative Method

Position the nozzle operator to wash with the wind or **downwind** (wind blowing away from the nozzle operator). Keep the wash stream in line with the wind direction, washing the farthest **downwind** insulator or insulator string first. Move the wash stream as shown in Figure 3-2 below to wash the other insulators in sequence.

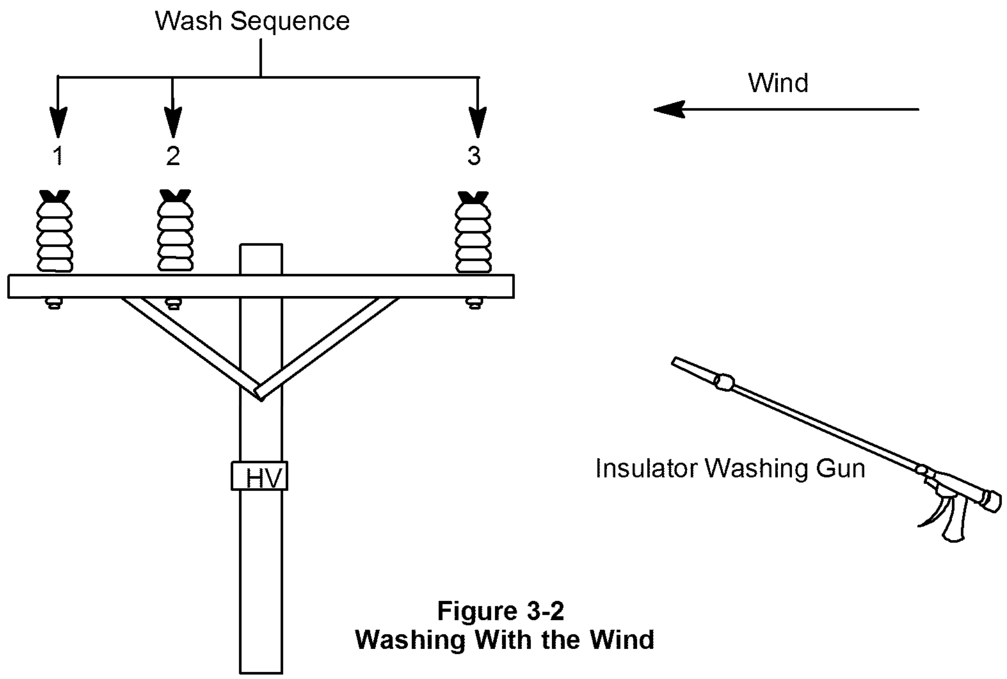

Figure 3-2
Washing With the Wind

3.5. Washing Preparations

A. A nozzle operator, washing from the basket, and an operator for the wash vehicle make up a typical crew used to wash distribution lines with lift equipment. At times, it may be necessary for the field supervisor to add more employees to the crew to ensure public safety, especially to maneuver equipment, notify the public to close vehicle windows, etc.

B. Have an appropriate supply of hot sticks available for use in the event that jumpers, disconnects, or fuses become dislodged during the wash. To reduce the risk of a circuit interruption or facility damage, inspect the insulators, crossarms, poles, and hardware before washing for the following conditions:

- Breakage or cracking
- Evidence of tracking
- Burning
- Deterioration

C. Develop a method for determining short time intervals (in seconds) to ensure that the washing action will be effective. One effective method to count seconds is by slowly counting “one thousand one, one thousand two, etc.”

D. In general, clearances and nontest orders are not required to hot wash insulators on distribution lines. However, before washing, notify the electric control center in charge of the section(s) of line(s) to be washed. Always maintain radio contact, or a combination of radio and telephone contact, with the electric control center in charge of the line(s) being washed. Notify the electric control center when washing is completed.

E. Flashed insulators that are not cracked, broken, or arcing excessively **can be** hot washed. However, they must be changed out as soon as practicable in accordance with the Electric Preventive Corrective Maintenance (EPCM) program guidelines of Work Management.

⚠ WARNING

Do not hot wash cracked, broken, or squatted insulators. They must be changed out as soon as practicable in accordance with the EPCM program guidelines. Use EPCM notifications to report any damaged equipment found while washing.

3.6. Washing Techniques

A. In general, warm water has a lower resistance than cold water. Therefore, direct the initial water stream away from the energized equipment until any warm water is flushed from the hose line and piping. Minimize overspray that may moisten unwashed, contaminated insulators. Minimize dripping dirty water that may contaminate clean insulators when hot washing insulators that are supporting energized parts or conductors. This action will minimize flashovers.

⚠ WARNING

Do not direct the stream where overspray can moisten unwashed, contaminated insulators.

B. Bring the water stream to full nozzle pressure before directing it at the insulator. Then, direct the water stream at the insulator surface to be washed and keep the water stream on during the entire washing action. Move the water stream away from the insulator surface and conductor before shutting down the water stream.

C. When washing insulators or insulator strings, start the water stream in the air near the starting point on the insulator to be washed. When washing is completed, move the water stream away from the insulator surface and conductor before shutting down the water stream. For the most effective washing action, position the nozzle below the associated conductor level and direct the water stream to the bottom or inside insulator skirt surface. The water stream should create a swirling action and ringing sound inside the skirt surfaces to be effective.

D. Wherever possible, direct the water stream at a 30° to 45° angle upward toward the insulator. When the insulator cannot be washed at an angle of 30° to 45°, allow more washing time to permit the backspray from adjacent insulators, metal cap, and hardware to do the washing.

E. Avoid wetting wooden crossarms as much as possible during hot washing. Wetting crossarms can increase leakage current discharges and result in fires. Direct an additional water stream to the arm if it is burning.

F. When washing:

1. *Vertical, suspension-type insulators*, direct the water stream to the lowest insulator first, moving progressively upward on the string, returning to the lower units to rinse off water dripping from the higher units.
2. *Horizontal, suspension-type insulators*, direct the water stream first at the conductor, moving progressively toward the structure.
3. *Pin-* or *post-type insulators*, direct the water stream to the bottom of the insulator, moving progressively toward the top.

3.7. Miscellaneous Washing Techniques

A. When washing insulators on triangular or horizontal construction from the upwind side, start at the far side, away from the nozzle operator. Next, wash the kingpin or center insulator from the bottom up and then wash the closest insulator starting from the pole. When washing insulators on vertical construction, wash the lowest insulator first.

B. Due to their size, distribution insulators are moistened across the surface as they are washed. As the contamination on the insulator is moistened, conditions for a flashover become ideal. Remove the contamination rapidly to prevent flashovers.

C. The typical time required to remove contamination from a distribution insulator is 2-1/2 seconds with a ffffiffhch nozzle working at a minimum nozzle pressure of 400 pounds per square in gauge (psig). The actual time required to wash an insulator will vary depending on the amount and type of contamination.

D. When washing distribution insulators, make sure to direct the water stream away from jumpers, disconnects, fuses, and equipment, which can be dislodged, damaged, or cause damage due to the impact of the water stream.

E. When washing stacked insulators on airbreak switches, start washing at the lowest insulator surface and work upward. This is the same technique used for vertical insulator strings.

F. Distribution structures with vibration dampers, flight diverters, nonceramic insulators, surge arresters, transformers, capacitors, line reclosers, sectionalizers, and oil or vacuum switches installed **can be** hot washed.

⚠ WARNING

***Do not* hot wash distribution insulators with animal guards.**

G. Leakage current discharges, arcing, or tracking may extend from the metal cap to the porcelain on an insulator during hot washing and may be heard for a few seconds after the washing is completed. If this discharge continues, the washing may not be completed. In this case, reapply the water stream. If unusual arcing occurs when hot washing an insulator that supports an energized conductor, direct the water stream into the arc. In this manner, damage is kept to a minimum and the stream may extinguish the arc before the line relays.

3.8. Effective Insulator Cleaning

Effective insulator cleaning results in the following:

- Visibly Clean Surface

  The surface condition of the top and bottom of the insulator skirts are visually clean and shiny after the water has dried.

- Insulator Vibration

  Under the impact of high-pressure washing, the water stream creates an efficient, swirling motion resulting in a mechanical vibration or ringing sound inside the insulator skirts.

- Absence of Arcing or Tracking

  Leakage current discharges are not present.

- Clarity of Runoff

  The clarity of the water runoff may indicate the effectiveness of contamination removal. However, the clarity of the water runoff may be difficult to observe due to distance, wearing shaded safety glasses, etc.

- Removal of Contaminants

  On horizontal insulators, observe the drip point or the bottom side of the insulators. On vertical insulators, observe the backside of the insulators, opposite the point of impact of the water stream to see if contamination has been removed or just moved to another side.

5 SUBSTATION WASHING REQUIREMENTS AND TECHNIQUES

5.1. General

This section provides guidance, practices, and procedures to safely and effectively clean energized and de-energized insulators at substations.

Substation maintenance supervisors need to identify any obstacles in meeting the requirements of this manual and bring them to the attention of the substation superintendent for resolution on a case-by-case basis.

Several safety requirements must be met to protect employees washing energized insulators. This section lists only the requirements that are specific to substations. See Section 2, "Safety," and the *Code of Safe Practices* (*CSP*) for general safety information applicable to all employees who clean insulators.

5.2. Tailboard Requirements

Before cleaning insulators, a tailboard must be conducted in accordance with Section 2.3, "Tailboard Requirements," on Page 2-1. Discuss and complete the "Washing Tailboard Check-Off Sheet" on Page 5-28 for each station being washed and file the check-off sheet daily at the substation headquarters. Add and discuss any issues not listed that are specific to the station.

5.3. Water

5.3.1. Water Resistance

A. Minimum water resistance levels are designed to limit leakage current through the wash stream and to protect employees against electric shock when washing energized insulators. In substations, the minimum resistance level allowed is 1,000 ohms-per-inch-cubed. This level is conservative and is used, along with the nozzle size and pressure, to set the minimum wash stream lengths.

⚠ WARNING

Never use water that measures below 1,000 ohms-per-inch-cubed.

B. Water resistance varies from source to source. It is further influenced by contaminants in the tank, pump, hoses, and associated equipment. When tanks are exposed to prolonged sunlight or another heat source, the water resistance will decrease as the water temperature increases.

For example, if water measures 1,000 ohms-per-inch-cubed at 60°F, and the tank, plumbing, or hoses are exposed to the sun or some other heat source, the resistance of the water will drop to 820 ohms-per-inch-cubed when the water reaches 80°F.

5.3.2. Testing the Water

A. Use **only** water that is clean and is free of salts and minerals.

⚠ WARNING

Never use seawater, bay water, or salt water of any kind for insulator washing.

B. Test the water resistance:

- Before filling the tank.
- Each time the tank is filled.
- Immediately before use each day (even if the water was checked and not used the day before).
- If the tank heats up from prolonged exposure to the sun.
- Anytime questions arise concerning water resistance.

5.3.3. Minimum Stream-Length Distance

A. The minimum stream-length distance is designed to protect employees from electric shock while washing energized facilities. Use the minimum stream-length distance and minimum nozzle pressure using a 1/4-inch nozzle as shown in Table 5-1 on Page 5-3.

⚠ WARNING

Never allow the distance between the nozzle and the insulator to be less than the specified minimum stream-length unless the conductors are de-energized and grounded.

B. At all times and especially during windy conditions, position the water stream as closely as possible to the minimum stream-length distance to ensure that an adequate water stream impacts the insulator surface and quickly removes conductive contamination.

C. Pay special attention to low-profile installations since the base of these insulators can be very close to ground level. It may be impossible to achieve the desired 30° to 60° angular displacement **and** maintain the minimum stream-length distance at the same time. The minimum stream-length distance **always** takes precedence.

Table 5-1 Minimum Stream-Length Distance and Nozzle Pressure for 1/4-Inch Nozzles and Water Resistance of 1,000 Ohms-Per-Inch-Cubed

Voltage (phase-to-phase)	Minimum Stream-Length Distance (feet)	Minimum Nozzle Pressure (psig)
4 kV–12 kV	8	400
13 kV–23 kV	10	400
24 kV–70 kV	12	400
71 kV–115 kV	15	400
116 kV–230 kV	15	400
231 kV–500 kV	20	400

5.3.4. Maximum Stream-Length Distance

The maximum stream-length is the distance from the tip of the nozzle to the insulator surface. Exceeding the maximum stream-length reduces the impact of the water stream necessary for removing contamination and may increase the risk of flashover during an energized wash.

A. Do **not** exceed maximum stream-lengths of 35 feet on energized, cap-and-pin post-type insulators, or bushings.

B. Do **not** exceed maximum stream-lengths of 50 feet on string-bell insulators.

C. The approval for exceeding maximum stream-length distances is given on a case-by-case, location-specific basis by the area substation superintendent. Blanket approvals should **not** be given. All deviations and approvals must be documented and filed at the maintenance headquarters.

D. Estimating the height of overhead-mounted equipment is difficult. Review the station drawings to determine the height of insulators and string-bells to determine the maximum stream-length distances.

E. Reduce the **maximum** stream-lengths if wind causes excessive fogging of the water stream or an adequate impact cannot be achieved. In all instances, the shorter the maximum stream-length distance, the greater is the water impact on the insulator.

5.4. Washing Precautions

5.4.1. Introduction

A. It is the responsibility of each substation headquarters to determine the need and frequency of the insulator wash. This cycle can be based on the historical performance of the substation insulator wash schedules to prevent any dangerous build-up of contamination. The risk of flashover is very high when an energized, highly-contaminated insulator, regardless of its glaze-type, is used. Always wash these insulators **de-energized**. Periodic inspections of the insulators must be made to assess the condition of the insulators or changes in the substation environment. It is recognized that certain deposits cannot be successfully removed by washing, requiring clearances for hand wiping.

B. Without exception, **never** wash the equipment listed below in Section 5.4.3., "Equipment That Must Be Washed De-Energized," when it is energized. (Use caution when they are subjected to heavy overspray.)

C. De-energize **all** equipment before washing, whenever possible, if it can be readily taken out of service without interrupting service to customers, excessive overtime work, or extensive switching. If in doubt about the safety of washing energized equipment, **de-energize** the equipment before washing it, even if overtime work is required.

5.4.2. Requirements

A. Always wash energized insulators under the direction of an electric maintenance crew leader or substation supervisor.

B. A qualified observer must be used at all times while hot washing is in progress. The electric maintenance crew leader may act as the observer or assign another crew member to be the observer. The observer is responsible for:

- Ensuring the minimum stream-lengths and minimum approach and working distances are maintained.
- Ensuring the safe movement of wash equipment.
- Stopping the insulator wash if overspray is excessive.
- Redirecting the water stream if arcing occurs on adjacent insulators from overspray.
- Communicating with all members of the wash crew via a bull horn, radio headset, etc.

5.4.3. Equipment That Must Be Washed De-Energized

5.4.3.1. 20-Inch and 40-Inch, Post-Type Insulators

Due to the risk of flashover and regardless of their glaze-type, do **not** wash energized:

- 20-inch, post-type insulators on 60-kilovolt (kV) and/or 70-kV lines and buses.
- 40-inch, post-type insulators energized on 115-kV lines and buses.

5.4.3.2. Ohio Brass Bushings

A. Do **not** wash or subject to heavy overspray and/or runoff Ohio Brass bushings energized at 115 kV and higher that are highly tapered and mounted in a nearly-vertical position. This applies to bushings with or without room temperature vulcanized (RTV) silicone coatings.

B. Because of the design of these bushings and the angle at which they are mounted, contaminated wash water can bridge successive skirts, providing a conductive path to ground. These bushings are typically found on Federal Pacific Equipment (FPE) circuit breakers, but may be found on other equipment as well.

5.4.3.3. GE ATB Circuit Breakers

A. Do **not** wash energized, GE ATB circuit breakers, regardless of the voltage level.

B. Do not wash de-energized, 500-kV GE ATB circuit breakers at high-pressures due to the risk of water entering the mufflers.

C. On de-energized, 230-kV and below breakers, direct the water stream only at the insulator surface. Avoid directing the water stream at the buffer chamber, mechanical control valve, blast-valve, suppressor exhausts, or mufflers. Do not allow the water stream to ricochet or splash this equipment.

⚠ WARNING

After completing the insulator washing, close and open the breaker at least two times before closing any disconnects to the breaker.

5.4.3.4. SF6 Puffer Breakers

Do **not** wash energized, SF6 puffer breakers without the approval (on a case-by-case basis) of the area substation superintendent. SF6 puffer breakers have bushings mounted in close proximity or in the nearly-vertical position. The positioning of these bushings increases the risk of flashover when washed energized.

5.4.3.5. Capacitor Banks

A. Station capacitor banks operate with various configurations and voltage levels. Do **not** wash energized capacitor banks located in substations, regardless of the voltage level or configuration. When washing de-energized, do not allow the water stream to damage components, fuse clips, fuse holders, and jumpers.

B. Before re-energizing the capacitor bank, visually inspect the equipment to ensure that no components were damaged during cleaning.

5.4.3.6. Nonceramic Polymer Insulators

A. If bushings, insulators, and lightning arrestors made of nonceramic polymer/composite insulation need to be cleaned, do **not** clean them energized. Always clean them de-energized and grounded.

B. Use a low-pressure water stream by setting the pump on idle or using the municipal water tap pressure. If a more thorough cleaning is necessary, follow the manufacturer's instructions.

5.4.3.7. RTV Silicone Coatings

A. Check the usual indicators such as tracking, noise, and corona to determine the cleaning cycle for RTV silicone-coated insulators that are subjected to heavy contaminants.

B. Do **not** clean energized, RTV, silicone-coated insulators. If cleaning is necessary, the insulators must be de-energized. If they are not grounded, follow the requirements listed below:

- Use the water pressure as outlined in Table 5-1 on Page 5-3.
- Always maintain the minimum stream-length distances for energized equipment.
- Use the same washing patterns and techniques required for energized equipment.

C. After washing RTV, silicone-coated insulators, visually inspect the surface. If the surface appears damaged, contact the substation maintenance supervisor.

5.4.3.8. Silicone Grease

A. **Never** clean silicone grease with high- or low-pressure water streams.

B. Silicone grease may be subjected to overspray during washing. Do not hit the silicone grease with the wash stream. Depending on the level of contamination embedded in the silicone grease, the surface may heat up and glow, smoke, or arc when oversprayed.

C. Arcing occurring in silicone grease can cause extremely high temperatures that can crack the porcelain. If arcing occurs, discontinue the wash, allow the silicone surface to dry, and notify the maintenance supervisor to determine if it is safe to proceed.

5.5. Washing Preparations

5.5.1. Assessing the Station

A. Before starting the wash at a station, determine:

- The wind direction. The direction of the wind at the time of the wash will dictate where to begin.
- The wind speed. Reschedule the wash if the wind causes excessive water dispersion, fogging, or overspray.
- Which equipment requires the use of two water streams.
- Which equipment cannot be washed energized.
- Which fuses or disconnects may become dislodged during the wash.
- The location of lightning arrestor exhaust-ports. (Never direct the water stream toward the exhaust ports.)
- The location of pressure-relief semaphores, switch target plates, equipment air vents, oil-level gauges, animal guards, etc., that may be damaged by the water stream. (Do not direct the water stream toward this equipment.)

- Any broken insulators or damaged equipment.
- The presence of obstacles above or tripping hazards on the ground.
- If the station configuration will keep outages to a minimum in the event of a flashover.

B. Resistive-Glaze (RG) Insulators

1. RG post-insulators have been used at substations with high contamination since 1995. RG insulator flashovers have not occurred in the Company under various weather and contamination conditions. However, several flashovers involving RG insulators have occurred **during** energized washing. Since RG insulators respond the same as standard-glazed, porcelain insulators during energized washing, wash vertical and horizontal RG insulators using the same techniques.
2. In locations where washing the non-RG insulators will result in overspray on to the RG insulators, include the RG insulators in the **first** wash cycle and subsequent cycles with the rest of the non-RG insulators. Do **not** skip washing the RG insulators during one or two washings and include them in a later wash cycle.
3. The risk of flashover is very high when an energized, highly-contaminated insulator, regardless of its glaze-type, is washed. Always wash highly-contaminated insulators **de-energized**.

5.6. Washing Techniques

5.6.1. Introduction

A. Insulators are effectively cleaned by the strong impact of the water stream followed by a thorough rinsing. Listen for a clean ringing or impact sound to indicate adequate impact when the water stream strikes the insulator.

B. Use a systematic method to ensure all contaminants are removed. Contaminants remain on the surface when:

- The water stream does not impact the insulator effectively.
- Wash patterns are not followed.
- Insulators are washed and rinsed too quickly without a thorough backwash (second wash and rinse).

C. Always wash the lower levels of the structure or bus first. Periodically wash and rewash the vertical leads and lower insulators during the upper-insulator wash to prevent dirty water from returning to the insulator surface. Use caution when washing the leads. The impact of the water stream may move them, reducing phase-to-phase or phase-to-ground clearances.

D. After washing insulators in a bay or bus section, observe a short waiting period before leaving the area until the arcing or corona diminishes. If the corona does not diminish, rewash the insulators.

5.6.2. Energized Washing Requirements by Voltage Level

5.6.2.1. Below 50 kV (Distribution)

Use one **or** two water streams to wash energized equipment and buses operating below 50 kV. See Table 5-1 on Page 5-3 for minimum stream-length distances and nozzle pressures.

5.6.2.2. 50 kV to 115 kV (Transmission)

A. Wash energized equipment and buses operating from 50 kV, up to and including 115 kV.

B. Use two water streams when the following equipment is energized:

- Vertically mounted, post-type insulators
- Lightning arrestors
- Potential transformers
- Potential devices
- Coupling capacitors
- Bushings

C. While two water streams are always preferred, it is acceptable to use one water stream on:

- Horizontally mounted, post-type insulators.
- Vertically or horizontally mounted string-bells.
- Vertically or horizontally mounted, cap-and-pin insulator stacks.

5.6.2.3. 230 kV (Transmission)

A. Limit energized washing of 230 kV insulation to:

- Buses
- Air switches
- Suspension strings
- Dead-end strings

B. Use two, high-pressure water streams when washing the hinge-end of vertical break switches where two stacks of insulators are in close proximity.

C. Do not wash insulation on **energized** bushings, lightning arrestors, potential transformers, potential devices, or coupling capacitors. If an energized wash is absolutely necessary, get approval from the area substation superintendent.

5.6.2.4. 500 kV (Transmission)

A. Only personnel **trained** in the techniques of washing 500 kV are authorized to wash this equipment.

B. Limit the energized washing of 500-kV equipment to bus insulators, insulation on the jaw side of gang-operated switches, suspension, and dead-end strings. **One** water stream may be used for suspension insulators and dead ends. Use **two** water streams for all other insulators.

C. Do **not** wash **energized** insulators on the hinge-end of gang-operated switches where two stacks of insulators are in close proximity (as on line trap supports).

D. Only wash **de-energized** 500-kV circuit breakers.

5.7. Backwash

A. Use the wash and backwash method to effectively clean all four sides of the insulator surface. For example, two nozzle operators, positioned 180° apart, should wash and rinse an insulator ensuring that enough contamination has been removed to prevent a flashover. Then the nozzle operators reposition themselves 90° in either direction from their previous position and, while maintaining a 180° displacement, thoroughly wash and rinse the insulator from this new position. The second position is commonly referred to as the backwash. (See Figure 5-1 below.)

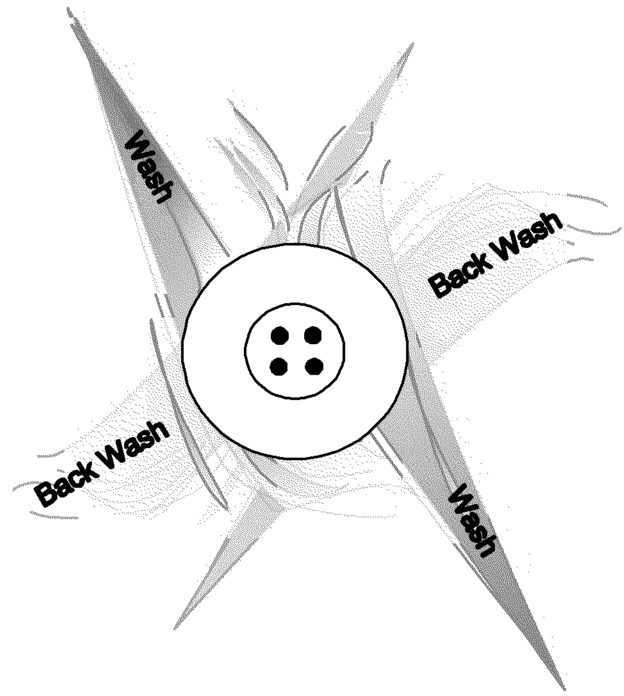

Figure 5-1
Backwash

B. Wash and rinse several insulators while moving down a bus section, ensuring that enough cleaning has been achieved with the initial strike to remove enough contamination to prevent a flashover. Then reposition and perform a backwash from another angle.

C. In some cases, due to obstructions, overspray, and wind, it may be necessary to thoroughly wash and backwash a single insulator before moving to the next insulator.

5.8. Wind Conditions

A. Contaminants do not always accumulate evenly on insulators. The prevailing wind direction will cause heavier deposits on the downwind side of the insulator than on the upwind side. (See Figure 5-2 below.)

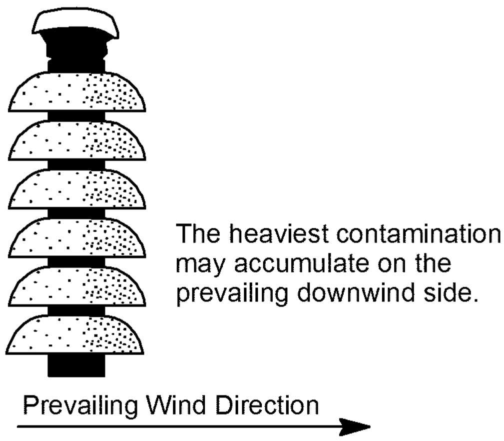

Figure 5-2
Prevailing Winds

B. When washing with one nozzle, begin on the dirtier side before repositioning to the other sides. When washing with two nozzles, position one nozzle to directly impact the dirtier side, taking wind direction and overspray into consideration.

5.8.1. Starting Point of the Wash

A. In Figure 5-3 below, the wind is blowing from the top right to the bottom left across the station. In this example, start washing at insulator number 1. Move to number 2, then number 3, then number 5, then number 4, then number 6, and so on. First, wash the downwind insulator to prevent overspray from landing on the unwashed insulator. If the wash procedure was started at insulator number 5 or number 6, overspray caused by washing may be carried by the wind and fall onto insulator number 4 or number 3 possibly resulting in a flashover.

B. Decide on the starting point for washing insulators in a station just before starting the wash. Changing wind conditions can require a new starting point at any time before or during the wash. It is not uncommon for a crew, having washed a few insulators at one end of a station, to reposition and start washing at the other end of the station due to wind shifts.

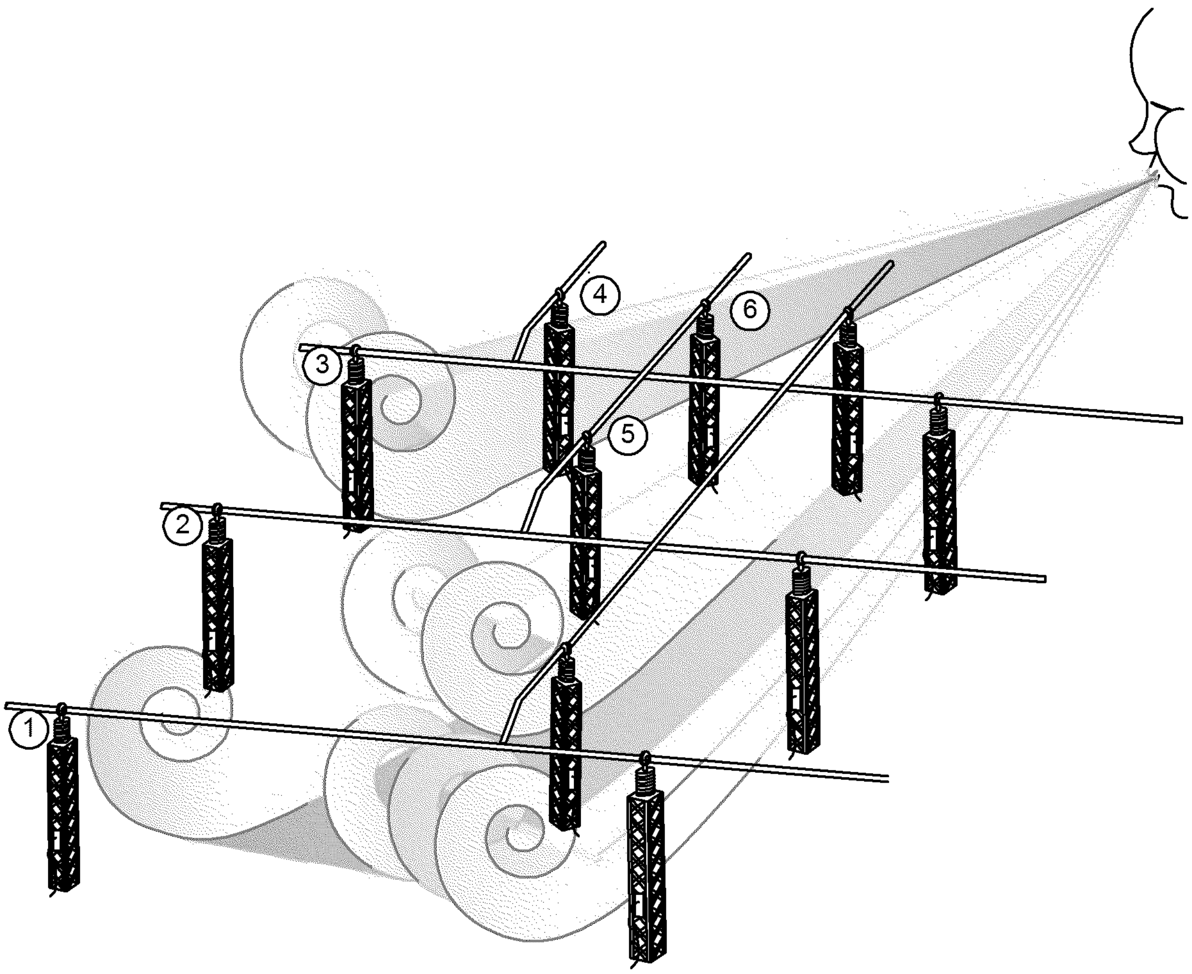

Figure 5-3
Where to Start the Station Wash

5.9. Nozzle Positioning

A. The positioning of cleaning employees is critical to effectively wash insulators and reduce the risk of flashovers. The cleaning employees must be positioned to:

- Direct the water stream on the entire insulator surface with an unobstructed path.
- Achieve adequate water stream impact on the insulator surface.
- Move the water stream to an adjacent insulator if arcing should occur.

B. Do not brush against steel towers, etc., while operating the spray gun nozzle.

C. For insulators mounted on low-profile buses, wash from the ground without obstructions between the water stream and the insulator surface. When the complete insulator surface cannot be impacted by the water stream from the ground, wash from an elevated position to effectively impact all insulator surfaces.

D. When washing insulators on tower structures, position the wash truck with the bucket elevated to enable washing in an unobstructed path as close as possible to the minimum stream-length distance. This creates adequate water stream impact on the insulator surface.

E. The climbing position to wash insulators on energized equipment can be used on all voltages up to and including 500 kV when access does not allow using aerial equipment. A complete guide to safely washing insulators from supporting structures can be found in Section 4, "Transmission Line Washing Requirements and Techniques." Make sure the hoisting ropes, hoses, and other equipment do not exceed the minimum approach and working distances to conductors.

F. If necessary, use a combination of wash positions, such as one employee in an aerial lift truck and another on the ground. This can become necessary when washing bushings installed on transformers.

5.9.1. Using Two Nozzles

A. When using two water streams, the nozzle operators **must** always stay synchronized. If they are out of synchronization, the two water streams may oppose each another, eliminating any swirling action and possibly flooding the insulator. Flooding the insulator with dirty water results in insulator failure and subsequent flashover. Two nozzle operators can wash effectively by using the following procedure.

1. On the signal of the lead nozzle operator, fire each wash gun near the insulator without hitting it, to allow the pump to come up to full pressure. Watch out for overspray. Anticipate where the water stream will land before directing it at the insulator.
2. Once full pressure is obtained, the lead nozzle operator should aim at the bottom right side of his or her stack. Positioned opposite as described in Step B. on Page 5-13, the secondary nozzle operator will immediately follow and aim at the bottom right side of his or her position. As the lead nozzle operator starts washing up the insulator, the secondary nozzle operator must follow in unison.

B. Nozzle positioning, when washing with two hose-streams, is very important. Use the well-established, 180° offset as the best practice and most effective position to ensure the contaminants are removed. It is critical to be as close to 180° on all types of post insulators, regardless of the skirt design.

C. Due to obstructions, both aloft and on the ground, the 180° displacement is not always possible to obtain. Instances may occur where nozzle operators need to position themselves at angles other than 180° to avoid overspraying unwashed insulators. However, angles other than 180° may leave a conductive path on the surface of the insulator. In all cases, obtain positions fully opposite one another as much as possible, **unless** overspray results in a hazardous situation.

D. In Figure 5-4 below, the two nozzle operators have stayed just to the right of the vertical centerline of the post-type insulator. Staying together and moving nozzles up and down the insulator produces a slight, swirling effect carrying water around the insulator.

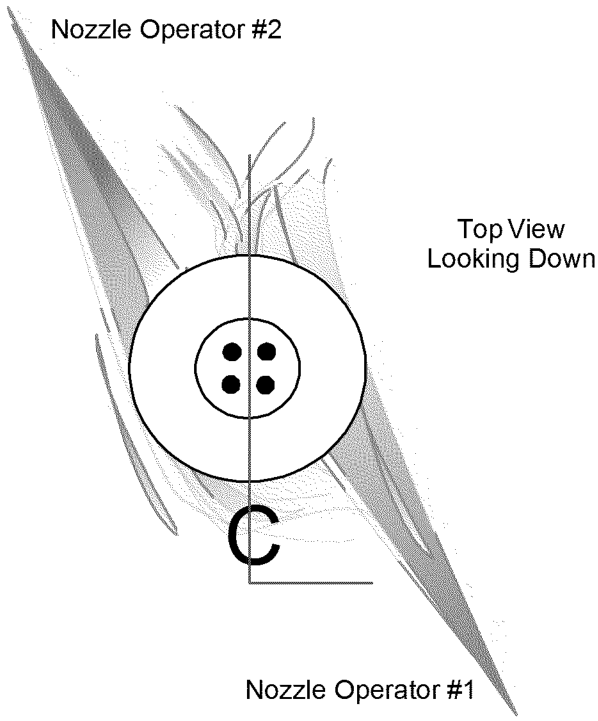

Figure 5-4
Proper Nozzle Displacement

E. In Figure 5-5 below, the nozzles are positioned approximately 100° apart. Using this displacement may leave contamination on the surface providing a conductive path to ground. If, due to obstructions and overspray, it is necessary to wash from these angles, backwash immediately to remove all contaminants.

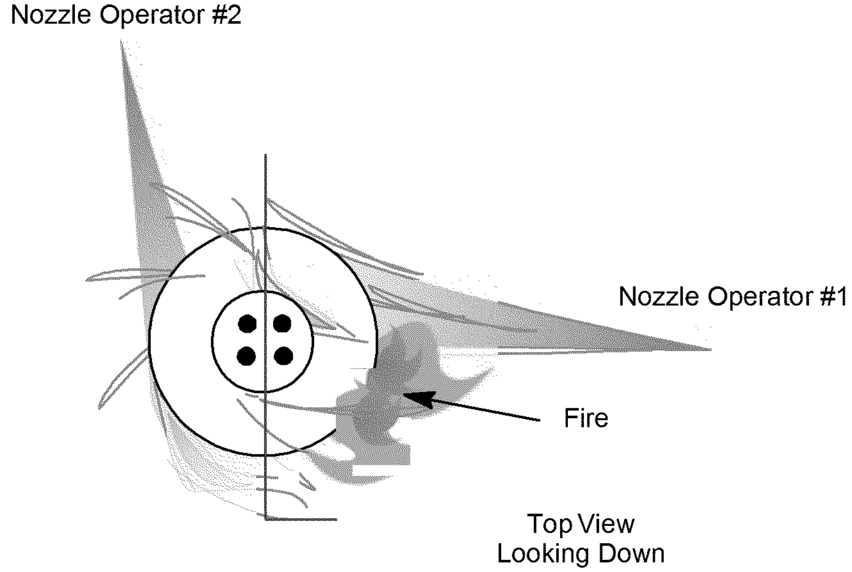

Figure 5-5
Improper Nozzle Displacement

5.9.2. Nozzle Angle

A. Make sure that the impact of the water stream cleans all surfaces of the insulator including the top of the skirts, the underside of the skirts, and the neck area between the skirts. If the angle is too great, large areas of contamination will be left. As with nozzle displacement, the optimum angle is not always achievable. On vertically-mounted post-type, cap-and-pin type, and string-bell insulators, the optimum angle is to aim up at 30° to 60° in relation to the insulator.

B. Figure 5-6 below demonstrates the optimum angle to ensure that the underside and neck-surface areas of the insulator are thoroughly cleaned.

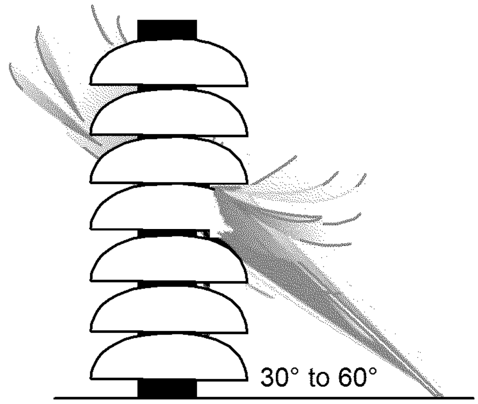

Figure 5-6
Nozzle Angle: Most Effective

C. In Figure 5-7 below, the angle is too great. The water stream catches the outside edge of each skirt or bell but does not fully impact the center of the insulator. This moistens the contamination but does not thoroughly clean the insulator.

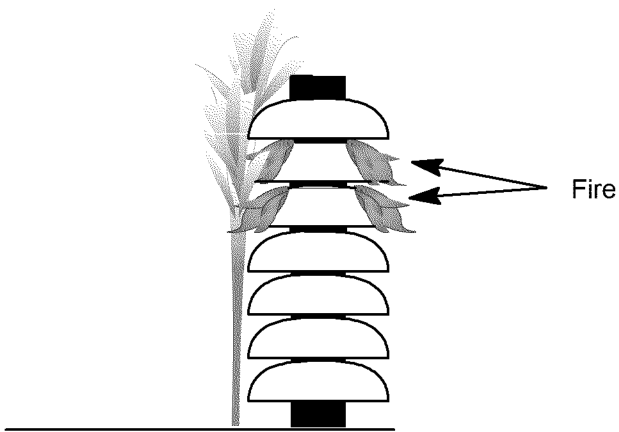

Figure 5-7
Nozzle Angle: Too Severe

D. In Figure 5-8 below, the angle of the water stream is nearly perpendicular to the insulator. While this is not the optimum angle, this angle is often the result of washing low-profile equipment or while elevated in an aerial lift truck. This angle cleans the insulator, but may not effectively clean the underside of the skirts and the neck area of the stack. Use a thorough wash and backwash when washing at these angles to ensure all contaminants are removed.

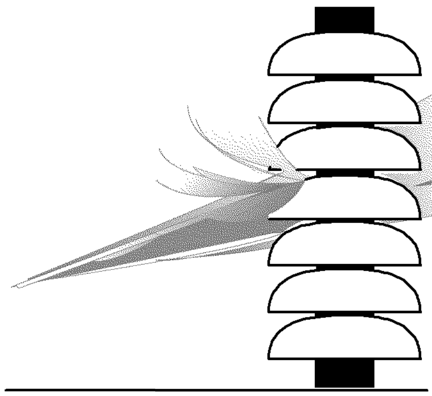

Figure 5-8
Nozzle Angle: Alternative

5.10. Washing in Sections

Divide insulators energized at 115 kV and above into sections and wash according to their voltage level.

5.10.1. Washing Vertical Insulators

A. Whenever practical, divide each post-type and set of string-bells into sections, regardless of mechanical breaks or joints as outlined below. (See Figure 5-9 on Page 5-17.)

1. Wash 70 kV and below in one section.
2. Wash 115 kV in two sections.
3. Wash 230 kV in three sections (thirds).
4. Wash 500 kV in five sections (fifths).

B. "Wash up" and "rinse down" vertically-mounted post-type and string-bell insulators in stages, depending on the voltage level, to remove contamination from the lower sections before washing to the top of the insulator.

C. Wash and rinse vertically-mounted cap-and-pin insulators, regardless of voltage, one insulator at a time and not necessarily in sections as required with post-type insulators. Remove contamination from the lower insulator before moving up to the next insulator.

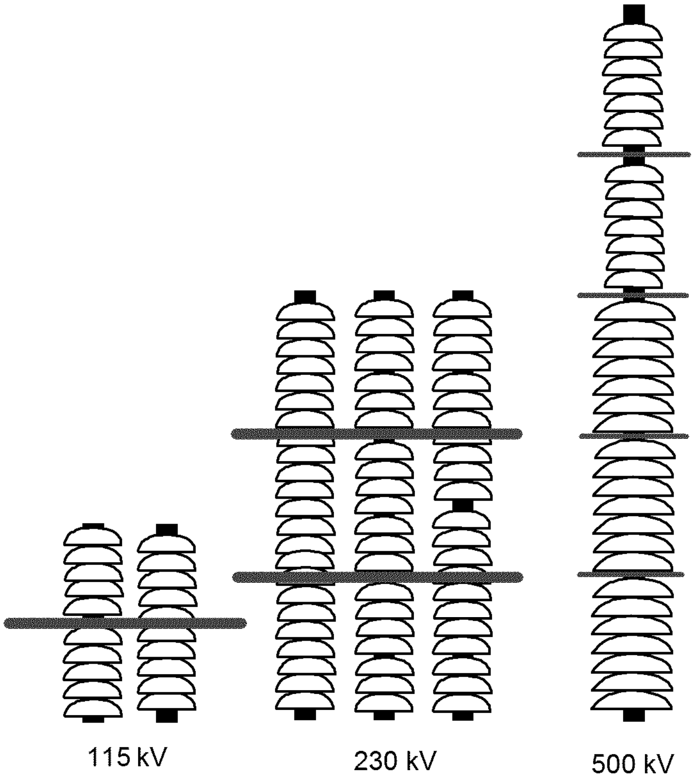

Figure 5-9
Post Insulator Vertical Sections

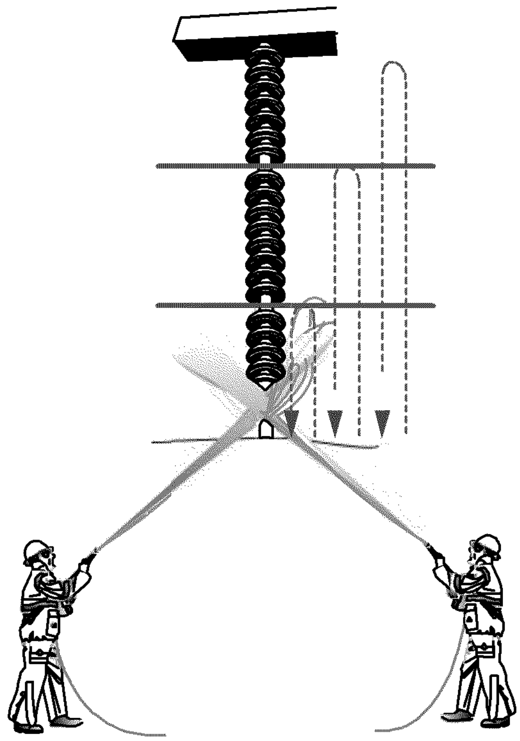

Figure 5-10
Washing in Sections

5.10.2. Washing Vertical Post-Type and String-Type Insulators

A. Always start washing vertically-mounted insulators from the bottom for both top-mount and under-hung installations.

B. Wash vertical post-type insulators and string-type bells in sections from the bottom depending on the voltage level.

C. Figure 5-10 above shows a post-type insulator energized at 230 kV. Start at the bottom of the post and slowly wash upward one-third the length. Then, rinse down to the bottom. Next, wash two-thirds the length and rinse back to the bottom. Then, wash all the way to the top followed by a thorough rinsing along the entire length to the bottom.

D. Observe the equipment below as runoff may contaminate equipment and cause a flashover.

5.10.2.1. Mounted at the Bottom

When washing energized insulators mounted at the bottom, begin at the bottom and wash up toward the conductor or bus. (See Figure 5-11 below.)

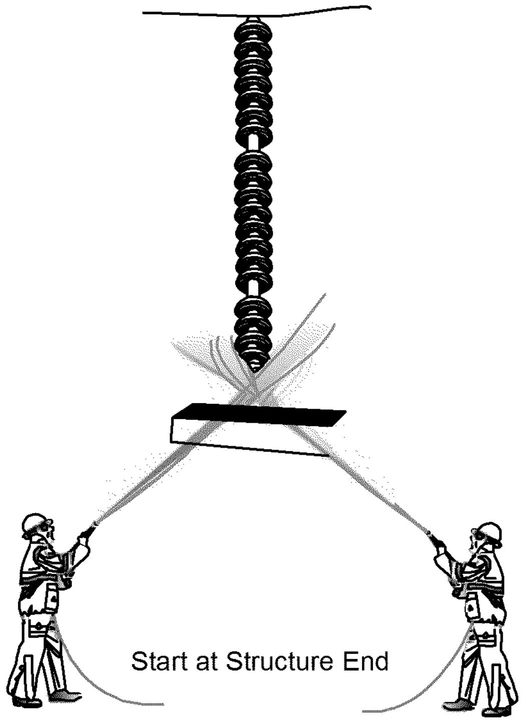

Figure 5-11
Conductor at the Top

5.10.2.2. Mounted at the Top

When washing energized insulators mounted at the top, begin at the bottom and wash up toward the supporting structure. (See Figure 5-12 below.)

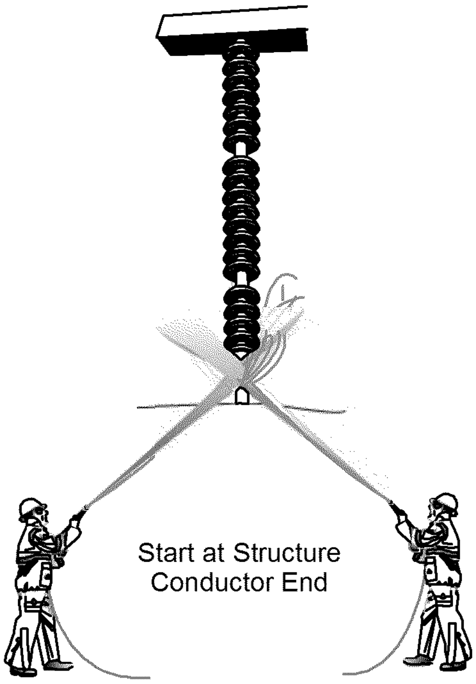

Figure 5-12
Conductor at the Bottom

5.10.3. Washing Horizontal Insulators

A. Divide each post-type insulator into sections as outlined below, regardless of the mechanical breaks or joints. (See Figure 5-13 below.)

1. Wash 70 kV and below in one section.
2. Wash 115 kV in two sections.
3. Wash 230 kV in three sections (thirds).

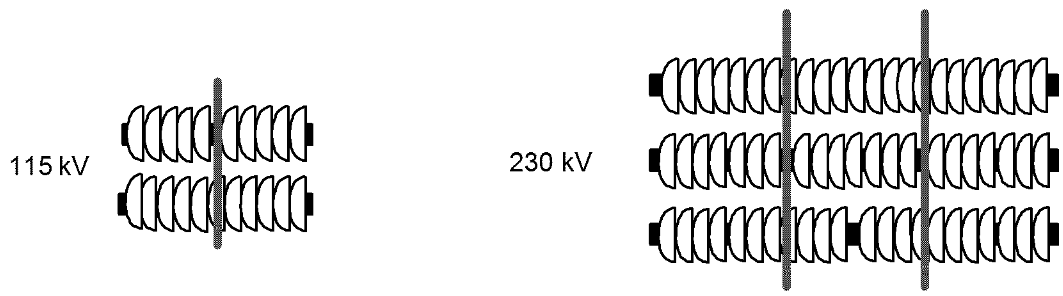

Figure 5-13
Post Insulator Horizontal Sections

B. Wash and rinse horizontally-mounted cap-and-pin insulators one insulator at a time. Remove contamination from the first insulator before moving to the next insulator.

C. During an energized wash, horizontally-mounted post insulators and string-bells are less susceptible to flashover than vertical insulators. Wash and rinse them in sections as shown in Figure 5-13 on Page 5-20.

5.10.4. Washing Horizontal Insulators, Bushings, and String-Bells

A. Wash horizontal insulators, bushings, and string-bells using either one or two water streams directed at the proper angle, off to one side. Wash slowly in one direction and then, rinse back along the same section.

B. Figure 5-14 below shows the washing of a horizontally-mounted post-type insulator energized at 230 kV.

1. Start the wash at the right side, wash to the left **one skirt at a time**, wash one-third of the distance, and then, rinse back to the start.
2. Rewash the first third and then, **wash the second third one skirt at a time**. Repeat the rinse to the right, all the way to the base.
3. Finish by rewashing the first two thirds and **then washing the final section one skirt at a time**. Rinse the entire insulator back to the right, finishing at the base. The entire process should take several seconds depending on the level of contamination.

C. Be cautious with equipment, such as breakers and switches located below the insulator, that are subjected to dripping water. Rinse this equipment if necessary.

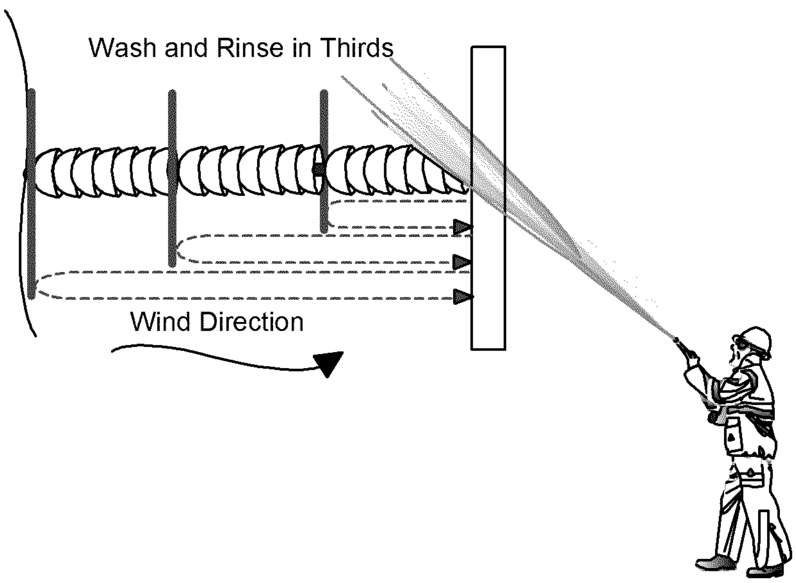

Figure 5-14
Washing Horizontal Sections

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5.10.5. Starting Point for Washing Horizontal Insulators

A. For **all** horizontally-mounted insulators, start washing at the end to limit the amount of water spray hitting the unwashed portion of the insulator. Wind velocity and direction, physical obstructions, and employee accessibility determine the starting point.

B. Figure 5-15 below shows the nozzle operator starting at the structure and working towards the conductor. The wind is blowing left to right so the overspray will not fall on the unwashed section of the insulator.

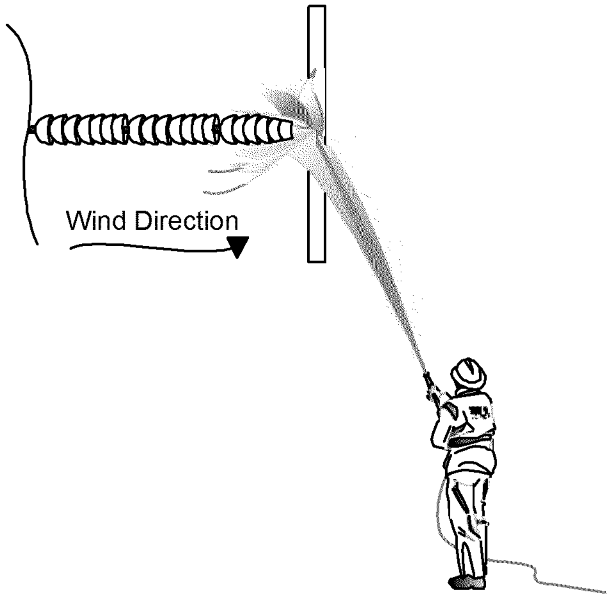

Figure 5-15
Horizontal Washing: Where to Start #1

C. In Figure 5-16 below, the nozzle operator starts at the conductor end of the insulator and works back toward the structure. The wind is blowing right to left so the overspray will not fall on the unwashed section of the insulator.

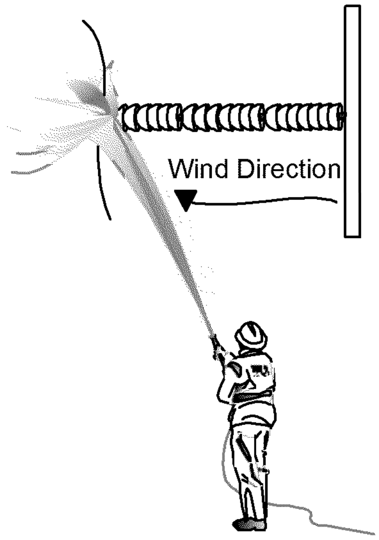

Figure 5-16
Horizontal Washing: Where to Start #2

5.11. Washing Patterns

5.11.1. Introduction

A. The "straight" and "box" washing patterns used with a sweeping action ensure that the water stream impacts more insulator surface and thereby effectively removes contamination. (See Section 5.11.4., "Sweeping Action," on Page 5-26 for more information.)

B. Use the following sequence to wash one insulator:

1. Wash the insulator from the bottom to the top (in sections, if required) to remove heavy contamination.
2. Without stopping, continue to wash and rinse the insulator a second time from the bottom to the top. Add the sweeping action at this second pass.
3. Reposition the nozzles 90° perpendicular to the starting position to prepare for a backwash.
4. Backwash the insulator from the bottom to the top, using the box or straight pattern while adding the sweeping action.

C. Evaluate each situation individually. If necessary, wash a few insulators or bushings from one position before repositioning for the backwash. (See Section 5.7., "Backwash," on Page 5-9 for more details.)

5.11.2. Straight Pattern

A. The straight method uses an up-and-down pattern to wash and rinse the insulator. This method includes a backwash and may take several seconds to complete.

B. Use one style of the straight method to wash a single-segment, 60-kV to 70-kV insulator. (See Figure 5-17 below.)

1. Start at the bottom of the insulator and wash up along the length (direction 1). Then, rinse back down the length (direction 2).
2. Next, wash across the bottom (direction 3).
3. Wash up the left side all the way to the top (direction 4). Then, rinse back down the left side to the bottom (direction 5).
4. Finish by rinsing from the bottom to the top and down again. Add a sweeping action to thoroughly remove all contaminants.

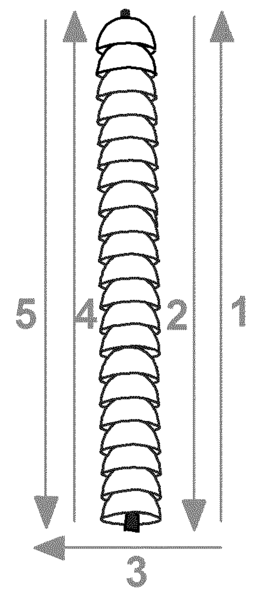

Figure 5-17
Straight Wash Pattern

5.11.3. Box Pattern

A. Use the box washing pattern on all vertically-mounted, post-type insulators and bushings. Similar to the straight pattern, use this pattern when washing in sections to remove the contaminants from the lower sections before moving up the stack. Figure 5-18 below shows the box pattern for a 230-kV, post-type insulator. The insulator is divided into three sections, regardless of mechanical breaks.

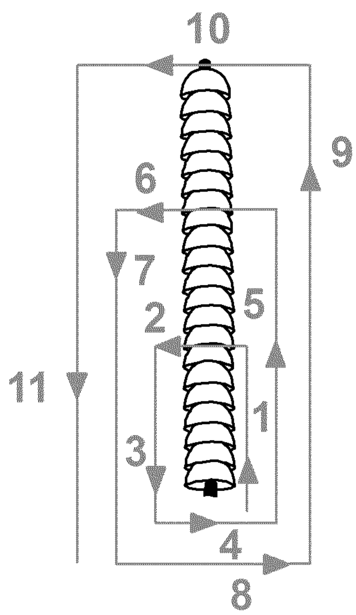

Figure 5-18
Box Wash Pattern

B. Complete the first pass by washing in the shape of three boxes as follows.

1. Start at the bottom right. Move the hose stream up the right side, washing one-third (direction 1). Move left (direction 2). Move down the left side (direction 3). Move across at the base (direction 4). The first box is completed.
2. Wash up the right side two-thirds (direction 5). Move left (direction 6). Move back down the left side to the bottom (direction 7). Wash back across to the right (direction 8). The second box is completed.
3. Continue to wash up the right side all the way to the top (direction 9). Wash across the top (direction 10). Wash back down the left side (direction 11) to the bottom. The third box is completed.
4. Immediately start rinsing from the bottom to the top and back down in one section, adding a sweeping action as described in Section 5.11.4., "Sweeping Action," on Page 5-26.
5. Reposition and complete a backwash from an angle perpendicular to the previous position.

5.11.4. Sweeping Action

Move the hose stream in a sweeping, back-and-forth motion across the insulator, on the second pass, to effectively remove contamination. (See Figure 5-19 below.)

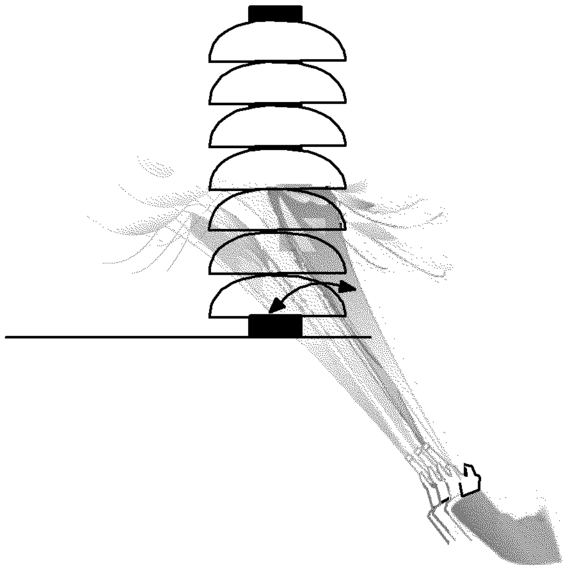

Figure 5-19
Sweeping Action

5.12. Flashovers and Arcs

A. If an arc develops on an insulator or bushing while being washed, continue to wash. Saturate the arc with as much water as possible, sweeping the arc away from the supporting structure or conductor. After extinguishing the arc, stop the wash. The crew foreman will determine if it is safe to proceed with the energized washing.

B. If the arc cannot be extinguished and a flashover occurs, keep the wash stream directed at the arc. The wash stream has a cooling effect and minimizes damage to the equipment.

5.13. Effective Insulator Cleaning

Effective insulator cleaning results in the following:

A. Visibly Clean Surface

The surface condition of the top and bottom of the insulator skirts are visually clean and shiny after the water has dried. Use binoculars to inspect, if necessary.

B. Insulator Vibration

The impact of high-pressure washing results in a vibration or ringing sound.

C. Absence of Arcing or Tracking

Leakage current discharges are not present.

D. Clarity of Runoff

The clarity of the water runoff may indicate the effectiveness of contamination removal. However, the clarity of the water runoff may be difficult to observe due to distance, wearing shaded safety glasses, etc.

E. Removal of Contaminants

On horizontal insulators, observe the drip point or the bottom side of the insulators. On vertical insulators, observe the backside of the insulators, opposite the point of impact of the water stream to see if contamination has been removed or just moved to another side.

Washing Tailboard Check-Off Sheet

The purpose of the "Washing Tailboard Check-Off Sheet" is to assist the electric maintenance crew leader and washing crew in discussing key issues before starting the insulator wash in substations. Be sure to list and discuss other specific issues, situations, and obstacles not included in this sheet.

For more information, see the *Insulator Cleaning Manual* and the *Code of Safe Practices* (CSP). Mark the check box next to each item as the discussion is completed.

File this check-off sheet at the maintenance headquarters.

Electric Maintenance Crew Leader: Date:

Station:

Switching Center:

Wash Crew Members		Wash Assignment
1		
2		
3		
4		
5		
6		

STATION WALK-DOWN BEFORE THE WASH

ff Checked

- ☐ Determine the wind speed and direction. Is it changing? Is it too strong to wash safely?
- ☐ Check for broken or cracked insulators.
- ☐ Check for lightning arrestors with open vents.
- ☐ Check for fuse disconnects and switch blades that may become dislodged during washing.
- ☐ Identify any obstructions (i.e., tripping hazards, etc.) in the path of equipment and workers.
- ☐ Determine nozzle positioning during the wash (i.e., from the ground, bucket, structure, or combination). What is the best position to conduct an effective wash?
- ☐ Determine the minimum approach and working distances as outlined in *CSP* Rule 809.
- ☐ Determine the minimum and maximum stream-length distances as outlined in the *Insulator Cleaning Manual*.
- ☐ Identify equipment requiring two hose streams for energized washing.
- ☐ Check for RG insulators and their proximity to the wash.
- ☐ Identify equipment and insulators that require two hose streams or ***must*** be de-energized to clean.
  - ☐ Bushings
  - ☐ Capacitive coupled devices
  - ☐ Potential transformers
  - ☐ Post-type insulators
  - ☐ Lightning arrestors
  - ☐ Vacuum circuit breaker vents
  - ☐ Vertical break switches with stacks mounted close together

Wash Truck and Equipment

(Check at the start of the wash day.)

ff Checked

- ☐ Complete the Truck Check-Off Sheet as required for all CA509 vehicles.
- ☐ Check the fuel, oil, and fluid levels in the truck and pump motors.
- ☐ Ensure that all communication devices, such as bucket-to-cab communications gear, bull horns, etc., work properly.
- ☐ Ensure that the nozzle(s) pressures are properly set and manual or automatic controls are functioning.
- ☐ Ensure that a gun valve rebuild kit and nozzle replacement are available on the truck.
- ☐ Check hoses for any frayed or bulging outer jackets.
- ☐ Review the truck control operation.
- ☐ Review the Azimuth (rotational) controls. Lock them out as applicable.
- ☐ Ensure that the bucket truck stiff-legs (outriggers) are operational.
- ☐ Check for any hydraulic leaks.

Safe, Effective Washing Techniques

ff Checked

- ☐ While washing energized equipment, do not stand on the switch platforms or contact metal objects when operating the nozzle, unless the nozzle is bonded to the object.
- ☐ Discuss the appropriate actions (e.g., extinguishing, restoration, notification, etc.) in case of a flashover.
- ☐ Discuss working as close as possible to 180 ° apart when using two hose streams.
- ☐ Discuss striking the insulator between 30° to 60° with the hose stream(s) to effectively clean the underside of the skirts and center post.
- ☐ Discuss using the appropriate washing patterns and techniques.
- ☐ Discuss positioning the nozzles as close to possible to the minimum stream-length distances without exceeding the maximum stream-length distances.
- ☐ Check the water resistance.
- ☐ Ensure that all employees use personal protective equipment as outlined in Section 2.4., "Personal Protective Equipment (PPE) Requirements," on Page 2-1 of the *Insulator Cleaning Manual.*

☐ Additional topics: ____________________

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