ADVANCED LIVE-LINE INSULATOR WASHING SYSTEM

DESIGNED TO EFFICIENTLY CLEAN POLLUTED GLASS, CERAMIC, COMPOSITE, AND RTV-COATED INSULATORS ON CRITICAL MV, HV, EHV, AND HVDC T&D INFRASTRUCTURES - POWER LINES - POWER PLANTS, AND DISTRIBUTION SUBSTATIONS - **POWER TRANSFORMER BAYS** - GANTRIES

PREVENTIVE MAINTENANCE OF POWER TRANSFORMER BAYS AFFECTED BY:

SALINITY - SAND DUST - COOLING TOWER EFFLUENT - CEMENT - LIME – ORGANIC SMOKE CHEMICAL INDUSTRIAL - AGRICULTURAL - SMOG (VEHICULAR EMISSION) COAL DUST - METALLIC PARTICLES – OTHERS

WITHOUT POWER OUTAGE

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1. OVERVIEW

1.1 Introduction to Automated Washing System (AWS) and Mobile Pumping Station (MPS)

Automated Washing System (AWS) and Mobile Pumping Station (MPS): A Revolutionary Solution for Cleaning Polluted Insulators on Power Transformer Bays, **eliminating** yearly days/weeks of **POWER OUTAGES**.

Conventionally, cleaning polluted insulators on **Power Transformer bays** was a laborious, time-consuming undertaking with substantial budgetary constraints. The introduction of Mobile Pumping Stations (MPS) coupled with an Automated Washing System (AWS) has transformed the maintenance process for polluted insulators, substantially lowering maintenance expenses and offering a more efficient, cost-effective, and safer alternative.

The scope of this paper is to document the Wilorton Advanced Automated Jet Washing System (AWS) with Mobile Pumping Station (MPS) for cleaning polluted insulators on **Multiple Power Transformer Bays.**

The Mobile Pumping Station (MPS) is engineered to provide a reliable and efficient solution. It is valuable for serving multiple Automated Washing Systems (AWS) pre-installed in different locations.

Users can efficiently and effectively wash an entire insulator network with one pumper truck driver and one service operator.

Utilities and Maintenance Companies can benefit from this innovative, cost-saving solution for providing preventive maintenance services and eliminating **Power Outages**.

A single investment in cleaning polluted insulators mounted on multiple locations, such as:

- **GIS/AIS Power Plants and Distribution Substations.**
- **Switchyards, Gantries, and Power Transformers.**

Wilorton is a leading provider of innovative cleaning solutions for the T&D power lines, power plants, distribution substations, gantries, and power transformers polluted insulators' washing systems - **WITHOUT POWER OUTAGES** -

The MPS-AWS system has advanced features, such as high-pressure automated nozzle control and a touch-screen control panel, making it easy to operate and maintain.

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1.2 Scope:

Identifying a user's seasonally adjusted preventive Live Line maintenance program to resolve polluted insulator maintenance WITHOUT A POWER OUTAGE for Nos. 8 **485 MVA Steam Turbine Generator Transformer bays.**

Saving time, maintenance budget money, days and weeks of yearly POWER OUTAGES, Labor costs, and repair time.

1.2.1. Key Benefits of Automated Washing Systems (AWS) and Mobile Pumping Stations (MPS)

Power leakages and polluted insulator flashovers are multi-million-dollar problems. They are known to outstrip maintenance budgets and T&D network efficiency.

The Automated Jet Washing System (AWS), with a Mobile Pumping Station (MPS) system, is designed to clean **polluted insulators on multiple power transformer bays**.

Eliminate	RTV Coatings, Hand Cleaning, Greasing, Loss of Production, and Revenue Losses.
Improve	Electricity Production, Distribution efficiency, and overall Network Reliability and CAIDI, CAIFI, SAIDI, and SAIFI Indexes.
Efficiency	Multiple insulators are cleaned simultaneously and in "**No Time**."
Staff	One MPS, **one** pumper truck **driver,** and **one serviceman** only.

MPS and AWS are designed to be reliable and robust, with built-in safety features. They can withstand harsh environments and ensure continuous operation, even in extreme weather conditions.

POWER OUTAGE IS NOT AN OPTION

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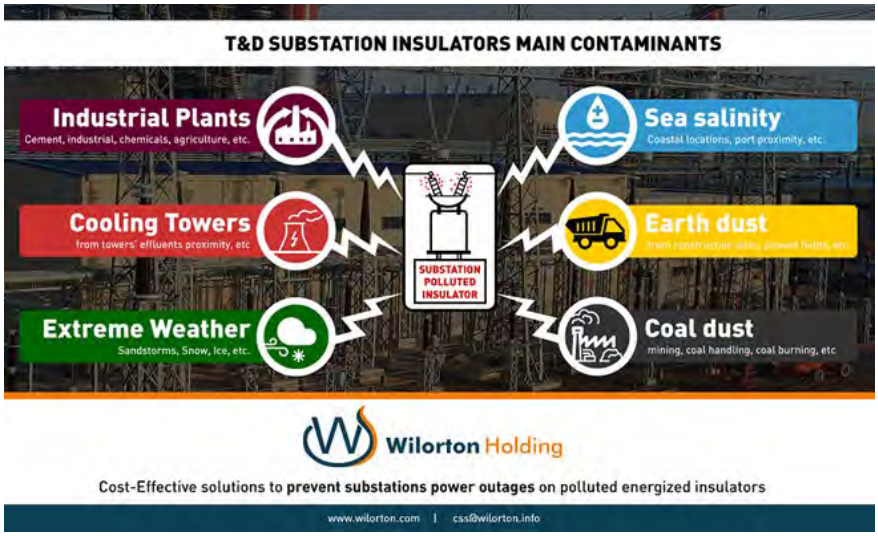
1.2.2. LIVE-LINE INSULATORS ADVANCED WASHING SYSTEM (AWS) INTRODUCTION:

Wilorton Advanced Washing System is a cutting-edge solution designed for live-line cleaning of contaminated insulators on critical medium-voltage, high-voltage, extra-high voltage, and high-voltage direct current transmission and distribution infrastructures. Live-line insulator jet washing facilities shall be installed on critical transmission and distribution (T&D) infrastructures located in climatic areas with high temperatures, humidity, dense fog, and a short rainy season that does not allow for natural washing, and dry weather periods followed by fog, mist, and light rain. The AWS is particularly suited for use in coastal and inland areas with climatic conditions characterized by dry periods followed by fog, mist, light rain, and proximity to contaminant sources.

THE AWS IS INSTALLABLE ON NEW AND OPERATIONAL INFRASTRUCTURE.

1.3. Sources and Type of Contaminants/Pollutants

- Salinity/Sand dust
- Cement/Lime/Organic/Smoke/Bird excrement
- Chemical/Industrial/Agricultural/Smog (Vehicular emission)
- Cooling tower effluent
- Metallic particles
- Others



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2. The Case Study: 485 MVA Steam Turbine Generator Transformer, OUTLINE

2.1 Case study location: Beni Suef Combined Cycle Power Plant (SIEMENS) / Egypt





CASE STUDY SOURCES AND TYPE OF CONTAMINANTS/POLLUTANTS: The degradation of insulators due to contamination by salt and cooling tower effluents is the primary cause of failures. These failures frequently occur during periods of high humidity or the onset of the rainy season.

2.2. Eight Bay - Equipment Summary:

Equipment Description	Quantity One Bay
485 MVA STEAM TURBINE GENERATOR TRANSFORMER BUSHINGS	3
485 MVA STEAM TURBINE GENERATOR TRANSFORMER SURGE ARRESTER	3
SF6 INSULATED VOLTAGE TRANSFORMERS	3

2.3. Power Transformer Bay - outline, general

The installation of the Wilorton AWS on multiple power transformer bays is relatively straightforward. The rigid pipeline and spray rings are installed at each bay's insulator base (TRAFO bushings, SA, SF6).

The Advanced Washing System (AWS) rigid piping system is divided into three (3) washing zones.

The MPS is completed with a 4 Cubic Meters (CM) storage tank, control panel, high-pressure water pump diesel engine driven, hose reel with a flexible hose, controls, etc. Three power transformer bays could be washed with a 4 CM water tank capacity before the refill.

With the water storage tank filled, the mobile washer is transported near the selected power transformer location to wash nos. 3 (three) transformer bushings, nos. 3 (three) SA insulators and nos. 3 (three) SF6, connecting the flexible hose to the rigid piping system connection point, available outside the bay's fence.

Once the flexible hose mounted on the mobile washer is connected to the quick coupler fixed to the rigid pipe manifold outside the transformer location fence, multiple insulators are simultaneously washed.

Three insulators are washed simultaneously: the water envelopes and swamps three insulators in one surge.

The pollutant type dictates water pressure and washing time. Actual parameters are fixed during test and commissioning activities, and the estimated **wash time for one bay location is approximately 5 minutes.**

Demineralized water with minimum permissible conductivity not exceeding 20 µS/cm (micro-Siemens per cm) is mandatory.

Wind speed may limit washing effectiveness. To avoid overspray, no washing activities shall be planned with wind speed above 25 Km/H. **Once the power transform bay washing activity is completed, the MPS moves to the next bay.**

2.4. AWS Operating conditions and maintenance requirements

- Wash effectiveness is limited by **wind speed**. High washing rates are achieved with calm or no-wind conditions. With **wind speed > 6/7m/s**, the washing operations should not be performed.

- Nozzle cleaning is unnecessary, as they will self-clean at the start of every washing cycle.
- Self-cleaning spray nozzles do not require maintenance throughout the life cycle.
- Spray nozzle misalignments: if spray nozzles are correctly installed, misalignments cannot occur. If, for any reason, a nozzle's misalignment is required, the operator should manually replace it with a new set.

- **Test with the Power Transformer's Bay de-energized**: The test procedure should be implemented to verify the installation correctness, spray nozzle alignment, and pipeline water leakages.

- **Commissioning, with the Power Transformer's Bay energized**: The commissioning procedure should be implemented. High-pressure demi-water is required. The demi-water will be pumped into the washing system pipeline, and the operator will open and close the circuit valves to perform the live line washing activities.

2.5 Washing water requirements:

Line voltage	Minimum nozzle-to-conductor distance	Minimum water resistivity	Minimum nozzle pressure	Maximum orifice diameter
(kV)	(m)	(Ω·cm)	(kPa)	(mm)
500	4.27	50 000	5516	6.35
500	6.10	3000	3792	7.94

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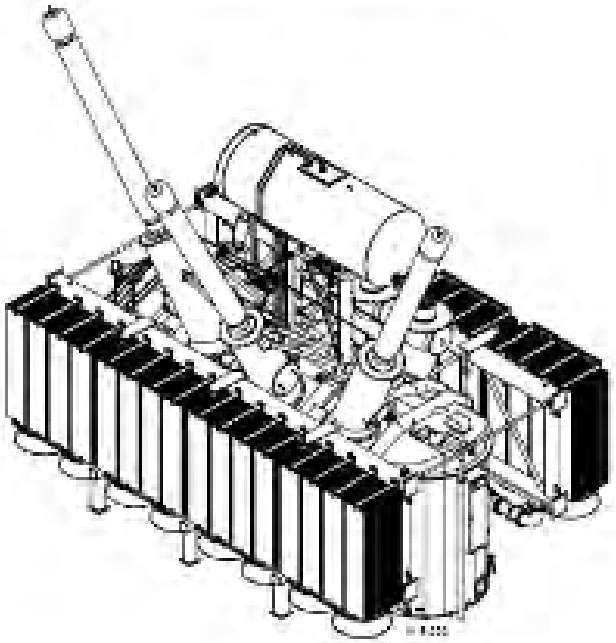
3. Insulator/Bushing types

3.1. 485 MVA STEAM TURBINE GENERATOR TRANSFORMER

SIEMENS

TECHNICAL DATA

485 MVA STEAM TURBINE GENERATOR TRANSFORMER



TRANSFORMER TYPE	
PROJECT No.	EG1018
PROJECT TITLE	BENI SUEF COMBINED CYCLE POWER PLANT
RATED POWER	485 MVA
RATED VOLTAGES	0 IG=9 X 1.25/22 kV
FREQUENCY	50 HZ
COOLING	ODAN/ODAF
TOTAL MASS	295 T
MASS OF OIL	97 T
MASS OF ACTIVE PARTS	175 T
ALTITUDE	MIN 1000 M
INSULATORS TYPE	HV TRANSFORMER BUSHING TYPE GOT 1550-4000
	HV NEUTRAL TRANSFORMER BUSHING TYPE GOT 250-1001
	LV TRANSFORMER BUSHING TYPE GOH 170-16

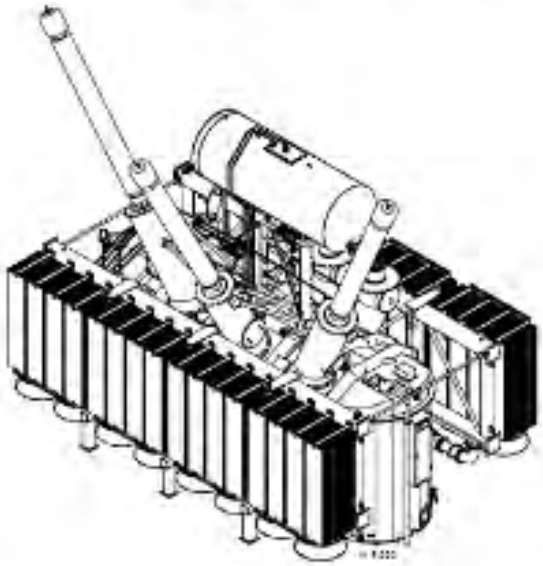
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3.2. Insulator/Bushing types: HV **BUSHING**

TRENCH

TECHNICAL DATA

485 MVA STEAM TURBINE GENERATOR TRANSFORMER
HV BUSHING



TYPE	
DESCRIPTION	OIL IMPREGNANT PAPER CONDENSER
PROJECT No.	EG1018
PROJECT TITLE	BENI SUEF COMBINED CYCLE POWER PLANT
HIGHEST VOLTAGE	550 kV
MAXIMUM PHASE	318 kV
FREQUENCY	50/60 HZ
RATED CURRENT	1000 A
ALTITUDE	MIN 1000 M

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3.3. Insulator/Bushing types: SURGE **ARRESTER**

SIEMENS

TECHNICAL DATA

485 MVA STEAM TURBINE GENERATOR TRANSFORMER
SURGE ARRESTER

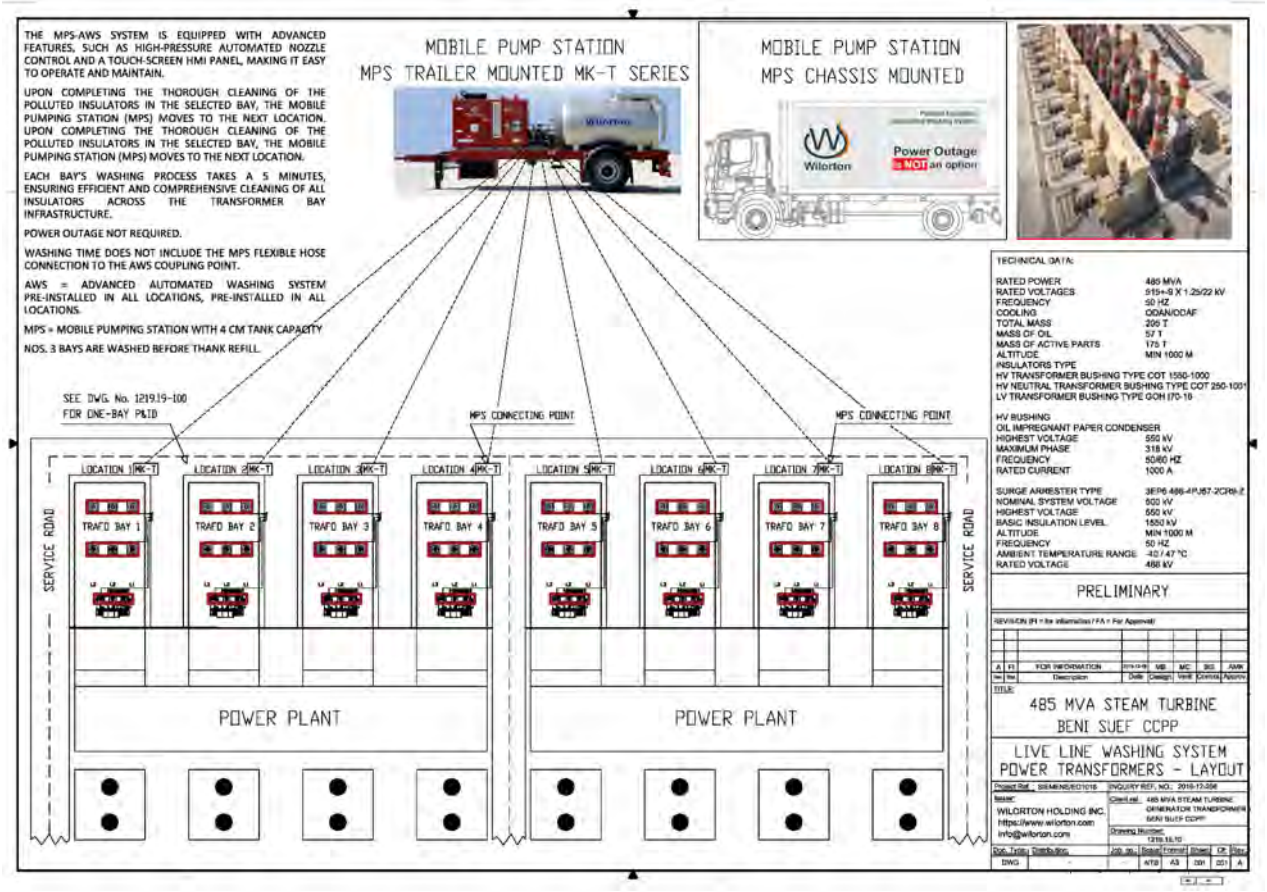


TYPE	
DESCRIPTION	3EP6 468-4PJ57-2CR3-Z
PROJECT No.	EG1018
PROJECT TITLE	BENI SUEF COMBINED CYCLE POWER PLANT
NOMINAL SYSTEM VOLTAGE	500 kV
HIGHEST VOLTAGE	550 kV
BASIC INSULATION LEVEL	1550 kV
ALTITUDE	MIN 1000 M
FREQUENCY	50 HZ
AMBIENT TEMPERATURE RANGE	-40 / 47 °C
RATED VOLTAGE	468 kV

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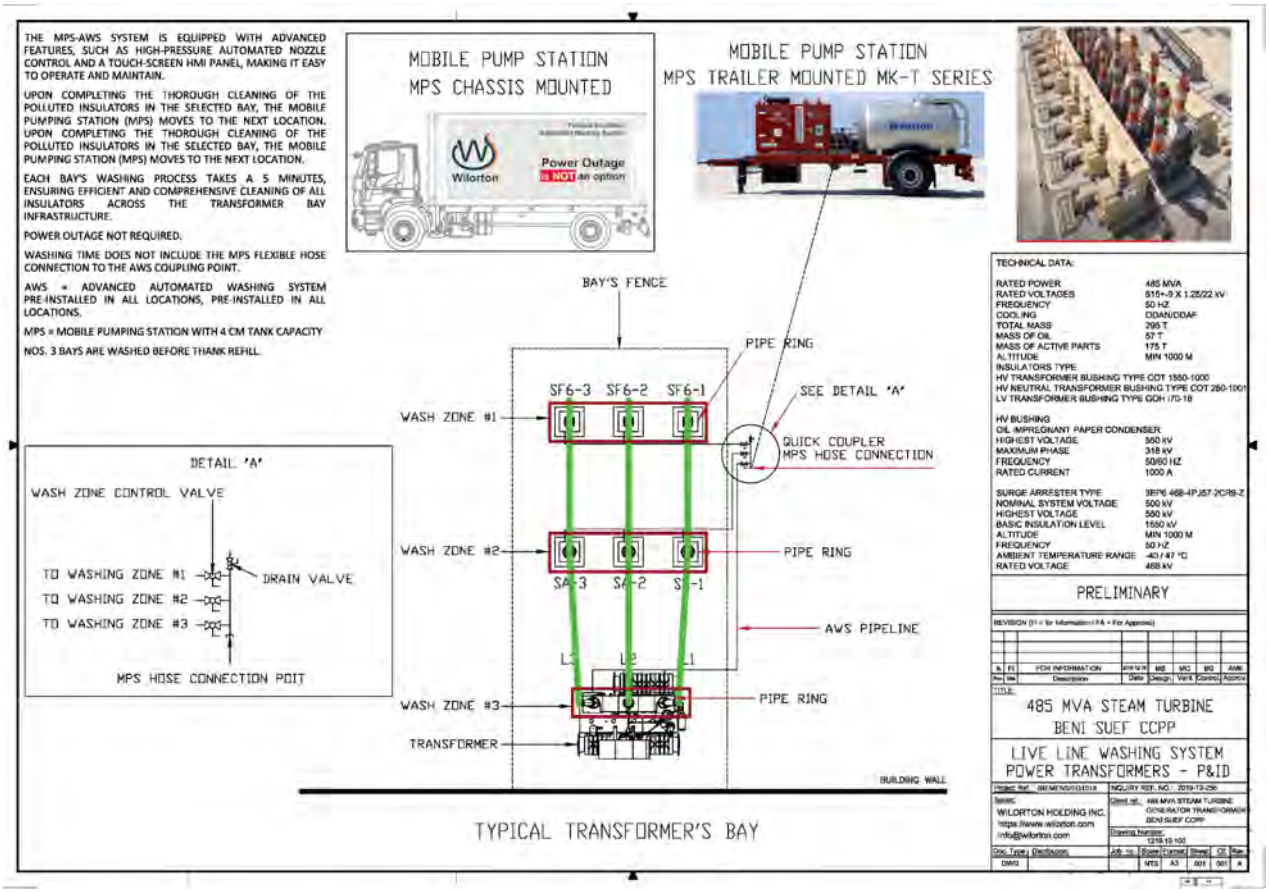
4.0. Multiple Power Transformer Bays - General Layout & P&ID

4.1. The Case Study Power Transformer Bay - LAYOUT -



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4.2. The Case Study Power Transformer Bay - P&ID - ONE BAY -



4.3. Mobile Pumping Station and AWS CONTROL SYSTEM

The Mobile Pumping Station washing system control settings are defined according to each location's environment and specific needs.

- The manual option is available on the **MPS-B** Series.
- The PLC-SCADA-HMI option is mounted on the **MPS-A** Series.

The **AWS** PLC can store customized parameters of multiple locations. The operator selects the required location through the HMI.

The **MPS-A** Control Panel includes a Siemens S7300 PLC CPU or higher and a TPXX00 Comfort - Siemens touch panel - HMI - (HMI touch screen 15" or higher).

- The **MPS-A** Series HMI allows the operator to start program steps by clicking buttons and viewing process data, set points, etc., on screen. Navigation buttons are available at the bottom of the screen to change from one screen picture to another.
- The **MPS-A** Series includes the wind speed and direction sensor (Anemometer), which detects the wind direction and speed. The Advanced Automated Washing System (**AWS**) is designed to provide an effective washing cycle without the danger of over-spraying in the wind up to 4/5 m/sec from any direction.

5.0. Savings and Efficiency

Eliminate	Days/Weeks of Outage, Materials, and Staffing Costs. RTV Coatings, Hand Cleaning, Greasing, Loss of Production, and Revenue Losses. Yearly - multi-year costly maintenance contracts award. Expensive mobile washer trucks, aerial platforms - telescopic booms, video cameras, etc., with very low washing efficiency. A single investment in cleaning polluted insulators in multiple locations.
Improve	Electricity Production. Infrastructure Distribution Efficiency. Overall Network Reliability. CAIDI, CAIFI, SAIDI, and SAIFI Indexes.
Efficiency	Multiple insulators are cleaned simultaneously and in "**No Time**".
Staff	One pumper truck driver and one serviceman only.
Convenient	A Mobile Pumping Station is an effective solution to wash polluted insulators installed in multiple locations and easily transported to different locations to perform insulator washing operations as needed.

Clean the polluted insulators as needed throughout the year

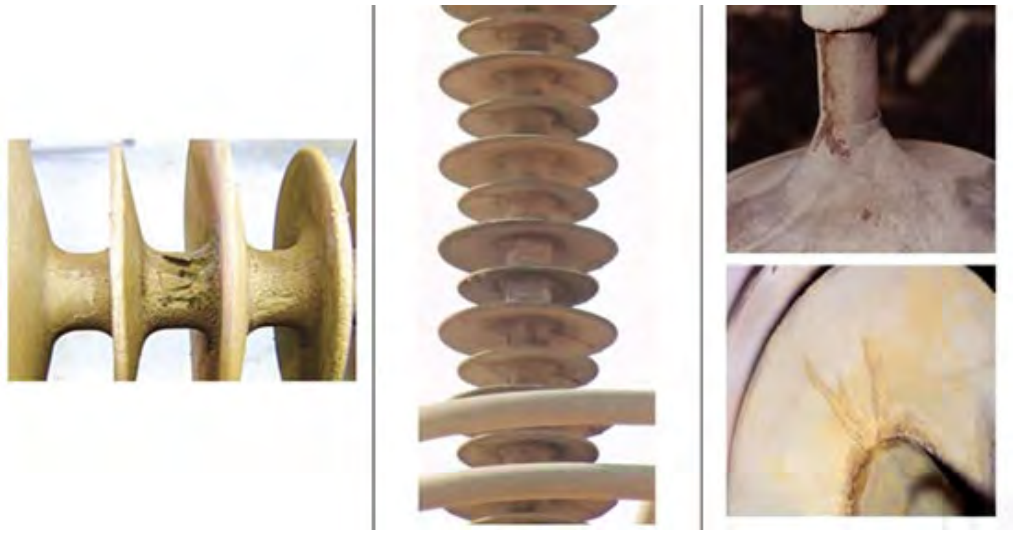
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6. BRIEF NOTE ON Polymer/Composite and RTV-Coated Insulators

The polymer/Composite and HVIC/RTV-Coated Insulators perform well in all areas where a "**Natural washing**" is in place.

Because contaminants settle in dry and relatively humid periods, the pollutant layer covers the surface of Polymer/Composite and HVIC/RTV-coated Insulation, voiding the hydrophobicity feature.

6.1 RTV Coated and Polymeric Insulators Failures Examples



FAILURE ON T/L POLYMER INSULATOR - Transmission and Dispatch Company (TRANSCO) United Arab Emirates

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6.2 AWS OPERATING CONDITIONS AND MAINTENANCE REQUIREMENTS - GENERAL:

Washing effectiveness is limited by wind speed. High washing rates are achieved with calm or no-wind conditions. Washing operations should not be performed with wind speeds > 5/7m/s.

Nozzle cleaning is unnecessary, as they will self-clean at the start of every washing cycle. Self-cleaning spray nozzles do not require maintenance throughout the life cycle.

Spray nozzle misalignments: with spray nozzles correctly installed, misalignments cannot occur. If, for If a nozzle's alignment is required, the operator should replace it with a new set.

After the installation, AWS Test with de-energized OHTL: Test procedure should be implemented to verify the installation's correctness, spray nozzle alignment, and pipeline water leakages.

Live Line AWS Commissioning: The commissioning procedure should be implemented. Demi-water is required and mandatory. Demi-water is pumped into the main pipeline, and the operator opens and closes the circuit valve to perform the live line washing activities.

AWS washing system preventive maintenance program is not required.
In case of extreme natural disasters, such as earthquakes, strong winds, etc., the operator should check whether the pipelines have suffered damage before starting the washing activities.

The life span of the AWS washing system: The Wilorton AWS does not include degradable components or sensitive to climatic conditions; its life cycle is theoretically indefinite and equivalent to the life span of the T&D infrastructures.

OVERCOMING THE CHALLENGES & COSTS OF POWER OUTAGES CAUSED BY POLLUTED INSULATORS, ELIMINATING RTV COATINGS, GREASING, HAND CLEANING, AND INEFFECTIVE AND OUTDATED COSTLY LIVE LINE MOBILE WASHING SYSTEMS.

PREVENTIVE MAINTENANCE HOLDS THE KEY TO ENERGY PRODUCTION IN ELIMINATING LOSSES OF	
POWER PRODUCTION	**REVENUE AND TURNOVER**
CURRENT LEAKAGES	**MANPOWER MOBILIZATION**
DAYS/WEEKS OF OUTAGES	**MATERIALS/CONSUMABLES**
THE BENEFITS OF ADVANCED WASHING SYSTEMS IN PREVENTIVE MAINTENANCE FOR ENERGY EFFICIENCY.	

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7. Normative References (Main Standard)

The following documents apply to the design of the Energized Insulators Manual Washing System. For dated references, only the edition cited applies. The latest edition of the referenced document
(including any amendments or corrigenda) applies for undated references.

- CEI 11-27 Edition IV - CEI EN 50110: Works on electrical plants (D. Lgs. 81/08) 2014 - Adjustment of the DL and DV distances to the CEI standard EN 50110-1.
- ESTI n. 407: Safety rules for works on high voltage overhead lines, Switzerland.
- EN 353/EN 361/EN 363: Part 1/Personal protective equipment against falls from a height Body harnesses/Fall arrest systems.
- IEC 60383-1 Insulators for overhead lines with a nominal voltage above 1000V Part 1: Ceramic or glass insulator units for AC systems–Definitions, test methods, and acceptance criteria.
- IEC 60383-2 Insulators for overhead lines with a nominal voltage above 1000V Part 2: Insulator strings and insulator set for AC systems–Definitions, test methods, and acceptance criteria.
- IEC 60433 Insulators for overhead lines with a nominal voltage above 1000V.
- Ceramic insulators for AC systems–Characteristics of insulator units of the long rod type.
- IEC 60479-2:1987, Effects of Current Passing Through the Human Body.2.
- IEC 60815 Guide for selecting insulators in polluted conditions.
- IEC 61467 Insulators for overhead lines with a nominal voltage above 1000V AC power arc tests on insulator sets.
- IEEE Std 4™-1995, IEEE Standard Techniques for High-Voltage Testing.3,4.
- IEEE Std 80™-2000, IEEE Guide for Safety in AC Substation Grounding.
- IEEE Std 516™-2003, IEEE Guide for Maintenance Methods on Energized Power Lines.
- IEEE Std 957-2005, Guide for cleaning insulators.
- IEEE Std 1048™-2003, IEEE Guide for Protective Grounding of Power Lines.
- IEEE 1523 IEEE Guide for Application, Maintenance, and Evaluation of Room Temperature Vulcanizing (RTV) Silicone Rubber Coatings for Outdoor Ceramic Insulators.

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