

Applicability of Factory Test Criteria to Diagnostics in the Field

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Requirements as of 2010

Factory Testing of Joints

By

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Background

- Joint standard, IEEE-404, and modular standard, IEEE-386, requires 100% testing of all
 - pre-molded push on and
 - cold shrink joints
- Two options for testing:
 - 1) PD and 1 minute AC withstand test or
 - 2) PD and BIL test (Basic Impulse Level)
- Requirements correspond to the voltage rating of the joint

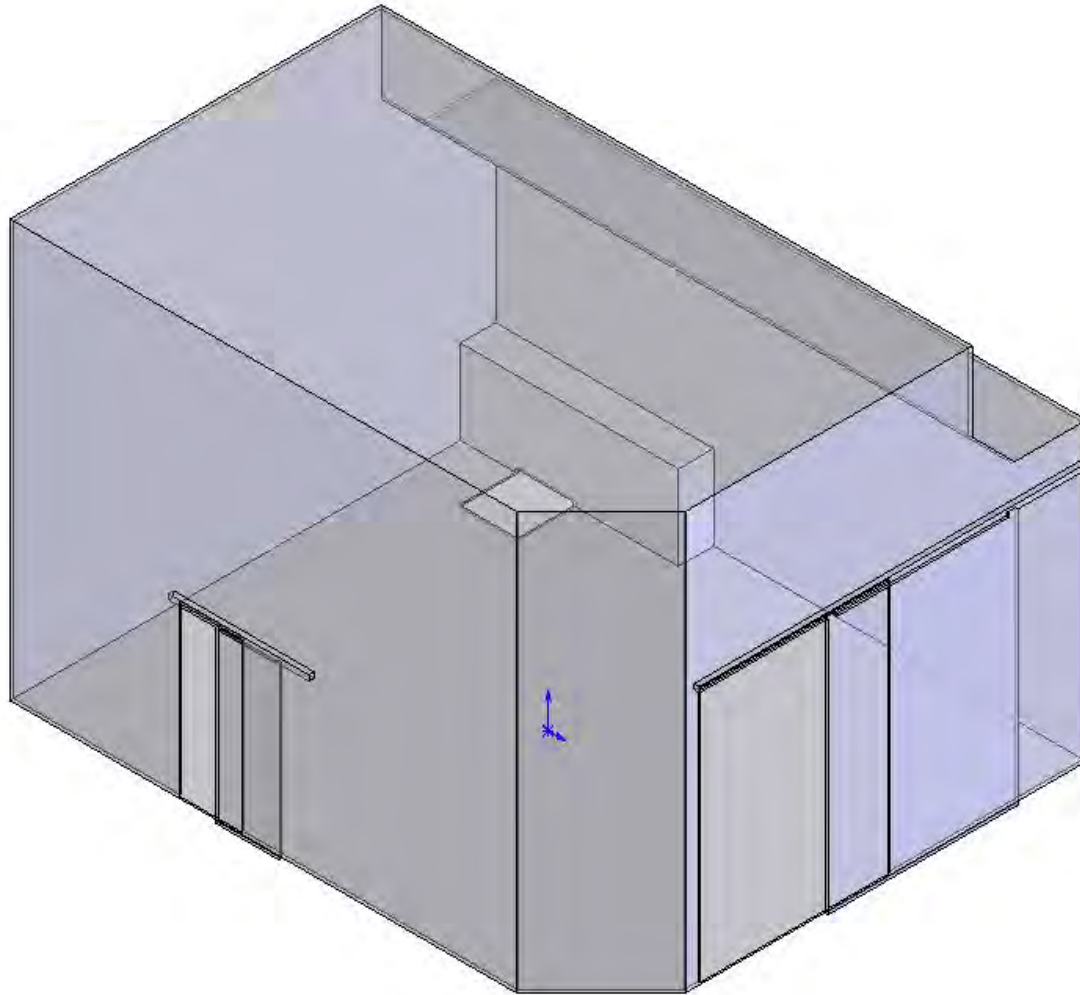
Items Critical for Factory PD Testing

- Items to consider
 - Shielding of test area
 - Grounding of test area and joints
 - Noise free AC source
- We'll now look at each of these areas in some detail

Shielding of Test Area

- Normally have a separate building
- Entire building is shielded
- Shielding mesh is calculated to keep outside noise from interfering with test
- Test requirement is the joint must have less than 5 pC of noise at 1.5 times the phase to ground voltage rating of the joint
- Typically noise levels without this shielding can be 10 to 50 times higher than the requirement

Test Cage



Grounding

- To minimize noise interference, an isolated ground is run for the test area
 - This keeps noise from ground grid from affecting the PD measurements
- Low impedance ground connections are required for the cage and all grounds to the joints
- Single ground point for all test equipment and tested objects

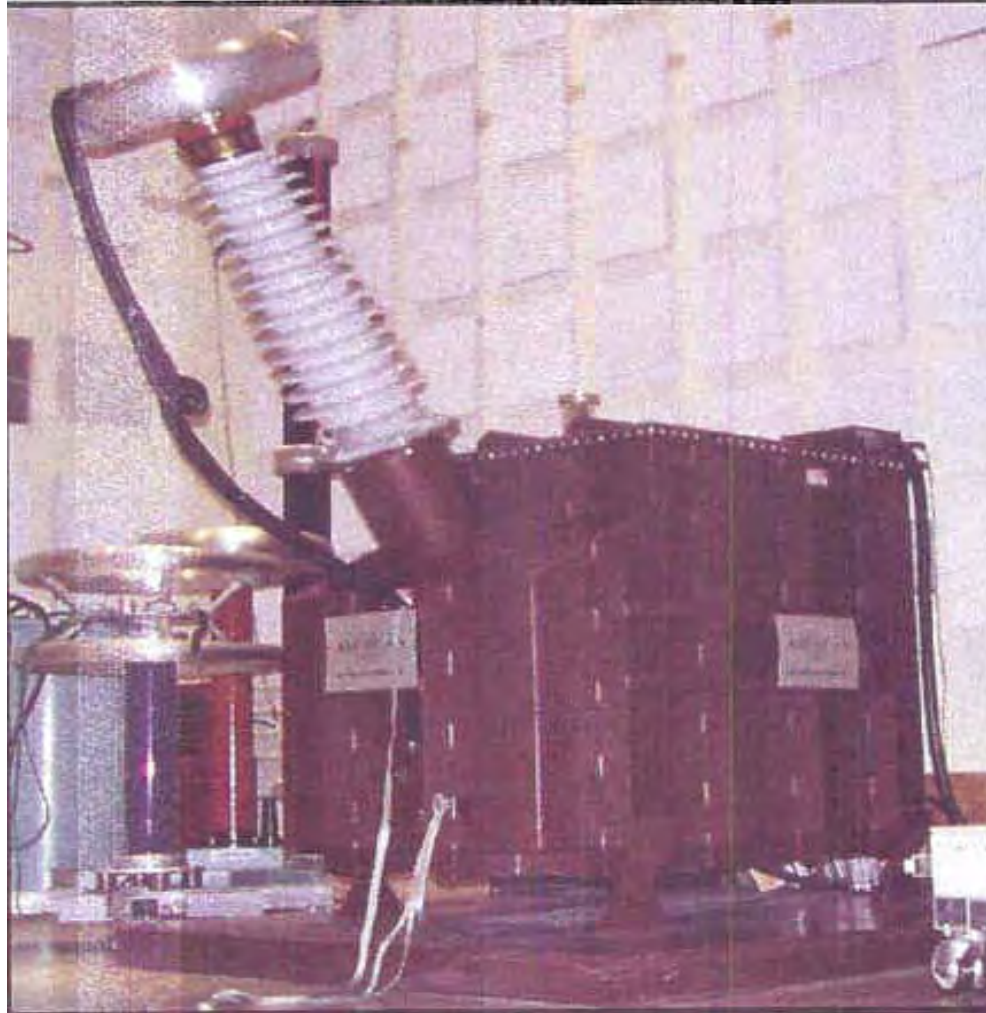
AC Source

- Specially designed low noise transformer, typically less than 2 pC discharge at 250 kV
- Power filtering to eliminate power line noise

Typical Test Value Requirements for Joints

Voltage (kV)	PD Requirement (pC)	AC Withstand Requirement (kV)
15	13	35
25	22	52
35	30	69

Test Transformer



Miscellaneous Information

- Have full voltage calibration signal injection capacitors
- All equipment is checked for calibration at least once per year
- All fixturing to hold samples being tested are designed for low noise, e.g. toroids, low noise connections, etc.

Medium Voltage Cable Production Electrical Testing

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MV Cable Production Electrical Tests

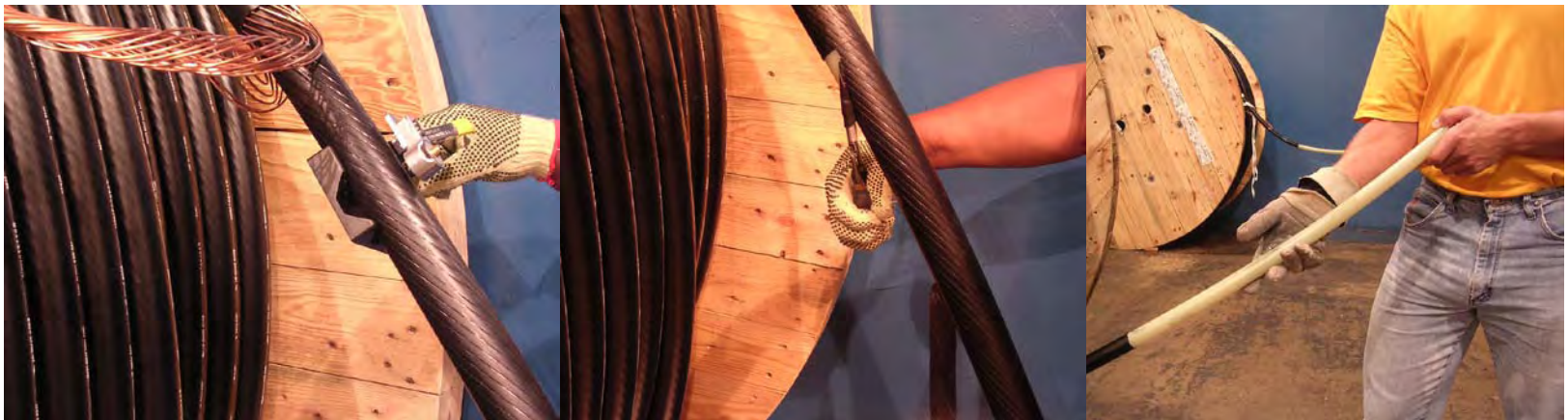
- Utility Cable Industry Standards & Specifications
 - AEIC CS8-07: Specification for Extruded Dielectric, Shielded Power Cables Rated 5 Through 46 kV (3rd Edition)
 - ANSI/ICEA S-94-649-2004: Standard For Concentric Neutral Cables Rated 5 Through 46 kV
 - ANSI/ICEA S-97-682-2007: Standard for Utility Shielded Power Cables Rated 5 Through 46 kV
 - CAN/CSA-C68.3-97: Shielded and Concentric Neutral Power Cables Rated 5-46kV
 - CAN/CSA C68.5-07: Primary Shielded and Concentric Neutral Cable for Distribution Utilities

Summary of MV Cable Production Tests

1. Conductor
 - dc Resistance; Diameter; Temper
2. Extruded Conductor Shield
 - Elongation After Aging; Volume Resistivity; Thickness; Voids, Protrusions and Irregularities; Wafer Boil
3. Insulation
 - Unaged and Aged Tensile and Elongation; Hot Creep; Voids and Contaminants; Internal Irregularity Test (TRXLPE); Diameter; Shrinkback Test (TRXLPE); Thickness; Insulation Eccentricity
4. Extruded Insulation Shield
 - Elongation After Aging; Volume Resistivity; Thickness; Indent (CN); Voids and Protrusions; Stripping Tension; Wafer Boil; Diameter
5. Metallic Shields / Conc. Neutrals
 - Dimensional Measurements; Cross-sectional Area
6. Jacket (if required)
 - Unaged and Aged Tensile and Elongation; Thickness; Heat Distortion (Deformation); Heat Shock; Cold Bend; Oil Immersion
7. **Electrical Tests**
 - **ac Voltage Withstand Test; Partial-Discharge Test;** Jacket Spark Test
8. Other Tests
 - Water in Conductor; Water Under Jacket; Longitudinal Water Penetration Test – Optional Sealant for Stranded Conductors; Longitudinal Water Penetration Test – Optional Water Blocking Components for Metallic Shield/CN

MV Cable Production Electrical Tests

- Cable Preparation for ac Voltage Tests
 - Correct Jacket, Metallic Shield, Insulation Shield Removal Length
 - Cable Test End Preparation
 - Insulation shield / insulation step must be smooth with no jagged edges
 - Termination paint must be smooth and level



MV Cable Production Electrical Tests

- ac Voltage Tests
 - Partial-Discharge Test (Conducted 1st)
 - ac Voltage Withstand Test
- Test Voltage
 - Tests conducted with an ac power supply of ample capacity but in no case less than 5 kVA
 - The frequency of the test voltage shall be nominally between 49 and 61 Hz and shall have a wave shape approximating a sine wave as closely as possible
 - The test voltage shall be applied between the conductor and the metallic component of the insulation shield with the metallic shield grounded
 - The test voltage shall be selected based on the rated voltage of the cable, the size of the conductor and insulation level

ac Voltage Production Tests



Partial-Discharge and ac Withstand Tests

MV Cable Applicable ac Test Voltages

Rated Circuit Voltage, Phase-to-Phase Voltage	Conductor Size, (AWG or kcmil)	Insulation Level (mils)				ac Test Voltage, kV	
		100 Percent		133 Percent		100 % Insulation Level	133 % Insulation Level
		Minimum	Maximum	Minimum	Maximum		
2001-5000	8-1000	85	120	110	145	18	23
	1001-3000	135	170	135	170	28	28
5001-8000	6-1000	110	145	135	170	23	28
	1001-3000	165	205	165	205	35	35
8001-15000	2-1000	165	205	210	250	35	44
	1001-3000	210	250	210	250	44	44
15001-25000	1-3000	245	290	305	350	52	64
25001-28000	1-3000	265	310	330	375	56	69
28001-35000	1/0-3000	330	375	400	450	69	84
35001-46000	4/0-3000	425	485	550	610	89	116

Partial-Discharge Test

- Partial-discharge test shall be performed in accordance with ICEA Publication T-24-380
- Manufacturer shall wait a minimum of 7 days after the insulation extrusion process before the tests are performed
 - The 7 day waiting period may be reduced by mutual agreement between the purchaser and manufacturer when effective degassing procedures are used
- Each shipping length of completed cable shall be subjected to a partial-discharge test
- The partial discharge level shall not exceed 5 pC for any test voltage at or below the applicable ac test voltage

Partial-Discharge Test

Power Supply

- Filters, inductors, and other necessary equipment up to the point at which the cable under test is connected shall be considered to be part of the power supply
- The high voltage circuits, the cable terminations, and the test facility shall be designed and operated in such a manner that the basic interference level indicated on the measuring device corresponds to a charge transfer of not more than four pC
- The rate of increase from the initially applied voltage to the specified test voltage shall be approximately uniform and shall be not more than 100 percent in 10 seconds nor less than 100 percent in 60 seconds
- The applied voltage shall not be maintained for more than three minutes during any single test

Voltage Measuring Device

- A voltage-measuring device connected directly to the test cable in such a manner that it corresponds to the voltage impressed across the cable dielectric

Partial Discharge Measuring Device

- A partial discharge measuring device shall consist of a primary detection circuit, an amplifier and an oscilloscope

Partial Discharge Calibrator

- A partial discharge calibrator shall consist of a pulse generator and a capacitor

Calibration Schedule

- The test equipment shall be calibrated at the beginning of each working shift of testing. In addition, the test equipment shall be recalibrated any time the cable being tested is not of the same general construction as the cable used for the most recent calibration, or any time the length of the cable being tested differs from the length of the cable used for the most recent calibration by more than 25 percent

Supplementary Partial Discharge Meters and Graphic Recorders (X-Y Plot)

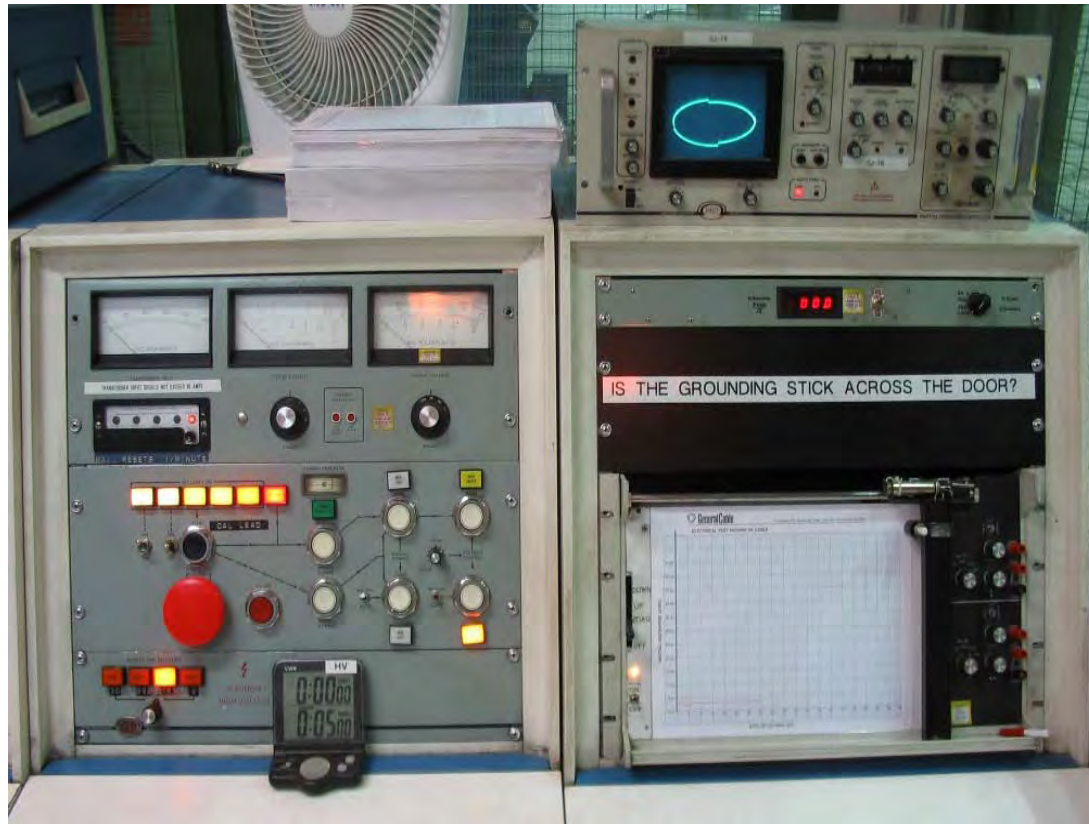
- Supplementary partial discharge meters and graphic recorders may be used to monitor the amplifier or oscilloscope output of the partial-discharge measuring device

Production Electrical Tests

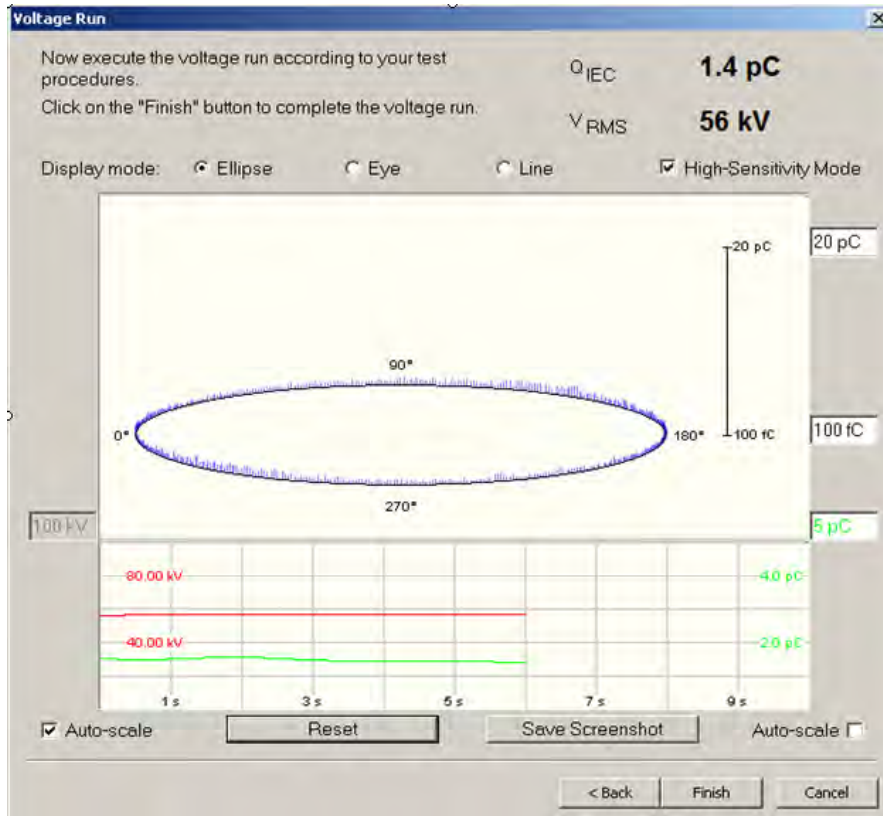


Partial-Discharge and ac Withstand Test Setup

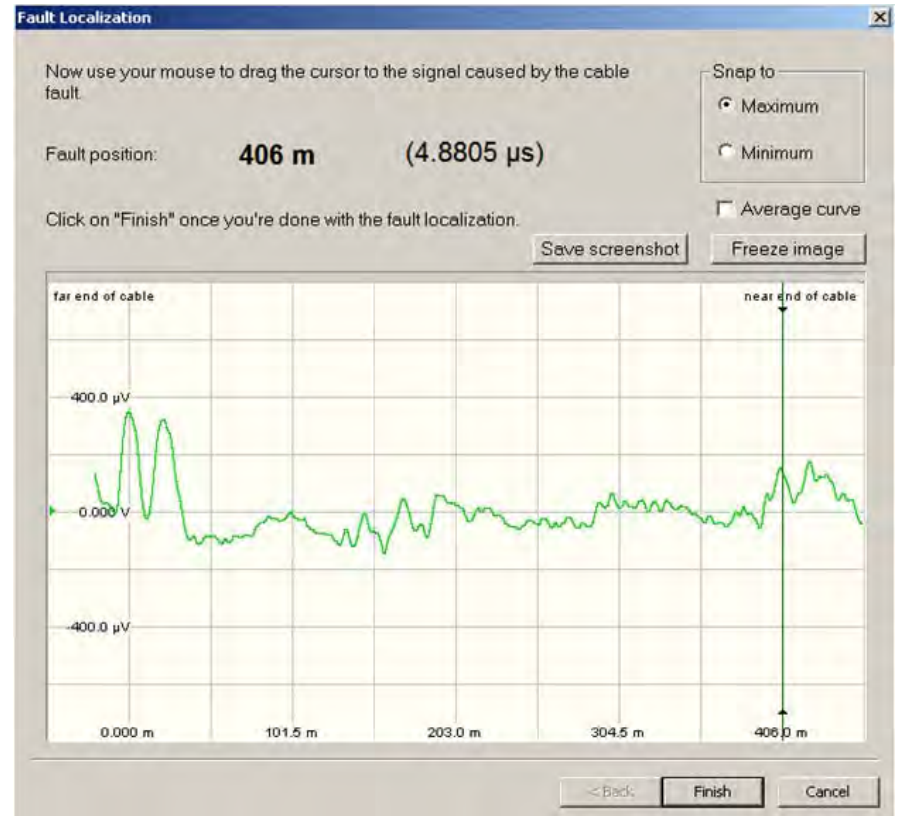
Partial-Discharge Test



Partial-Discharge Test



Partial-Discharge



Fault Localization

MV Cable Production Electrical Test Requirements

- ac Voltage Withstand Test
 - The initially applied ac test voltage shall be not greater than the rated ac voltage of the cable under test. The duration of the ac voltage test shall be 5 minutes
 - Each shipping length of completed cable shall withstand the applicable ac test voltage without failure