

Contact Voltage Detection

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Overview

- Contact Voltage Definition
- History
- Equipment
- Inspection Procedures
- We Energies Infrastructure
- Contact Voltage Testing Results
- Case Studies

What is 'Contact Voltage'?

- Existing IEEE Definition: A voltage accidentally appearing between two points with which a person can simultaneously make contact.
- "Accidentally" implies an abnormal system condition or a fault condition. Faults may be due to one or more factors, such as:
 - mechanical damage
 - damaged cables
 - deteriorated, frayed or missing insulation
 - improper maintenance
 - improper installation

Present EPRI Description

In the context of the EPRI work, contact voltage is a term that collectively describes the wide range of perception and shocking concerns involving humans and animals.

The IEEE 1695 Working Group has not published any official documents yet, but that work may result in a modification of this definition, where the generic term for all contact scenarios would be termed perceptible voltage.

From: Elevated Neutral-to-Earth and Contact Voltages in Distribution Systems, 2009 Research Update and Guidebook Materials

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Working Definitions of the IEEE Stray Voltage Working Group

Contact Voltage: A voltage resulting from power system faults which may be present between two conductive surfaces that can be simultaneously contacted by members of the general public or their animals. Contact voltage is not related to the normal delivery or use of electricity, and can exist at levels that may be hazardous. (See also Stray Voltage)

Stray Voltage: A voltage resulting from the normal delivery or use of electricity which may be present between two conductive surfaces that can be simultaneously contacted by members of the general public or their animals. Stray voltage is not related to power system faults, and is generally not considered hazardous. (See also Contact Voltage)

History

- 'Contact Voltage' has caused injuries and deaths to domestic animals and humans in several US cities
 - New York, Boston, Las Vegas, Columbus, San Diego, and Miami
- New York PSC refers to this issue as "Stray Voltage" and now requires utilities to test all 'publicly accessible' equipment (owned and served) every year
 - \$100M cost per year according to Con Ed (investigation and urban rebuild)
 - Non-Compliance Penalty: 75 basis points on rate of return
- Massachusetts utilities have agreed to a voluntary inspection program
 - NSTAR inspected more than 18,000 NSTAR manholes and an estimated 70,000 other structures near NSTAR manholes in Boston in 2004

Purpose of Testing

- We Energies is committed to public safety
- Reports of Contact Voltage have raised national concerns
- Gain experience with detection equipment, costs of on-going inspections, and learn specifics of potential sources of contact voltage
- Use inspection findings to improve installation and maintenance programs

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We Energies Inspection Programs

- Padmount Equipment Inspection
- Pole Inspection and Treatment
- Street Light Lamp Replacement
- Manhole and Vault Inspection
- Special Inspection Programs



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Equipment

- HD Electric LV-S-5 (Proximity Tester)
 - PV-LT-5 (Testing Source)
 - GS-LV
- Fluke 1-LAC-II (Proximity Tester)
- Fluke 87A (Digital Multimeter)
- Fluke SV225 (Shunt Resistor)

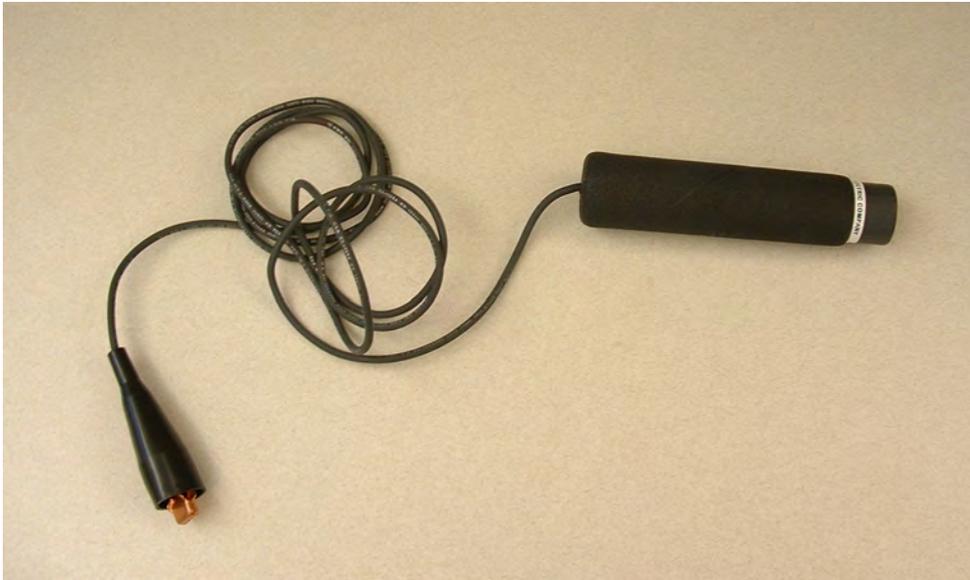
HD Electric tester (LV-S-5)

- Designed for utility use
 - Sensitive down to 5 volts AC
 - (PT-LV-5) AC source for testing
 - Senses 600V at 7"
 - Most sensitive
- Some 'false positives'
 - Non-metallic surfaces (e.g. meter glass, fiberglass poles)
 - Metallic surfaces non-grounded (e.g. metal bolt on a fiberglass pole)
 - Strong electric field from another source (e.g. overhead conductors)



GS-LV

- Ground Shield
- Used with the LV-S-5
- Helps to eliminate the false positives under overhead conductors
- Takes the inspector out of the testing circuit



Fluke 1LAC-II

- Similar to LV-S-5
- On/Off feature
- Has audible tone
- Less sensitive than the LV-S-5
- Good results when used for padmount inspections
- False positives similar to the LV-S-5
- Less expensive than LV-S-5



Fluke SV225

- Used with a digital multimeter (Fluke 87A)
- Shunt resistor (3.3K Ohm)
- Used to differentiate between high impedance and low impedance voltage sources
- Used only after testing without a resistor
- Simulates an animal or human load coming in contact with the voltage
- Note: Auto scaling voltmeters may switch to millivolts



Inspector Procedures

- Approach unit and visually inspect earth contact (burned grass, fault indications)
- Standing 3' from unit slowly extend tester toward surface
- Stop on positive signal or when tester contacts the surface
- Repeat for all metal (conductive) surfaces
- Positive indications are reported and guarded until follow up can be complete by qualified personnel

Positive Indication

- Qualified personnel perform a voltage test to earth ground (Multimeter)
- If voltage is greater than 50V, investigate the cause
- If voltage is less than 50V, install shunt resistor and re-measure the voltage
- If voltage with resistor is greater than 10V, inspect equipment for possible cause
- If voltage with resistor is between 5-10V, report to maintenance for further follow up
- If less than 5V, no further action is required
- If source of unacceptable voltages cannot be determined, an Application Engineer will be called out

We Energies Distribution System

- 680,000 wood distribution poles
- 190,000 ground-mounted equipment
 - Padmount transformers, pedestals, etc.
- 120,000 street lights (12,000 non-wood)
- 12,000 manhole and vault covers
- 350 substation fences

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2007 Results

- 55774 locations tested
- No false positives
- No locations with unacceptable contact voltage

2007 Contact Voltage Inspection Data Report

Inspection Program	Equipment Type	Target	Number of Inspections	Locations Tested	Surfaces Tested	Induced Voltage Measured	Percent of Surfaces Tested	Contact Voltage Measured	Percent of Surfaces Tested
	transformer			22292	22292	0	0.00%	0	0.00%
	switch_fuse			246	246	0	0.00%	0	0.00%
	pedestal			22707	22707	0	0.00%	0	0.00%
	meter_transformer			10	10	0	0.00%	0	0.00%
	meter_pedestal			407	407	0	0.00%	0	0.00%
	junction_box			1005	1005	0	0.00%	0	0.00%
2007 GME Inspection				46667	46667				
	wood pole			9107	10501	0	0.00%	0	0.00%
2007 Pole Inspections				9107	10501				
Report Total				55774	57168				

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2008 Results

- 67745 locations tested
- 4 false positives
- 1 location with unacceptable contact voltage

2008 Contact Voltage Inspection Data Report

Inspection Program	Equipment Type	Target	Number of Inspections	Locations Tested	Surfaces Tested	Induced Voltage Measured	Percent of Surfaces Tested	Contact Voltage Measured	Percent of Surfaces Tested
	junction_box		1473	1473	1473	0	0.00%	0	0.00%
	pedestal		15267	15267	15267	3	0.02%	0	0.00%
	switch_fuse		212	212	212	0	0.00%	0	0.00%
	transformer		20793	20793	20793	1	0.00%	1	0.00%
2008 GME Inspection		37745	37745	37745	37745	4	0.01%	1	0.00%
	wood pole		29040	7693	12341	0	0.00%	0	0.00%
2008 Pole Inspections		30000	29040	7693	12341	0	0.00%	0	0.00%
Report Total		67745	66785	45438	50086	4	0.01%	1	0.00%

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2009 Results

- 55280 locations tested
- 0 false positives
- 0 locations with unacceptable contact voltage

2009 Contact Voltage Inspection Data Report

Inspection Program	Equipment Type	Target	Number of Inspections	Surfaces Tested	Induced Voltage Measured	Percent of Surfaces Tested	Contact Voltage Measured	Percent of Surfaces Tested
	junction_box		1540	1501	0	0.00%	0	0.00%
	pedestal		18527	18261	0	0.00%	0	0.00%
	switch_fuse		486	478	0	0.00%	0	0.00%
	transformer		22456	22101	0	0.00%	0	0.00%
2009 GME Inspection		43009	43009	42341	0	0.00%	0	0.00%
	wood pole		10750	7427	0	0.00%	0	0.00%
2009 Pole Inspections		10000	10750	7427	0	0.00%	0	0.00%
	unknown pole		2271	2269	0	0.00%	0	0.00%
NW SAL CV Testing		2271	2271	2269	0	0.00%	0	0.00%
Report Total		55280	56030	52037	0	0.00%	0	0.00%

Important Point

- A positive indication does not mean that a human or animal exposure would result in harm. The amount of exposure current is dependent on the characteristics of the exposure circuit, not the characteristics of the test circuit.

Testing Costs

- Addition to existing inspections
 - Equipment cost (\$20 - \$400)
 - Time for call outs
 - Contractor adder to existing inspections
- Separate program has a greater cost per test
 - Higher cost for Line Mechanics or Troubleshooters

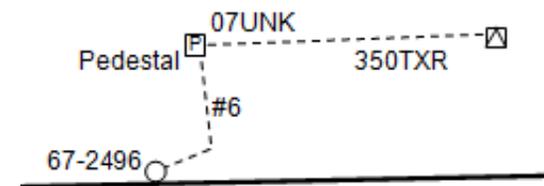
Pedestal Testing

- Cover and base of pedestals not always electrically connected
- Test both sections separately
- Top & cover can have false positives



Location #1

- Wood street light pole
- Child received shock from metal u-guard
- U-guard to earth potential was 105 V (1 foot away)
- Neutral conductor that fed the streetlight was connected to the phase connector block at the pedestal
- Cable vintage had poor differentiation between neutral and phase conductor



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Location #2

- Time Warner pedestal
- Time Warner employee received shock
- Pedestal and Trailer (aluminum) potential to earth was 92 V
- Bad neutral connection within the customer-owned service entrance equipment



Location #3

- Padmount transformer
 - Potential to earth was 16 V
- Meter Pedestal
 - Potential to earth was 41 V
- Potential cleared when meter was removed
- Cause was due to customer owned equipment
- Electrician was required to make repairs before reconnection



Location #4

- Pedestal feeding 2 streetlights
- Tester signaled 12" away from unit
- Measured 117 Volts between surface of pedestal and earth
- Hot and neutral conductors switched at transformer



Location #5

- Backyard pedestal
- Tester signaled 6-7" away from front cover
- Measured 117 Volts
- Sharp corner of connector block had worn through the insulating cover



Location #6

- Aluminum street light pole
- Tester signaled 1" away from pole
- Damaged conductor insulation



Location #7

- Fiberglass street light pole
- Tester signaled 2" away from pole
- Wires inside had been chewed by a squirrel.



Location #8

- Meat processing plant
- Wood pole fire
- Firefighter received shock from fence
- Fire started 6-12" below ground and melted the plastic u-guard and cable insulation
- Cause by overloaded cables



Discussion & Questions

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ScopeMeter Waveform Analysis Helps with Source Identification

- 60 Hz Faulted Phase Conductor (Source path Issue)
- Higher Harmonic Content Neutral to Earth Voltage (return path issue)
- Voltage Snapshot Gas Pipeline to Remote Earth (high % return path issue)

