IEEE Working Group on Voltages at Publicly and Privately Accessible Locations

(aka "The Stray Voltage Working Group")

Activity Update

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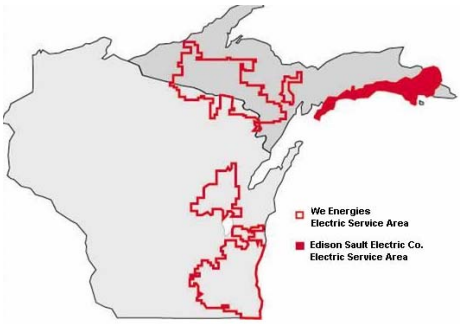
WE ENERGIES PROFILE



Serves about 2.3 million people in a service area of 12,600 sq. miles in Wisconsin and Michigan's Upper Peninsula

- Electric and gas utility
- 1,026,000 electric service customers
- Service area of 12,600 square miles
- Generating capability of 5900 MW
- Peak demand of 6,400 MW
- Urban & rural service areas
- Voltages from 4kV through 34.5kV
- 28,000 miles of primary power lines
- 30,000 miles of secondary/service power lines
- Number of employees: 5,800

we energies

Working Group on Voltages at Publicly and Privately Accessible Locations

Why was the WG formed?

Media Misinformation

Frivolous and Expensive Litigation

Unnecessary and Expensive Government Regulation

Conflicting Official Definitions

Media Misinformation

Stray Voltage Frustration Builds

Country Today 05/08/02

"The No. 1 health problem in the country right now."

Frivolous and Expensive Litigation

Michigan Taking Legal Action Over Stray Voltage

LaCrosse Tribune 02/13/02

"The case boils down to a single point -- electricity belongs on the power lines, said Peter Lark, assistant in charge of special litigation."

Unnecessary and Expensive Government Regulation

2004 Wisconsin Assembly Bill 529 "The Electrical Bill of Rights"

- No current on utility grounding conductors for longer than 5 seconds
- Creation of an Electrical Pollution Board
- Creation of an Electrical Pollution Fund
- Large utility fines for non-compliance ($1000/grd/day)

Conflicting Official Definitions

Public Service Commission of Wisconsin (PSCW)

Stray voltage is a special case of voltage in which the neutral to earth voltage is present across points (generally grounded metal objects) in which a current flow is produced when an animal comes into contact with them.

Stray voltages are low-level voltages and should be distinguished from painful shocks felt by humans.

Conflicting Official Definitions

New York State Public Service Commission

"The term stray voltage means voltage conditions on electric facilities that should not ordinarily exist. These conditions may be due to one or more factors, including but not limited to damaged cables, deteriorated, frayed or missing insulation, improper maintenance, or improper installation."[1]

[1]: **CASE 04-M-0159** - Proceeding on Motion of the Commission to Examine the Safety of Electric Transmission and Distribution Systems.

Complicated Technical Issue

Publicly Misunderstood

Controversial & Emotional

Litigious

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P1695 PURPOSE

There is presently no industry wide guide or standard that describes the variety of publicly and privately accessible voltages resulting from the delivery and use of electrical energy. This guide will help dispel misinformation surrounding this topic and enhance public safety.

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P1695 SCOPE

This guide addresses the normal and abnormal voltages that exist at publicly and privately accessible locations as a result of the delivery and use of electrical energy (often referred to as stray voltage). It focuses primarily on the presence of power frequency related voltages, and discusses definitions, causes, impacts, testing techniques, mitigation strategies, and hazard levels.

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Normal Voltages

Voltages that exists at accessible locations when the electrical system, from generator to appliance, is operating as intended.

These voltages:

- Can be found everywhere regardless of power system grounding technique.
- Are usually below levels that can be perceived by people and their animals.
- Are often described as "less than 10 volts".
- When perceptible these voltages are generally considered a nuisance voltage, not a hazardous voltage.

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Abnormal Voltages

Voltages that exist at accessible locations as a result of the presence of a system fault (i.e. short and/or open).

These voltages:

Are uncommon.
Can be hazardous.
Can be easily detected.
Can be successfully managed.

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That Exist at Publicly Accessible Locations

Lamp post to sidewalk voltage

Pad mounted equipment to earth voltage

Manhole cover to street surface voltage

Water fountain to earth voltage

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That Exist at Privately Accessible Locations

Animal contact voltage (private barn)

Water faucet to earth voltage (private back yard)

Pool water to pool apron voltage

That Are Not Accessible:

Voltages found within any electrical enclosure
Voltages found within any substation, manhole, or vault
Properly insulated phase conductors

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Measurable Voltages at Locations Accessible to the Public are from Many Sources:

Naturally Occurring Earth Surface Voltage Gradients (Earth's Magnetic Field)

Lightning Induced Transient Voltages

Radio Frequency Transmission Induced Voltages

Cathodic Protection Voltages

Galvanic Cells Due to Dissimilar Metals

Power System Operation

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Power Frequency Related Voltages

From IEEE 100:

power frequency
(1) The value of frequency used in the electrical power system, such as 50 Hz or 60 Hz. (EMC) C63.13-1991

Related to the operation of the power system:

harmonic voltages
switching transients (multi and sub-cyclical)
power line carrier voltages
fault voltages
etc.

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Controversial Topics

Terminology: Some of the terms used to describe the publicly accessible voltages related to normal and abnormal system operation are Stray Voltage, Contact Voltage, Tingle Voltage, Urban Stray Voltage, Metallic Object to Earth Voltage, Ground Fault Voltage, and Neutral to Earth Voltage. Each of these terms has its proponents. Some have existing official regional definitions.

Definitions: How do we define the terms eventually used to identify these publicly accessible voltages?

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In order to avoid confusion and keep the discussion moving forward, I have asked the working group to temporarily use the following terms:

Stray Voltage - Voltages that are the result of normal system operation (caused by return and induced currents).

Contact Voltage – Voltages that are the result of abnormal system operation (caused by fault currents).

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Stray Voltage:

Historically synonymous with the neutral-to-earth voltages issues that result from normal system operation (e.g. dairy farms and swimming pools).

Historically considered a nuisance voltage, not a hazardous voltage.

No existing IEEE definition.

Consistent with several non-IEEE definitions.

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Contact Voltage:

The IEEE 100 definition of "Contact Voltage" is:

Contact Voltage (human safety): A voltage accidentally appearing between two points with which a person can simultaneously make contact. (PE) [8], [84]

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Controversial Topic (Hazardous Level)

Do we establish "Levels of Hazard" for people and animals based on the working group's interpretation of existing science, or do we provide the information and resources necessary for the reader to make informed decisions about this complex topic?

Hazardous levels in terms of conducted current, for both people and animals, are well understood but vary slightly depending on the information source (e.g. IEEE, ICNIRP, NRPB, EU).

Hazardous levels in terms of voltage will be difficult to achieve because the amount of current in the exposure circuit is dependent on exposure circuit characteristics.

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Important Points

There are publicly accessible voltages related to normal system operation that must be present, and there are publicly accessible voltages related to abnormal system operation that should not be present. These are two very different things that should be defined and discussed separately.

Human and animal exposure to conducted current is well understood. We want the reader to learn something about the science behind existing exposure standards; where to find, and how to apply these standards. This is necessary so that informed decisions can be made regarding the degree of hazard that exists and what, if anything, should be done about it.

We want to provide the reader with the knowledge and tools necessary to make meaningful measurements. This will enable identification of sources and, if necessary, aid in selection of appropriate mitigation alternatives.

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Trial Use Guide for Assessing Voltages at Publicly and Privately Accessible Locations (IEEE-P1695) Outline Draft 6/24/2007

1. Overview (Required)
   - Scope and Purpose of the Guide
2. Normative References (Required)
   - Documents necessary to understand and use the Guide (e.g. USDA Handbook 696)
3. Definitions/Acronyms/Abbreviations (Required)
4. General Discussion
   - Reasons for confusion surrounding the issue, some amount of measurable voltage will always be present, contact voltage v. stray voltage, sources are both primary (utility) and secondary (customer), grounded v. ungrounded systems, etc.

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5. Human and Animal Electrical Sensitivity

5.1 General

Research summary, nerve stimulation model discussion, factors affecting sensitivity, sensitivity versus frequency and/or duration of exposure, people versus animals, etc.

5.2 Sensitivity to Conducted Current

5.3 Sensitivity in Terms of Voltage Exposure

Characteristics and importance of the exposure circuit (e.g. source impedance, contact impedance, body impedance, etc.), why it's difficult to create a voltage exposure standard, etc.

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6. Accessible Voltages Related to Abnormal System Operation ("Contact Voltage")

6.1 General

Potentially hazardous nature of contact voltage, degree of hazard dependent on exposure circuit not measurement circuit, number of incidents (i.e. putting the issue in perspective), existing proactive programs, etc.

6.2 Contact Voltage Sources

Fault current (i.e. shorts and opens), fault current availability, insulation degradation, wiring errors, broken conductors, voltages induced during fault conditions, etc.

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6.3 Contact Voltage Investigation

6.3.1 Test and Measurement Equipment

Electric field detection (e.g. proximity detectors, mobile platforms, etc.), multi-meters, load resistors, safety gear, etc.

6.3.2 Investigation Protocol

Safety precautions, understanding remote earth, measurement location, measurement technique, data analysis, false positives, etc.

6.4 Contact Voltage Mitigation

Insulation failure, wiring errors, open conductors, etc.

6.5 Case Studies

Street light, manhole, etc.

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7. Accessible Voltages Related to Normal System Operation ("Stray Voltage")

7.1 General

Historically considered a nuisance voltage. Generally associated with animal exposures, swimming pool & shower shocks. Primary (utility) and secondary (customer) sources. Harmonics, transients, etc.

7.2 Stray Voltage Sources

7.2.1 Return Current

Systems with a neutral conductor, systems without a neutral conductor, SWER, etc.

7.2.2 Induced Current

Transmission Source, Primary Source, Secondary Source, etc.

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7.3 Stray Voltage Investigation

- 7.3.1 Test and Measurement Equipment
  - Recording devices, load boxes, copper plates, etc.
- 7.3.2 Investigation Protocol
  - 7.3.2.1 Confined Livestock
  - 7.3.2.2 Swimming Pools
  - 7.3.2.3 Showers, faucets, drinking fountains, and other plumbing related exposure possibilities
  - 7.3.2.4 Other

7.4 Stray Voltage Mitigation

- Bad neutral connections, undersized conductors, poor grounding, phase balance, system voltage, etc.

7.5 Case Studies

- Dairy farm, swimming pool, outdoor shower, etc.

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Annex A: Flow Charts

Annex B: Sample Data Collection Forms

Annex C: Existing Regulation

- Wisconsin, Idaho, Michigan, New York, etc.

Annex D: Previously Established Voltage Exposure Standards

- IEEE, IEC, NEC, etc.

Annex E: Distribution System Grounding Alternatives

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- John Goodfellow - Biocompliance Consulting

Incidental Tree Contact and Publicly Accessible Voltages (CV)

- Doug Dorr - EPRI

Determining Voltage Levels of Concern for Humans and Animals (SV & CV)

- Frank Lambert – NEETRAC, Georgia Institute of Technology

Swimming Pool Equipotential Bonding (SV & CV)

- Doug Reinemann - University of Wisconsin

Review of Real World Cow Contact Circuit Impedances (SV)

- Randy Collins - Clemson University

Elevated Neutral to Earth Voltages Due to Harmonics – A T&D Update (SV)

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