Activities of the IEEE Working Group on Voltages at Publicly and Privately Accessible Locations

Midwest Rural Energy Conference

45th Annual Rural Energy Conference

February 21 – 23, 2007

St. Paul, Minnesota

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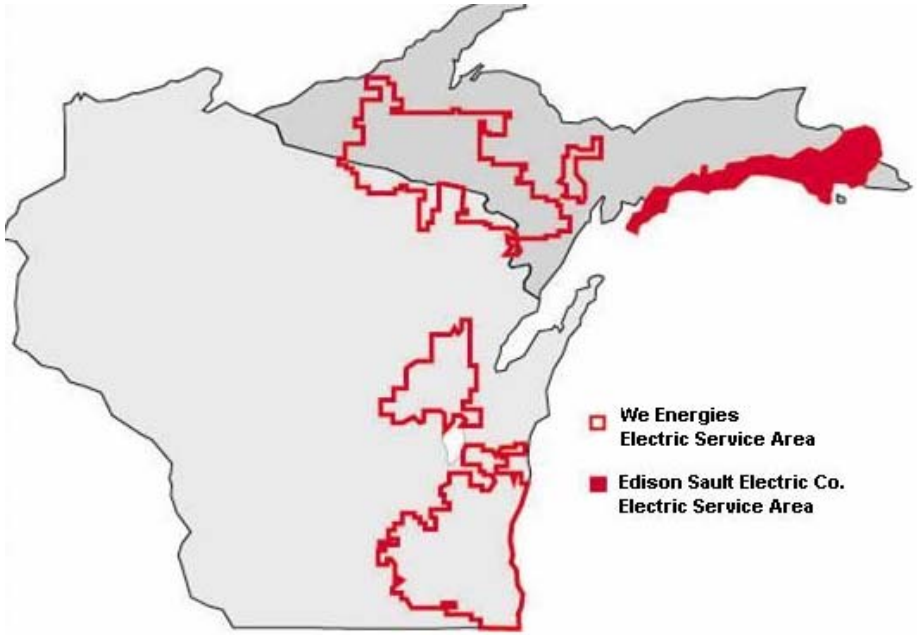
we energies

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

Institute of Electrical and Electronics Engineers, Inc (IEEE)

- 365,000 members in over 150 countries
- 311 sections in ten geographic regions worldwide
- 1,570 chapters that unite members with similar technical interests
- 1,430 student branches at colleges and universities in 80 countries
- 39 societies and 5 technical councils
- 128 transactions, journals, and magazines
- 300+ conferences worldwide each year
- 900+ active IEEE standards and more than 400+ in development

Mission

The IEEE promotes the engineering process of creating, developing, integrating, sharing, and applying knowledge about electro and information technologies and sciences for the benefit of humanity and the profession.

IEEE Societies (39)

Examples:

- IEEE Aerospace and Electronic Systems Society
- IEEE Communications Society
- IEEE Computer Society
- IEEE Consumer Electronics Society
- IEEE Electromagnetic Compatibility Society
- IEEE Industry Applications Society
- IEEE Instrumentation and Measurement Society
- IEEE Power Engineering Society

Power Engineering Society (18 Committees)

Examples:

- Electric Machinery Committee
- Insulated Conductors Committee
- Nuclear Power Engineering Committee
- Power System Communications Committee
- Power System Operations Committee
- Substations Committee
- Surge Protective Device Committee
- Transmission and Distribution Committee

Transmission and Distribution Committee (10 Subcommittees)

Examples:

- Capacitor Subcommittee
- DC and Flexible AC Transmission Subcommittee
- Lightning and Insulator Subcommittee
- Power Quality Subcommittee
- Towers, Poles and Conductors Subcommittee
- Distribution Subcommittee

Distribution Subcommittee

- Working Group on Prize Papers
- Working Group on Distribution Reliability
  - Task Force on Outage Reporting Practices
  - Task Force on Reliability Indices
  - Task Force on System Design from a Reliability Perspective
- Working Group on Switching and Overcurrent Protection
  - Distribution Networks
- Working Group on Distribution Automation
- Working Group on Distributed Resources Integration
- Working Group on Electrical Testing of Wildlife Protectors
- Working Group on Lightning Performance of Distribution Lines
- Working Group on Distribution Voltage and VAR Control
- Working Group on Voltages at Publicly and Privately Accessible Locations

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."

Media Misinformation

Shocked into Action

In the wake of the electrocution of a grad student, N.Y. got tough on utilities to curb stray voltage.

By Jenn Abelson, Boston Globe Staff | March 22, 2005

Media Misinformation

Stray Street Voltage Electrocutes Dog

By Jessica Bennett and David Abel, Boston Globe Correspondent and Globe Staff, 2/5/2004

Charlestown residents say their complaints were ignored.

Media Misinformation

INSIDE EDITION INVESTIGATION FINDS STREETS WITH DANGEROUS WIRING CONDITIONS THAT COULD LEAD TO ELECTROCUTION

Inside Edition tested streets in cities where there have been recent reports of stray voltage, and, in each city, found potentially dangerous conditions that could lead to electrocution – even death.

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."

Frivolous and Expensive Litigation

$740,000 Sought for Electrocuted Dog

[World News]: BOSTON, March 8 : The owners of a dog killed by "stray voltage" are demanding $740,000 from the Boston electric utility they say is responsible for their pet's death.

Frivolous and Expensive Litigation

Utility To Appeal Stray Voltage Verdict

Idacorp Bulletin Winter 2004

A Fifth Judicial District Court jury in Twin Falls, Idaho on Feb. 10 returned a $17 million verdict against Idaho Power in a lawsuit filed by a dairy operation that claimed damages as a result of *stray voltage* which allegedly impacted the health of their dairy cows.

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)

Ontario Bill Targets Stray Voltage from Power Lines as Threat to Human Health

Canadian Press: Gregory Bonnel Toronto (CP) Oct 19, 2006

Canada's dairy cows are acting as "canaries in coal mines" when it comes to detecting stray electricity in the ground that poses a significant threat to human health, experts said Thursday.

Unnecessary and Expensive Government Regulation

Public Service Commission

ELECTRIC SAFETY STANDARDS

Case 04-M-0159 - Proceeding on Motion of the Commission to Examine the Safety of Electric Transmission and Distribution Systems

Unnecessary and Expensive Government Regulation

Safety Standards

- **Implemented as a result of fatality in New York City**
- **Stray voltage testing requirement**
  - All utility's facilities and streetlight annually
  - Immediate corrective actions if voltage found
- **Inspect all facilities on a five year cycle**
- **Additional requirements**
  - Annual report and officer certification
  - Quality assurance program
  - Must adhere to National Electric Safety Code
  - Substantial revenue adjustments for failing to comply

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.

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.

The Standard Making Process

Types of Standards Documents

Standard--mandatory (*shall*)

Recommended Practice--suggested procedures (*should*)

Guide--guidelines (*may*)

PAR Request Date: 13 March 2006	
PAR Approval Date: 15 September 2006	
PAR Signature Page on File: Yes	
Type of PAR: New IEEE Standard	
Status: PAR for a New IEEE Standard	
Root Project:	
1.1 Project No.: P1695	
1.2 Type of Document: Guide	
1.3 Life Cycle: Trial-Use	
1.4 Is this document in ballot now? No	
2.1 Title Trial-Use Guide for Assessing Voltages at Publicly and Privately Accessible Locations	
2.1 Amendment/Corrigenda Title	
3.1 Working Group Name	Working Group on voltages at publicly and privately accessible locations
Working Group Chair	DeNardo, Chuck Phone: +1 414 221 3073 Email: chuck.denardo@we-energies.com
Working Group Vice Chair	Bouford, James D. Phone: 508-421-7648 Email: james.bouford@us.ngrid.com
3.2 Sponsor	IEEE Power Engineering Society Transmission and Distribution (PE/T&D)
Sponsor Chair	Grady, W. Mack Phone: 512-471-5231 Email: mack@ieee.org
Name of Standards Liaison Representative (if applicable)	Mortensen, Karl N Phone: 763-241-2365 Email: kmortensen@grenergy.com
3.3 Joint Sponsor	
4.1 Type of Ballot: Individual	
4.2 Expected Date of Submission for Initial Sponsor Ballot: April 2009	
4.3 Projected Completion Date for Submittal to RevCom: April 2010	
5.1 Approximate number of people expected to work on this project: 50	
5.2 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.	
5.3 Is the completion of this document contingent upon the completion of another document? No	

5.4 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.

5.5 Need for the Project: Publicly accessible voltages have been reported in the media over the past few years, including fatalities allegedly due to "stray voltage". This phenomena is undefined and no guide or standard exists to address this area of concern.

5.6 Stakeholders for the Standard: The stakeholders for this project include electric utilities, utility customers, state utility regulators, dairy industry, pool and spa industry, equipment manufacturers and other standards entities such as the National Electric Code.

6.1.a. Has the IEEE-SA policy on intellectual property been presented to those responsible for preparing/submitting this PAR prior to the PAR submittal to the IEEE-SA Standards Board? Yes **Presented Date:** 2006-06-19
If no, please explain:

6.1.b. Is the Sponsor aware of any copyright permissions needed for this project? Yes
If yes, please explain: Work done by EPRI and NEETRAC may be included in the document.

6.1.c. Is the Sponsor aware of possible registration activity related to this project? No
If yes, please explain:

7.1 Are there other standards or projects with a similar scope? No
If yes, please explain:

Sponsor Organization:
Project/Standard Number:
Project/Standard Date: 0000-00-00
Project/Standard Title:

7.2 Is there potential for this standard (in part or in whole) to be adopted by another national, regional, or international organization? ? Do not know at this time
Technical Committee Name and Number:
Contact person:
Contact person Phone Number:
Contact person Email Address:

7.3 Will this project result in any health, safety, security, or environmental guidance that affects or applies to human health or safety? Yes
Thresholds of body current for humans and animals will be discussed.

7.4 Additional Explanatory Notes:

8.1 Sponsor Information:
Is the Scope of this project within the approved scope/definition of the Sponsor's Charter? Yes
If no, please explain:

IEEE WORKING GROUP ON VOLTAGES AT PUBLICLY AND PRIVATELY ACCESSIBLE LOCATIONS

Web Cast November 30, 2006

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Working Group Web Site: (http://grouper.ieee.org/groups/td/dist/stray/)

Voltages at Publicly and Privately Accessible Locations (a.k.a. Stray Voltage)

Complicated Technical Issue

Publicly Misunderstood

Controversial & Emotional

Litigious

Imperative Principles of the Standards Process

Due Process

Openness

Balance

Right of Appeal

Consensus

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.

From the Scope of P1695

Normal and Abnormal Voltages

That Exist at Publicly and Privately Accessible Locations

As a Result of the Delivery and Use of Electrical Energy

Focuses Primarily on the Presence of Power Frequency Related Voltages

Discusses Definitions, Causes, Impacts, Testing Techniques, Mitigation Strategies, and Hazard Levels

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

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:

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

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

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 (sub-cyclical, i.e. higher frequency)
loose connection transient voltages
power line carrier voltages
fault voltages

As a Result of the Delivery and Use of Electrical Energy

Voltages resulting from the operation of:

Transmission Systems
Distribution Systems
Secondary Electrical Systems (Utility & Customer)

Not voltages from the operation of:

Cathodic Protection Systems
Telephone Systems
Radio Stations
Baby Monitors

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".
- Are generally considered a nuisance voltage, not a hazardous voltage.

Normal Voltages
(Primary and Secondary Neutral Return Current)

Measurable voltages at accessible locations develop as normal neutral return current flows through the impedances of the neutral conductor and all of its parallel conductive pathways.

Parallel Pathways Include:

Grounding Conductors (Primary & Secondary)
Telephone and CATV Messengers
Building Steel
Waterlines (Mains & Bldg Plumbing)
The Earth

Normal Voltages
(Power System Induced Current)

Measurable voltages at accessible locations develop during normal system operation from currents that are induced in the conductive loops formed by the neutral conductor (where one exists) and all of its parallel conductive pathways; and from currents that are induced in nearby conductive loops that are not directly connected to the electrical system.

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.

Abnormal Voltage (Fault Related)

From IEEE 100:

fault (1) (wire or cable) A partial or total local failure in the insulation or continuity of a conductor. *See also:* center of distribution. (T&D/PE) [10]

Whether a ground fault, a phase to phase fault through a grounded object, or an open conductor: a fault is an abnormal and potentially hazardous system condition.

Normal and Abnormal Voltages (Grounded v. Ungrounded)

Publicly accessible voltages related to normal or abnormal system operation can exist, at some level, nearly everywhere. This is true regardless of whether the electrical system (utility's or customer's) is grounded or un-grounded, three wire, four wire, five wire, or single wire earth return.

Discusses Causes, Impacts, Testing Techniques, and Mitigation Strategies

Causes, Impacts, Testing Techniques, and Mitigation Strategies are generally well understood.

True for both Normal or Abnormal Voltages

Discusses Hazard Levels

Hazard 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)

Hazard levels are the same regardless of voltage source (i.e. normal or abnormal system operation).

Hazard levels vary with frequency.

Hazard levels in terms of voltage that are consistent with existing guidelines will be difficult to achieve because the amount of current in the exposure circuit is dependent on exposure circuit characteristics.

Discusses Definitions

The terms we have used to describe theses voltages and their definitions often vary creating confusion.

Stray Voltage
Neutral-to-Earth Voltage
Contact Voltage
Urban Stray Voltage
Metallic Object to Earth Voltage
Animal Contact Voltage

At some point we have to agree on the terms and definitions that will be used to describe the normal and abnormal publicly accessible voltages covered in the proposed Trial Use Guide.

In order to avoid confusion as we move forward in this discussion I propose we 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).

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.

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]

Existing documents that include a description of the difference between "Stray" and "Contact" voltage, but may use different terminology.

From EPRI:

- Understanding Nuisance Shocking (March 2005)

- Neutral to Earth Voltage and Urban Stray Voltage Measurement Protocols, Test Equipment and Procedures, 1010652 (December 2005)

From NEETRAC:

- Stray Voltage: Concerns, Analysis & Mitigation (September 2001)

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