IEEE WORKING GROUP ON VOLTAGES AT PUBLICLY AND PRIVATELY ACCESSIBLE LOCATIONS

Web Cast November 30, 2006

CHAIR – CHUCK DENARDO
(414) 221-3073
(chuck.denardo@we-energies.com)

VICE CHAIR – JIM BOUFORD
(508) 421-7648
(james.bouford@us.ngrid.com)

SECRETARY – RUSS EHRLICH
(302) 283-6097
(russ.ehrlich@pepcoholdings.com)

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

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IEEE

This Web cast will have two parts:

Graciela Varela-Maloney: Consolidated Edison's Program for Detection and Mitigation of Stray Voltage

Chuck DeNardo: Do We Have Big Picture Consensus? Can we move forward?

Questions at any time during the presentation.

Please mute your phones when not speaking.

Consolidated Edison's Program for Detection and Mitigation of Stray Voltage

Program for Detection and Mitigation of Stray Voltage

Distribution Engineering

November 30, 2006

Outline

- Overview
- PSC Requirement
- Implementation
- Additional Mitigation Programs

Con Edison Service Territory

Con Edison Company of NY

- NYC and Westchester
- Area: 660 sq. mi. (Elec & Gas)
- Population: 9.1million

- 3.1 million electric customers
- 13,141 MW

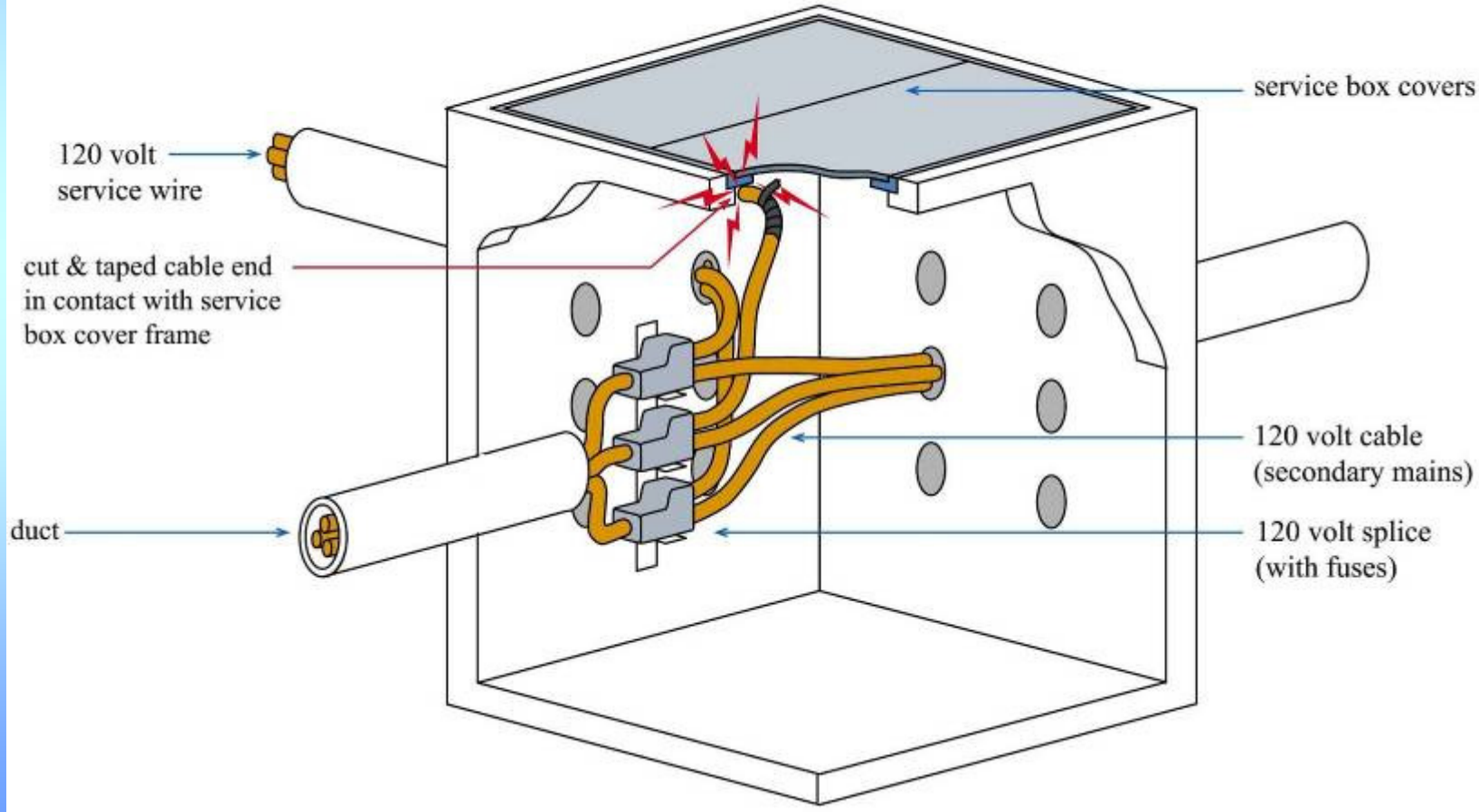
  2006 Peak
- In some areas, Load Density greater than 2100 MW per Sq Mile

Background

- 2003
  - Columbus, OH – 9 year old boy
  - Las Vegas, NV – 39 year old woman
- 2004
  - New York City, NY – Jodie Lane
- 2005
  - France - Dog
  - Baltimore – Dog
  - South Korea – 23 year old woman
- Some Recent Incidents (2006)
  - Model shocked in Manhattan
  - Dog Barkis died in Brooklyn after snow storm
  - 8 year old Briana shocked in Staten Island

Service Box Findings – January 16, 2004

Service Box Representation



Public Service Commission (PSC) Order (CASE 04-M-0159)

State Wide Safety standards:

(1) Annual Stray Voltage Testing

(2) Inspections on a minimum of a five-year cycle

(3) National Electric Safety Code (NESC) compliance

Non-compliance revenue based penalty
(~ $120 million for 2006)

PSC Definitions

<u>Stray Voltage</u>

"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]

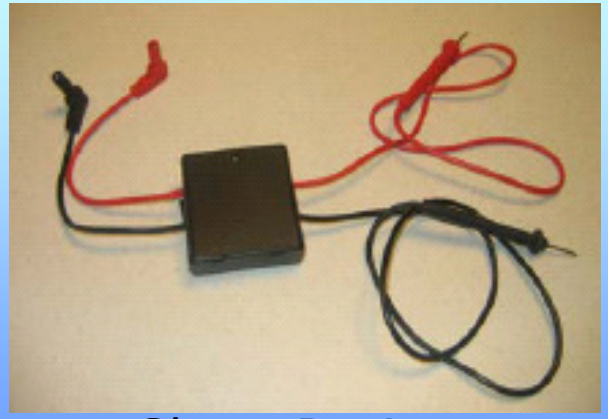
[1]: **CASE 04-M-0159** – Proceeding on Motion of the Commission to Examine the Safety of Electric Transmission and Distribution Systems.

Annual Testing Program

- Underground Structures
- Overhead
- Streetlights

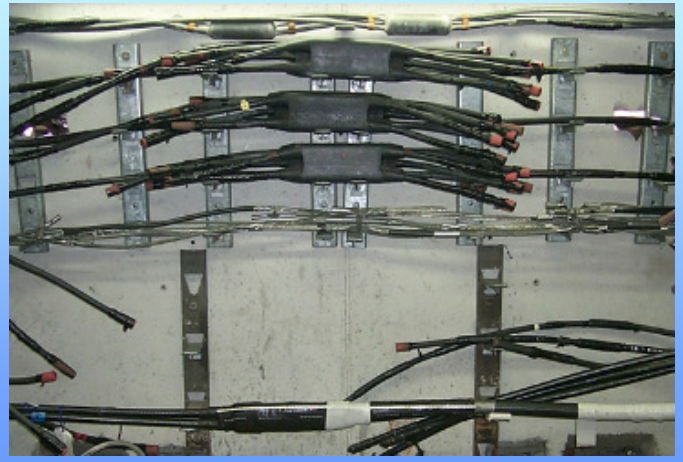
HD Voltage Detector

Multi-meter



Shunt Resistor

Manhole



Service Box

Transformer and Equipment Vault Gratings

Overhead Structures

Streetlights

Testing Results

- Slightly over half are non-Con Ed (~55%)
- Stray Voltage Location
  - ~ 85% on Street/Traffic Lights
    - Municipally owned
  - ~ 15% Variety (CE Structures, Pole/Riser, etc.)
- Root Causes
  - ~90% Services (primarily Street light services)
    - Insulation Breakdown
    - Neutral Corrosion
  - ~10% Other (Mains, Abandoned Services, etc.)

Inspection Plan

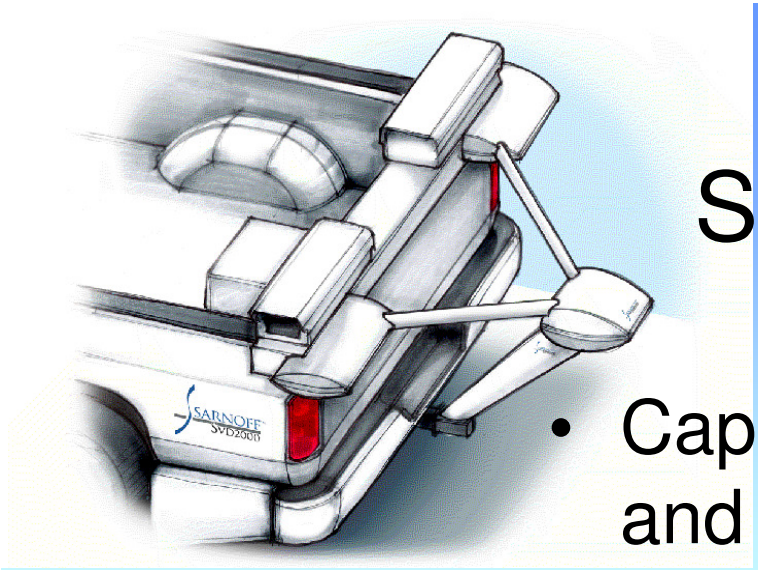
- Inspect each electric structure every 5 years
- Identify and make safe immediate hazards
- Identify items for future upgrade

Inspection

- OH inspections
  - ~280,000 inspections completed in 2005
  - What are we looking for?
    - Stay voltage, rotting or damaged poles, damaged cross arms, damaged or leaking equipment, damaged riser, cracked/broken insulators, etc.
- UG inspections
  - ~86,000 inspections completed since the beginning of 2005
  - What are we looking for?
    - Stray voltage, condition of cable and joints, condition of structure cover, condition of the structure, etc.

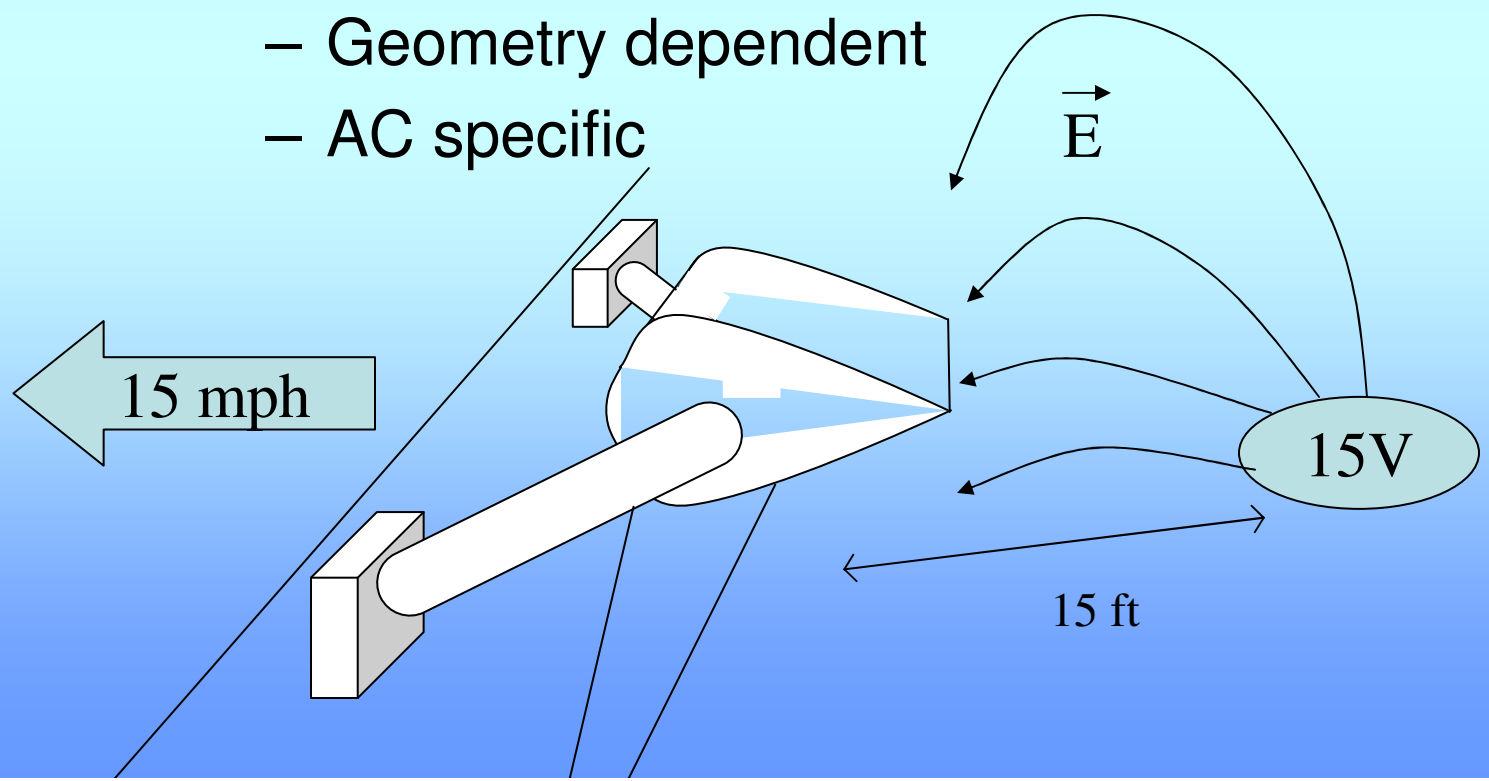
Other Mitigation Methods

- Mobile Stray Voltage Detection Vehicle
- Isolation Transformers
- Secondary Upgrade Plan



Mobile Stray Voltage Surveys Principal of Operation

- Capacitive coupling between detector and charged surface
  - Detects E Field, not voltage
  - Geometry dependent
  - AC specific



Positive Attributes

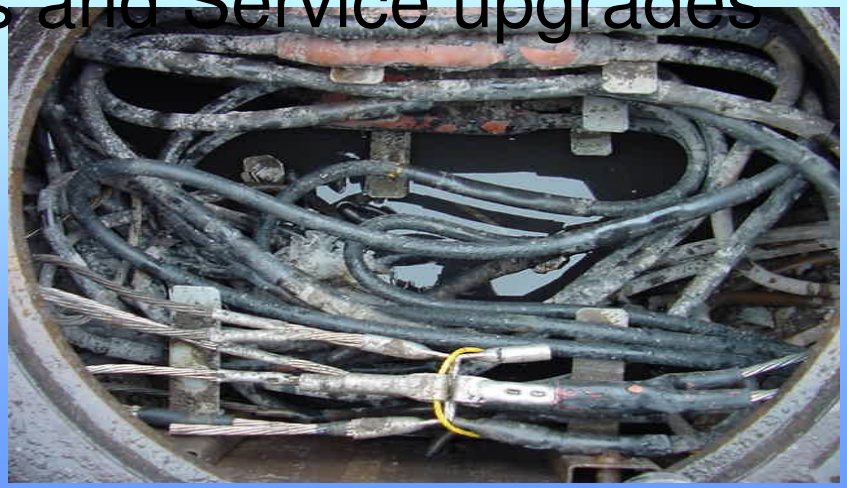
- Detection of voltage possible on any surface
- Voltage surveys may be targeted to specific areas based on operational needs or perceived high risk situations
- Surveys may be completed quickly with a small workforce
- Easy repetitive testing of specific areas
- Tests ANYTHING in its range

Streetlight Isolation Transformer

- Provides electrical separation between line & load side of S/L circuit
- Provides no return path for stray current
- Expected to prevent 78% S/L stray voltages
- Joint pilot program between Con Ed and DOT

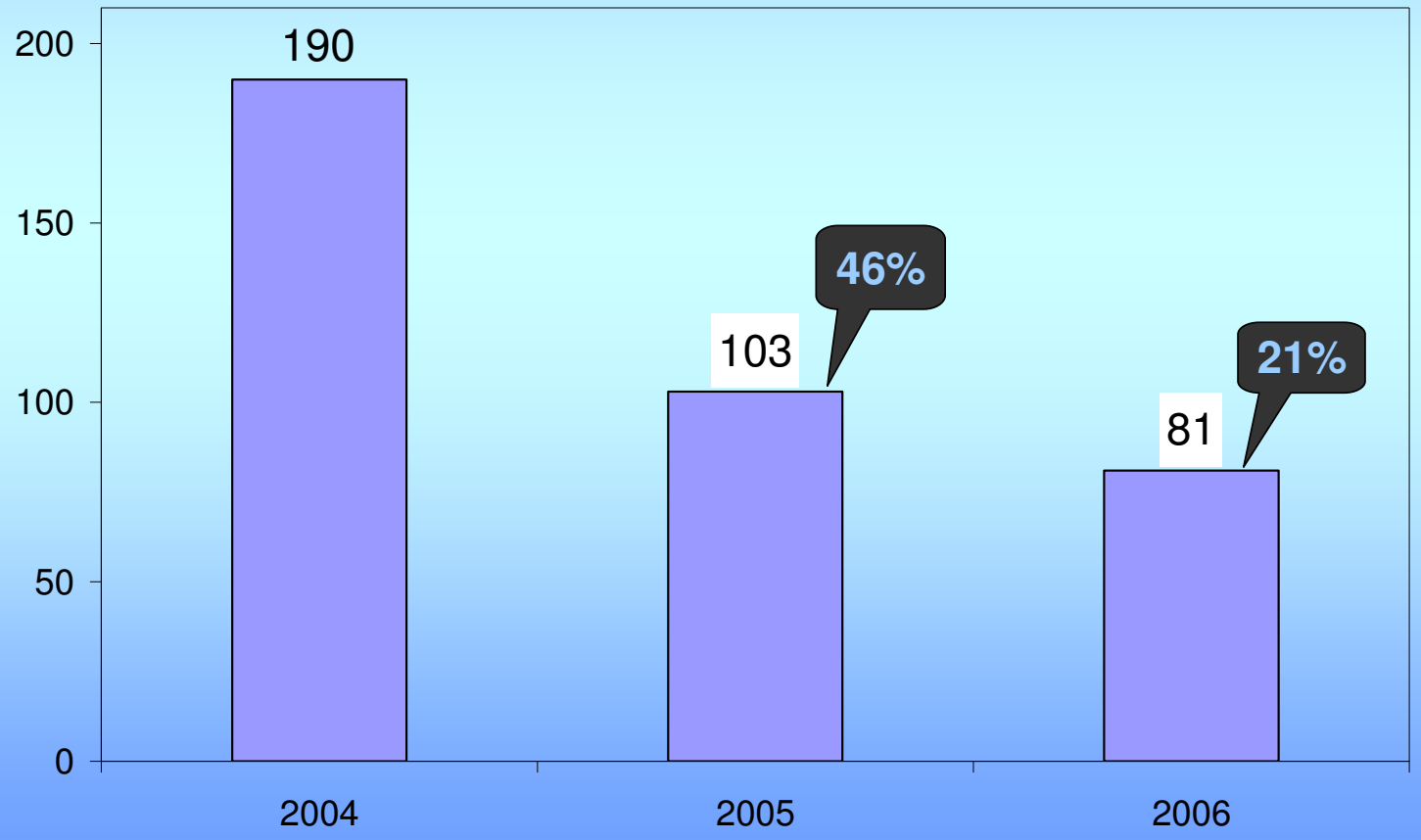
Secondary Upgrade Plan

- Secondary Rebuild: Budgeted to spend $65 million / year
  - Structure enlargements
  - Structure conductor upgrades
  - Transformer replacement/upgrade
  - Mains and Service upgrades



Conclusion

As a result of these programs efforts Con Edison's Electric Shock Events have been reduced by 21% over last year



Questions?

Project Authorization Request (PAR)

PAR Submittal Date - March 13th 2006

PAR On Hold Until IEEE 80 Concern Resolved

Scope and Purpose Language Modified in Montreal

Two NESCOM Concerns Received and Resolved:
- Conflict with Existing Standards
- Affiliations and Openness

PAR Approval Date – September 15, 2006

Approved Until December 31, 2010

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 <u>Privately Accessible</u> Locations

Animal contact voltage (private barn)

Water faucet to earth voltage (private back yard)

Pool water to pool apron voltage

That Are <u>Not Accessible</u>:

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 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.

<u>From EPRI:</u>

- Understanding Nuisance Shocking (March 2005)

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

<u>From NEETRAC:</u>

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

The Plan:

Use feedback from this presentation to make certain the Working Group is headed in the right direction.

If a majority of us agree that we should proceed along two tracks (i.e. Stray Voltage and Contact Voltage), then focus our initial efforts on Contact Voltage.

Use the January meeting in Orlando to discuss an outline for the Contact Voltage portion of the document.

Solicit contact voltage volunteers to begin a draft.

Your Homework……Provide Feedback:

In general:

What do you agree with and why?

What do you disagree with and why?

More specifically:

Are you OK with a normal versus abnormal voltage approach?

Are you concerned about use of the terms "Stray" and "Contact" voltage?

Your Homework……(continued):

Should the guide be about people, or people and their animals?

Are you OK with limiting our efforts to "power frequency related" voltages?

Do we establish exposure limits, or do we simply define exposure assessment protocols and reference existing exposure standards (e.g. IEEE, ICNIRP, NRPB, EU)?

More Homework……

Comments, Concerns, & Recommendations for the "Contact Voltage" Section of the Trial Use Guide.

What should be included in this section?

How should it be organized?

Do you have an existing test protocol you could share, or have you seen useful graphics?

Test instrumentation?

Safety concerns?

And Finally.....

If you would like to volunteer to work on the issue of "Contact Voltage", please let me know.

If you are affiliated with another IEEE group, or a group associated with another organization such as UL, IEC, CSA etc., and you think there should be a formal link between that group and this one, please let me know.

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