History and Application of the MN Stray Voltage Guide

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Saint Paul RiverCentre
History

• Collaborative effort starting in early 2015
• Based upon the Iowa Stray Voltage Guide
• Participants:
  • Minnesota Rural Electric Association
  • Minnesota Power
  • Xcel Energy
  • Otter Tail Power Company
  • Minnesota Farm Bureau
  • Minnesota Farmer’s Union
  • Cooperative Network
  • Minnesota Municipal Utilities Association
  • Minnesota Department of Agriculture
  • Minnesota Department of Labor and Industry

• Published in October 2015
• Closely follows other state’s activities
**Terms...**

**Stray Voltage:** Difference in voltage measured between two surfaces that may be contacted simultaneously by an animal* (cow contact areas)

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*Effects of Electrical Voltage/Current on Farm Animals: How to Detect and Remedy Problems; US Department of Agriculture, Beltsville, MD; December 1991; Page 9-4
Primary Neutral-to-Earth Voltage (PNEV)
- Voltage measured between the utility primary neutral and an earth reference point which is generally a ground rod placed specifically for this purpose

Secondary Neutral-to-Earth Voltage (SNEV)
- Voltage measured between the farm’s secondary neutral and an earth reference point which is generally a ground rod placed specifically for this purpose
Primary Neutral Current Returning to Substation Via Nearby Farm

Some current can return via the farm grounds which can contribute to stray voltage problems.

Current Returning to Substation through the Primary Neutral and Earth
Neutral and Equipment Grounding System

MidWest Plan Service, Agricultural and Biosystems Engineering Department, Farm Buildings Wiring Handbook, 2nd Edition (Ames, IA: Iowa State University, 1992), 40
Example of Stray Voltage

MidWest Plan Service, Agricultural and Biosystems Engineering Department,
Neutral-to-Earth or Stray Voltage?

- Is SNEV present in cow-contact areas?
- Measurements should be made to determine voltage levels in cow contact areas
- Initial inspection
- Chart recordings taken over a several-hour period
Stray Voltage

• All animals are affected by current flow, not voltage. However, current flow has historically been difficult to measure, which is why voltage has become the standard.

• Stray voltage (as defined by USDA) will exist on all farms. The investigator must properly measure the magnitude and interpret results.
MINNESOTA STRAY VOLTAGE GUIDE
A Guide Addressing Stray Voltage Concerns

SEPTEMBER 2015


The following organizations developed this guide.

www.minnesotastrayvoltageguide.com
Frequently Asked Questions

• Most Important Part of the Guide
• Follow Specific Action Items
  • Failure to follow opens the Utility to significant risk
  • Some things are free of charge
  • Policies and procedures need to align with the Guide’s FAQ
• Cow Contact Voltage Action Levels
  • 0.5 volt or more – must investigate further
  • Maximum of 0.5 volt contribution from the primary distribution system
Frequently Asked Questions Cont.

• Steps for Reducing Stray Voltage
  • On-farm changes
  • Off-farm changes

• Planning for the Future
  • Many publications are referenced various sources

• Electrical Licensing, Permits, Inspections and Codes
  • Lots of great information from the MN Department of Labor and Industry
Testing Procedures

Phase 1 Protocol

• Spot voltage checks

• Recording volt meters for at least 24 hours and two milkings
  • Nominal 500 ohm resistor for cow contact areas
  • Primary neutral-to-reference voltage
  • Secondary neutral-to-reference voltage

• Calculate and document the source resistance

• Detailed reports, data, and explanations

• Provide a summary document about farm wiring
Phase 2 Protocol

- Necessary when 0.5 volt or greater is found in a cow contact area
- Designed by the Wisconsin PSC
- Five specific tests are required:
  - Load Box Test
  - Secondary Neutral Voltage Drop Test
  - Signature Test
  - Primary Profile Test
  - 24-Hour Test
Load Box Test

The purpose is to determine utility contribution to cow contact voltages.

• All farm loads are disconnected
• A 240 volt resistive load box is connected to transformer
• Various measurements are made to determine if the utility system has the ability to contribute 1 mA or more of current to cow contact area
• A line crew will be needed for this test
Secondary Neutral Voltage Drop Test

The purpose is to determine the impact of each secondary service on NEV.

• A proxy load is applied to each service (typically a hair dryer)
• Measurements are taken to determine voltage drop
• Wire size and length are determined
• Expected voltage drop is calculated for the connected load
• Comparison of calculated and actual voltage drop are made
• Cow contact voltages are measured
• Mitigation may be necessary
Signature Test

The purpose is to determine the contribution of individual pieces of equipment to cow contact voltage.

- Individual electric loads are started, operated, and stopped
- Investigator records the equipment being tested and start/stop times
- Recording volt meters measure values at various places on the farm
- Chart is compared to equipment start/stop times to determine the impact of individual pieces of equipment
Primary Profile Test

The purpose is to measure or calculate neutral-to-earth voltages on the multi-grounded distribution system.

- Readings of the primary system grounding current and ground rod resistance are made
- Readings taken for all grounded poles within ¾ mile of the farm’s transformer pole
24-Hour Test

The purpose is to chart recording of voltages to monitor fluctuations over a 24-hour period and at least two milkings.

- Primary neutral-to-reference voltage
- Secondary neutral-to-reference voltage
- Cow contact areas with nominal 500 ohm resistor
Helpful Forms

- Standard forms available for the tests
- Sample report and letter to the farmer
- Farm wiring checklist
- Proper farm wiring summary
  - Provided by the MN Department of Labor and Industry
  - Six pages in length, very detailed
  - Has numerous uses for investigators
# Farm Wiring Checklist

This checklist will assist farmers and electrical contractors in visually inspecting farm electrical systems and noting potential stray voltage sources. A checkmark placed in the “Yes” column indicates a potential problem. A licensed electrical contractor should be contacted if any electrical equipment or wiring needs to be repaired or replaced.

## Main Farm Service or Distribution Point
- Connections to grounding electrodes – loose or corroded
  - Grounding electrode(s) missing at the building or structure disconnecting means
  - Grounding electrode(s) missing at the building or structure disconnecting means

## Building or StructureDisconnectingMeans
- Grounding electrode(s) missing at the building or structure disconnecting means
- Connections to grounding electrodes – loose or corroded
- Accumulation of dust, debris, corrosion, etc.
- Corroded or loose neutral connections
- Panel covers removed or missing
- Unused openings in equipment enclosures that are not properly sealed

## Milkhouse
- Cords and cables sitting in water
- Portable electric heaters on bulk tank
- Broken or missing bonding strap for milk line
- Damaged or missing covers or light fixtures, switches, receptacle outlets and other controls
- Damaged, corroded or inoperable lighting fixtures

## In the Parlor or around the Barn
- Pulator wiring
  - Pinched wires
  - Loose, hanging wires, stripped screws, etc.
  - Scrape, breaks or cracks in insulation with exposed conductors
  - Broken stall cords
- Loose, hanging cables
- Energized open conductors (not enclosed in conduit or electrical boxes)
- 120-volt equipment or appliances with attachment plugs that are not polarized
- or have no grounding prong
- Cow trainer insulators broken, missing, dirty or covered with paint
- Light fixtures alternately brightening or dimming when motors start
- Light fixtures appear to be brighter than normal
- Electrical shocks, tingles or perceptions from equipment or metallic objects
- Cords, cables, electrical equipment or motors in damp or wet locations
- Frequent tripping of overcurrent devices (fuses or circuit breakers)
- Electric fence or cow trainer ground conductor connected to building AC electrical system
- Electric fence or cow trainer ground conductor connected to water or milk lines or stanchions
- Damaged electrical conduit
- Damaged cable or wire insulation with exposed conductors
- Cords and cables wrapped around metal piping or other metal systems
- Damaged portable extension cords, connectors and plugs
- Motors, operating irregularly under load, arcing, overheating, etc.
- Receptacle outlets are not properly grounded or will not accept
- 3-prong attachment plugs
- Broken, damaged or missing equipment grounding pins on cord attachment plugs
- or connectors

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[Minneapolis Stray Voltage Guide](#)
PROPER FARM WIRING SUMMARY

Farm Wiring Summary Based on the National Electrical Code® (NEC®)

Customer Name | Representative, Inspector or Advisor Name | Date
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Farm Address | City or Township | County | Zip Code

Note: A comprehensive electrical inspection is not normally performed as part of the utility stray voltage investigation. An existing premises electrical safety and electrical system inspection should be performed by a licensed electrical contractor. All electrical installations are required by law to comply with the National Electrical Code® (NEC®). The licensed electrical contractor is encouraged to consult with the state or municipal electrical inspector to discuss or clarify required code provisions. The electrical contractor will also arrange for any required electrical inspections with the state or municipal inspector for any new construction, remodeling, replacement or repair.

The following is a general list of farm wiring requirements based on the National Electrical Code® and other resources.

The National Electrical Code® contains the minimum installation rules and provisions that are considered necessary for electrical safety. With proper maintenance, the electrical installation should be essentially free from safety hazards. However, an electrical installation that only meets the minimum safety standard may not necessarily be efficient, convenient or adequate for good service and it may not have the capacity to allow for future expansion.

For the purpose of this document the term “listed” means electrical equipment and materials that have been evaluated and tested by an OSHA accredited Nationally Recognized Testing Laboratory (NRTL) and that meet appropriate standards and have been found to be suitable for a specific purpose.

Grounding and Bonding

- Alternating-current (ac) premises systems must be properly grounded.
- The premise central distribution point and each building supplied with electricity must be properly grounded to one or more grounding electrodes in accordance with the NEC®.
- The type and quantity of available grounding electrodes may vary at each location.
- Typical grounding electrodes include metal underground water piping, metal frames of buildings or structures, concrete-encased electrodes (footings and foundations), ground rings and ground rods.
- In general, grounding electrode conductors must be installed continuous without a splice or joint and be secured and protected from physical damage. Grounding electrode conductor terminations must be made with listed lugs, connectors, clamps or other listed and approved means.
- Raceways, enclosures and equipment at a central distribution point or at buildings must be properly grounded and bonded.
- All electrical equipment must be connected to an equipment grounding conductor of the correct type and size. Equipment grounding conductor continuity must be assured and connections must be made with listed devices that are suitable for the application and location.
Glossary

• We have some definitions
• Use them in your policies and procedures
• Consistency across the industry is important
Typical Isolator Installation
Data Recorder
Water Cup
Steel Tie Stall Framing
Water Line
Steel Tie Stall
Stainless Steel Milk Line
Barn Floor Reference Point
Barn Floor Reference Point
Floor Drain
Step Voltage Measurement – Calf Pen
Step Voltage Measurement – Pasture
Cattle Waterer
Shower (Faucet to Floor)
Barn Neutral
Primary and Barn Neutral Reference Ground Rod
Primary Neutral (Pole Transformer)
Primary Neutral
Questions?

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