1C.7.1—Stray Voltage

1. Scope

This document provides basic information on stray voltage and some of its common causes. Information on measurement and verification protocols, and methods of mitigation, primarily for dairies, are addressed separately in Policy 208. The present document focuses on stray voltage as it relates to livestock, and does not directly address other problems such as low-level human shock hazards and equipment susceptibility to grounding issues. Equipment susceptibility is addressed in IEEE 1100 cited in the references.

2. References and Resources

For those desiring a more thorough knowledge of stray voltage and its effects, the references and resources listed below apply to the extent specified in the body of this standard:

IEEE 1100, Emerald Book. *IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment* (discusses stray voltage effects on electronic equipment)

IEEE Working Group on Voltages at Publicly and Privately Accessible Locations

ASABE EP473.2, *Equipotential Plane in Livestock Containment Areas*, American Society of Agricultural and Biological Engineers

United States Department of Agriculture, Handbook 696, *Effects of Electrical Voltage/Current on Farm Animals, How to Detect and Remedy Problems*

Public Service Commission of Wisconsin, Stray Voltage website

Midwest Rural Energy Council, website

3. Definition of Stray Voltage

Stray voltage is a steady-state voltage resulting from the normal delivery or use of electricity that 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.

Neutral-to-earth voltage (NEV) is a voltage between the neutral conductor and the earth when measured to an electrically remote ground reference point. Stray voltage is a special case of NEV, as it is defined at a specific location. NEV is a normal result of operating any grounded electrical system, including the customer's electrical system and the company's system. NEV is the result of normal return current flow through the impedance of the grounded neutral conductors and connections.

Stray voltage is *not synonymous* with contact voltage. Contact voltage results from power system faults, and is not related to the normal delivery or use of electricity. Contact voltage can exist at levels that may be hazardous. If a tingling sensation or painful shock is experienced, faulty wiring or defective equipment may be to blame; corrective action should be taken by a qualified electrical worker.

Low levels of AC voltage on the grounded conductors of a farm wiring system are a normal and unavoidable consequence of operating electrical farm equipment. Stray voltage is the general term used to describe these low-level voltages when they are measured between two objects that can be contacted simultaneously.

4. Possible Sources of Stray Voltage

Both on-farm and off-farm sources may contribute to the level of stray voltage present.

Some of the common on-farm sources of stray voltage are listed below. Customers may benefit from addressing these issues independently and with the aid of a licensed electrician.

- Interconnection of equipment grounding conductors and neutral circuit conductors at places other than those required by the National Electrical Code
- High-impedance connections on the neutral or ground wire system, such as corroded connectors or broken grounding wires
- Poor grounding conditions, such as high soil resistance or loose ground connections
- Undersized neutral conductors
- Dirty, dusty, corroded, cobwebbed or damaged electrical boxes and devices
- Unbalanced single phase loads
- Defective electrical equipment, such as insulation break down in a motor
- Normal operation of electrical equipment in distant parts of the barn or in remote areas, which may result in stray voltage within animal confinement areas
- Corroded underground cable neutral
- Electrical load with high harmonic currents

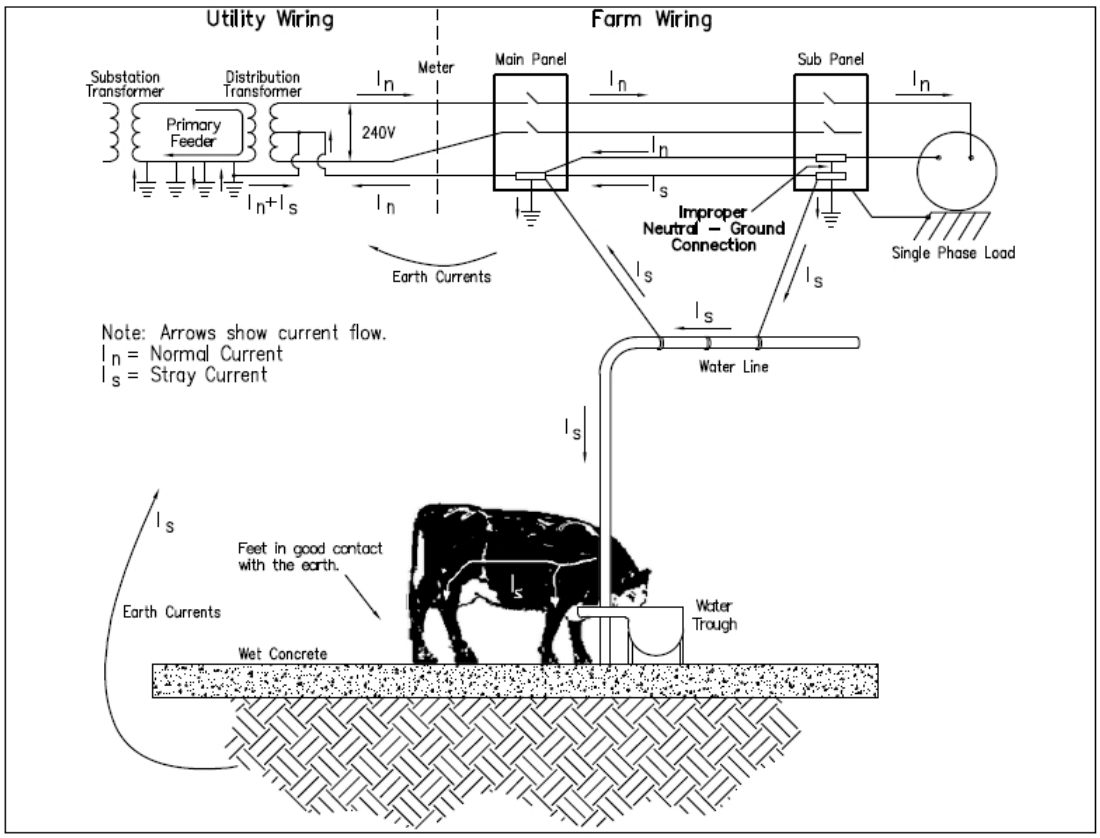

Figure 1—Typical Farm Electrical System

An improperly grounded neutral at a sub panel is shown in Figure 1 as an example of how stray voltage can come from an on-farm source. The improperly grounded neutral conductor can create additional return paths via the earth and its multiple ground connections. This stray current will result in voltages seen between grounded objects; this is stray voltage.

CAUTION!

To be safe, do not attempt to make electrical measurements on electrical wiring or within electrical boxes or cabinets unless you are qualified to do so. Follow safe work practices around any energized parts.

Some common off-farm sources of stray voltage are listed below. Company Policy 208, *Stray Voltage Investigation*, discusses the procedures used to identify and mitigate off-farm sources.

- Unbalanced load on the three phase utility system
- High-impedance connections on the neutral or ground wire system, such as corroded connectors or broken grounding wires
- Poor grounding conditions, such as high soil resistance
- High impedance neutral conductors
- Other nearby utility customers

5. Effects of Stray Voltage

Although the effects of stray voltage are sometimes debated by interested parties, peer-reviewed studies over the past several decades continue to indicate that low levels of stray voltage have only a minimal impact on the livestock. While not necessarily supported by peer reviewed research, dairymen indicate the following effects on cows from stray voltage:

- Reduced milk production
- Reduced food or water intake over time
- Disease or reduced immune function
- Hormonal changes
- Changes in blood composition
- Birth defects
- High “Somatic Cell Count” (SCC) in milk