

1C.7.1—Stray Voltage

ENGINEERING
Standards and Technical Support Department

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1 Scope

This document provides basic information on stray voltage and some of its common causes. Stray voltage can affect livestock and voltage-sensitive equipment (VSE) such as computers. Although the measurement and mitigation techniques presented are applicable for problems with VSE, this document does not thoroughly cover these applications; instead it focuses on livestock. For computer problems due to stray or neutral to ground voltages, see IEEE 1100 for recommended grounding practices or mitigation techniques. The other references are also excellent for those desiring a more thorough treatment of stray voltage and its effects.

2 References and Resource Documents

The references and resource documents listed below apply to the extent specified in the body of this standard.

Wisconsin Power Company, *Stray Voltage Detection*

IEEE 1100–1992, Emerald Book. *IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment* (Source for information on stray voltage and its effects on electronic equipment.)

Wisconsin Power Company, *Equipotential Planes for Stray Voltage Reduction*

United States Department of Agriculture, Handbook 696, *Effects of Electrical Voltage/Current on Farm Animals, How to Detect and Remedy Problems*, commonly called the “Cow Book.”

3 Definition of Stray Voltage

Stray voltage is a small voltage that can exist between two surfaces, which an animal can touch simultaneously. Stray voltage is a special case of neutral-to-earth voltage (NEV); it differs from NEV because it is defined at a specific location.

NEV is a normal result of operating any grounded electrical system; this includes the customer’s electrical system as well as PacifiCorp’s system. NEV is a voltage between the neutral conductor and the earth when measured to an electrically remote ground reference point. NEV is the result of current flow through the resistance of the grounded neutral conductors and connections. The current that flows may be either normal return current or electrical fault current.

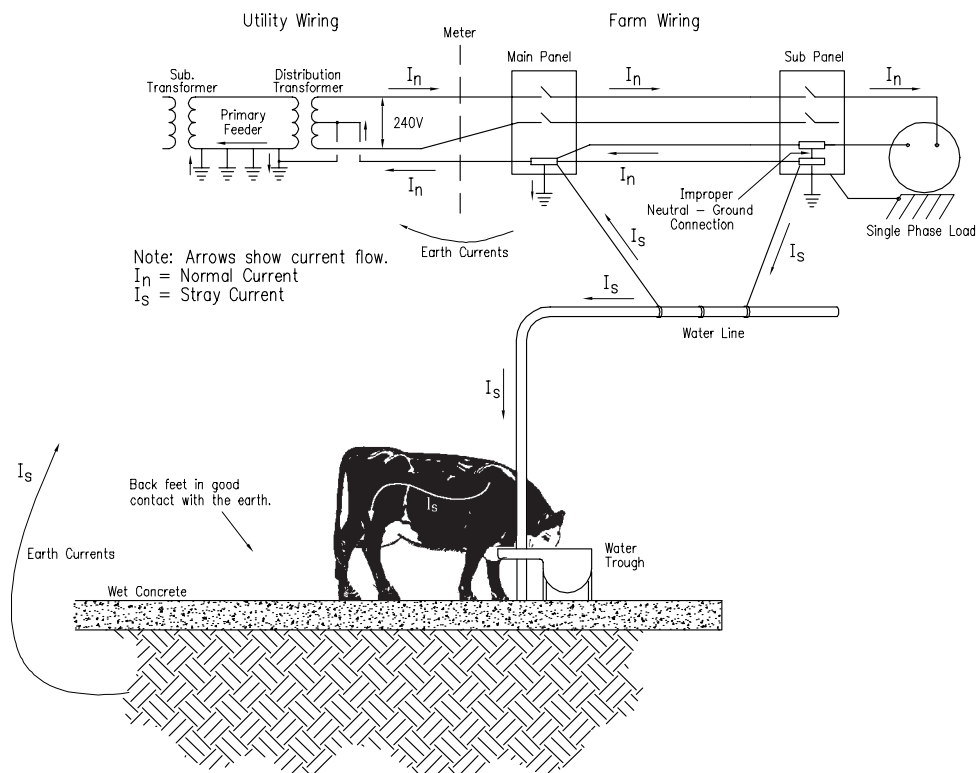
Low levels of ac voltage on the grounded conductors of a farm wiring system are a normal and unavoidable consequence of operating electrical farm equipment. Stray voltage is the general term used to describe these low-level voltages when they are measured between two objects that can be contacted simultaneously.

4 Possible Sources of Stray Voltage

Stray voltage on a farm is, typically, the result of several voltage sources acting simultaneously. 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:

1. Interconnection of equipment grounding conductors and neutral circuit conductors at places other than required by the National Electrical Code
2. Inadequate connections on the neutral or ground wire system (such as corroded connectors, or broken grounding wires)
3. Poor grounding conditions (such as high soil resistance, or loose ground connections)
4. Undersized neutral conductors
5. Dirty, dusty, corroded, cobwebbed or damaged electrical boxes and devices
6. Unbalanced 120 volt loads
7. Defective electrical equipment (such as insulation break down in a motor)
8. Normal operation of electrical equipment in distant parts of the barn or in remote areas (may result in stray voltage within animal confinement areas)
9. Defective underground cable
10. 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 be the source of earth currents via the ground wire and its multiple ground connections. This earth current will result in voltages seen between grounded objects; this is stray voltage.

5 Effects of Stray Voltage

Symptoms reportedly attributed to significant levels of stray voltage include:

1. Decreased milk output of dairy cows
2. Animals' reluctance to eat or drink from a feeder
3. Improper operation of sensitive electronic loads

6 Levels of Voltages Encountered

It is important to make a distinction between low-level stray voltage and the more hazardous voltages that produce a painful shock.

6.1 Personal Shock

When you experience a painful personal shock, you are not feeling stray voltage. Personal shock usually indicates defective phase or “hot leg” wiring or equipment. Since these conditions may be hazardous, call an electrician.

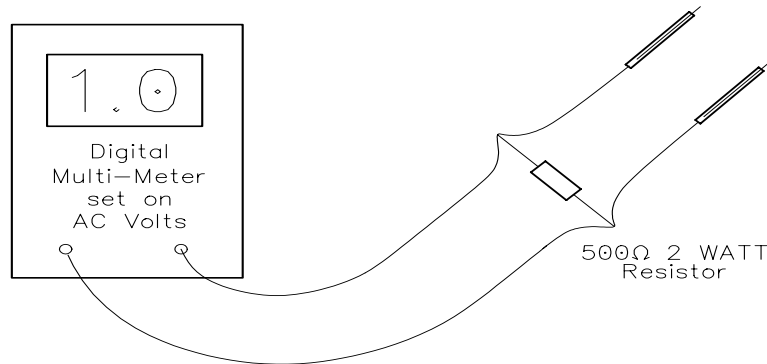
6.2 Tingle Shock

If you are feeling a low-voltage “tingling” when in the barn, this could be an indication of an electrical device with an internal short, particularly if it disappears when the device is unplugged. If this happens you should call an electrician to fix the device.

6.3 Symptoms Present but No Tingle Shock Can Be Felt

Livestock may feel voltages not sensed by humans because the animal's body resistance is less than that of a human. Voltage measurements should be taken wherever livestock exhibit symptoms attributed to stray voltage. If you are unsure of how to take voltage measurements, you should consult an electrician or PacifiCorp. Typically, stray voltage measurements are made with a digital voltmeter with a 500 ohm shunt resistor. The 500 ohm resistor approximates the body resistance of a full grown cow. Measurements can be made using the point-to-point method; that is, measuring the voltage between any two points that an animal may contact with a digital voltmeter and a 500 ohm shunt resistor.

Figure 2 – Digital Voltmeter with 500 ohm Two Watt Flame-proof Shunt Resistor



NOTE:

THE SHUNT RESISTOR MUST BE REMOVED FROM THE METER BEFORE USING THE METER TO MEASURE ENERGIZED CONDUCTORS. REFER TO USDA HANDBOOK 696 FOR DETAILS ON VOLTAGE MEASUREMENT.

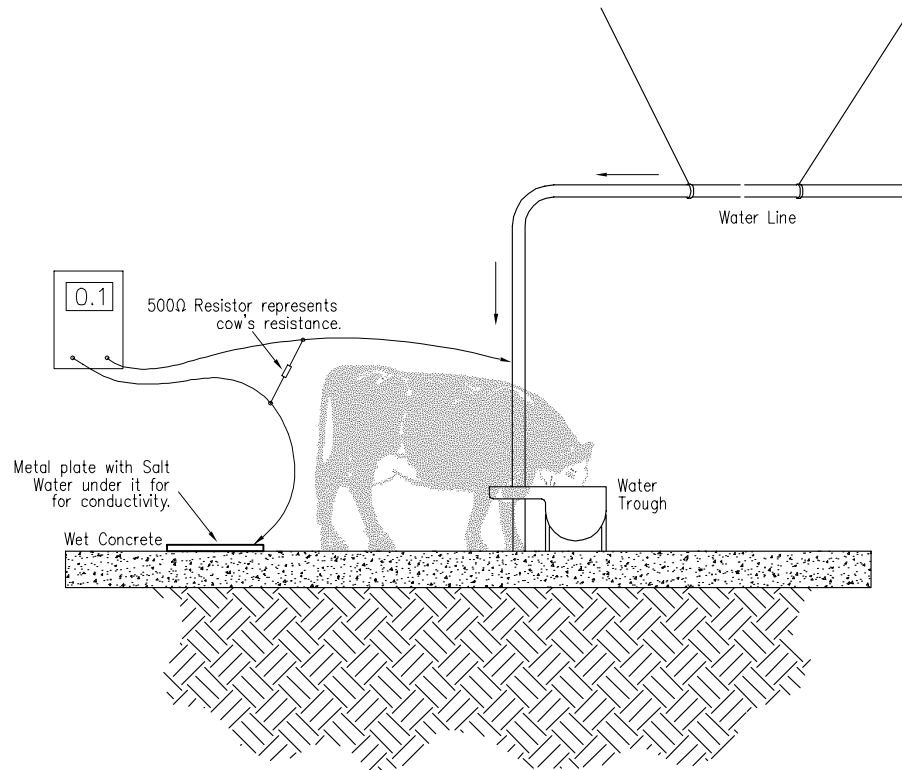
7 Interpreting Voltage Data

Research indicates that corrective action is not needed for voltages below 1.0 volt when using a 500 ohm shunt resistor to measure stray voltage. Usually voltages will be measured between points that the animals can touch simultaneously.

CAUTION

For your own safety, do not attempt to make electrical measurements on electrical wiring or within electrical boxes or cabinets unless qualified to do so. Do not use the voltmeter with the shunt resistor to measure voltage on any energized parts.

Figure 3 – Measuring Stray Voltage Using a Digital Voltmeter with a 500 ohm 2 watt Flame-proof Shunt Resistor



NOTE:

THE VOLTAGES MEASURED ARE AT POINTS THAT CAN BE CONTACTED SIMULTANEOUSLY.

8 Reducing Levels of Stray Voltage

Most of the sources of stray voltage are in the facility. Some of the methods used to reduce the level of stray voltage may require the use of an electrician and are listed below.

1. Confirm that the wiring meets the current National Electrical Code.
2. Bond all metal objects that animals can touch simultaneously.
3. Balance 120 volt loads, use 240 volt equipment when possible.
4. Replace bolted connections with compression connections.
5. Oversize neutral wires.
6. Use of 240 volt equipment to reduce neutral current.
7. Increase size ϕ and decrease length of the secondary conductors.
8. Install an equipotential plane.

9 Issuing Department

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10 Approvals and Authorization

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