

When stray voltage occurs, it can wreck havoc on a dairy. Avoid it at all cost.

# Reduce the risk of stray voltage

**Stray voltage isn't what the name implies.** It's not a voltage that has spilled out of the wires, and wandered off. Stray voltage is a natural electrical phenomenon associated with the normal functioning of an electrical system. It follows the laws of physics, notably Ohm's Law.

The secondary (farm) electrical system and grounded primary (utility) electrical systems both have a neutral conductor grounded to the earth. In all electrical systems, current flows from the source, through the electrical load and back to the source to complete the circuit. The source on the utility system is the substation; on a farm it's the transformer.

Though most of the current flows back to the source through the neutral wire, some may flow through the earth. This current can cause a small voltage that can be measured on metal objects, such as waterers, and the adjacent floor or earth. This is known as neutral-to-earth voltage (NEV).

If there's a voltage, current (amperes) can flow between the two points if they're contacted simultaneously. In a dairy facility, current may flow through a cow when she comes in contact with metal equip-

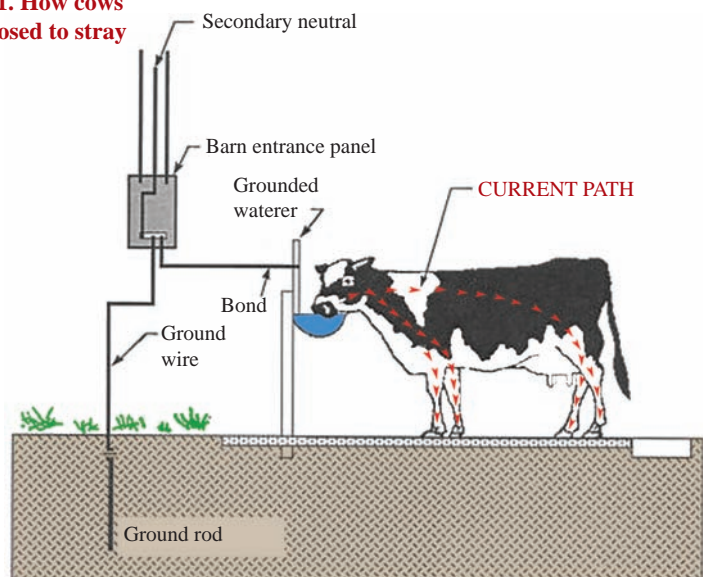
ment that has a different electrical potential than the concrete floor she's standing on. This is called stray, or cow contact, voltage.

Dairy cows have much lower resistance to electrical current flow than humans. Human resistance ranges from about 500 to 5000 ohms for broken skin to as high as 10,000 to 300,000 ohms for dry skin. Dairy cows' range of resistance is 300 to 1200 ohms. In wet areas, a cow's resistance is about 500 ohms.

Studies conducted at several universities suggest it takes at least 4 milliamp (mA) to cause behavioral changes in cattle. Using Ohm's law,  $E$  (voltage) =  $I$  (current) x  $R$  (resistance), a 4 mA current flow through a 500-ohm resistance equates to about 2 volts. Generally, voltages between the earth or concrete floor and metal cow-contact surfaces should be 1 volt or less.

This low voltage and current won't directly harm a cow, but exposure can cause avoidance behavior. A cow exposed to this current in the milking parlor may try to avoid entering the parlor or not let milk down properly. If she's exposed to the current from a metal waterer, she may avoid drinking.

**Figure 1. How cows are exposed to stray voltage**



## Common sources of stray voltage

On-farm sources include:

1. Secondary neutral-to-earth voltage caused by a high resistance neutral or unbalanced 120-volt loads. This is one of the most common causes of stray voltage.

## FYI

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■ Find information about the installation of equipotential planes in the American Society of Agricultural and Biological Engineers (ASABE) Standards book in the section titled Engineering Practice (EP473.2 Jan 01), Equipotential Plane in Animal Confinement Areas. Website: [www.asabe.org](http://www.asabe.org). Tel: 269-429-0300. Email: [hg@asabe.org](mailto:hg@asabe.org)

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### 2. Improper wiring.

3. Ground faults caused by loose wire connections, damaged wire insulation or wet electrical terminals.

Off-farm sources include ground faults at a neighboring location, telephone or cable television grounding systems and NEV on the primary electrical system, which can impose a NEV on the secondary wiring system on a farm.

### Nix stray voltage

When planning new dairy facilities, you can do several things to reduce stray voltage occurrences. Meeting these requirements in existing facilities will also reduce the possibility of stray voltage.

1. First, ensure all wiring meets the National Electric Code® (NEC) requirements. Improper wiring can create a variety of electrical conditions that can lead to higher levels of NEV voltage, increasing the risk of exposure to stray voltage at cow-contact points. Some wiring considerations:

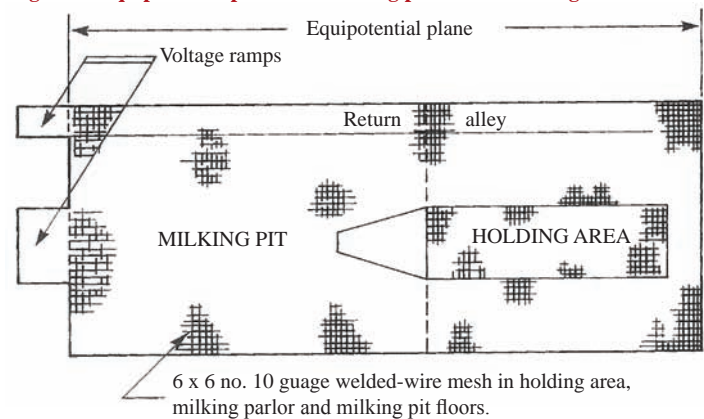
- Properly size electric service, considering future loads.
- If your dairy has a 120/240-volt electrical system, have your electrician carefully balance all 120-volt loads. Unbalanced 120-volt loads can cause a high level of NEV on the neutral, thus increasing the risk of stray voltage exposure. Whenever possible, use 240-volt rather than 120-volt motors to help reduce unbalanced loads.
- Provide for proper service and equipment grounding.
- Size electric wires based on circuit lengths and electric loads.
- Plan and install equipotential planes in all concrete floors in all livestock confinement areas where metal equipment could become energized and cattle can make contact. The equipotential plane puts the concrete floor at the same electrical potential as the adjacent equipment. When a cow comes in contact with the metal equipment, there's no potential difference, and current won't flow through the cow.

An equipotential plane, required in all new construction, is created by electrically bonding the reinforcing mesh in the concrete floors to the farm's grounding system. It's important to establish a transition where cows enter or exit the building. (Figure 2.)

- Properly ground all electric fencer systems. Keep fencer grounds separate from grounding on the farm electric system.
2. Have a qualified electrician inspect the farm electrical system annually. Routinely include a check for stray voltage.
3. Maintain your electrical system, including frequent inspection of wires, to evaluate its condition. Immediately repair damaged wires or panels, and check and tighten terminal connections and splices. Damaged wiring can lead to faults that produce abnormally high NEV levels.
- Loose or high resistance neutral connections can cause more return current to flow through the earth, thus increasing NEV levels.
4. Consider wiring all subpanels with four wires to allow separation of the system neutral and equipment grounding conductors. On most farms using a single phase 120/240-volt power system, subpanels are usually served from the main service panel by a three-wire system. It consists of two ungrounded conductors and a grounded neutral conductor.

Though NEC allows these systems, they have a drawback. Their

Figure 2. Equipotential plane in a milking parlor and holding area



Source: "Equipotential Planes for Stray Voltage Reduction," published by the Midwest Rural Energy Council.

electrical equipment grounds are tied to the neutral conductor. A fault in an electric motor causes a high fault current to flow onto the neutral and produce a serious NEV condition.

The four-wire system to serve subpanels avoids this. This system has two hot wires, a grounded neutral conductor and a separate equipment grounding wire. An electrical fault in a motor will cause current to flow through the grounding conductor directly to the service ground. NEV levels on the neutral conductor won't increase, and cows won't be exposed to stray voltage when they touch metal equipment tied to the neutral system.

5. If a dairy is supplied by a grounded neutral (wye) primary and there are elevated NEV on the primary system, consult with your utility about isolating the primary and secondary neutral systems. Request a stray voltage check. If high NEV levels are found on the primary electrical system, the utility will take corrective action. Any problems on the dairy's electrical system must also be corrected.

If the utility finds a significant voltage on the neutral that causes cow contact voltages of 1 volt or more, it may install a neutral isolation device that separates the utility neutral from the farm neutral system. This will prevent current flowing from one onto the other.

After the utility isolates the neutral system, notify telephone and cable companies so they can install isolation devices on their grounding systems. Otherwise, their systems can bypass the neutral isolation system, and the dairy will still experience elevated NEV.

In rural areas many utilities still operate delta systems which have no neutral conductor. Current flows from the source on one hot conductor and back to the source on another hot conductor. Since a delta primary system doesn't have a neutral, no NEV can be imposed onto the secondary neutral system from the utility. But NEV could still occur, probably related to wiring problems.

Rarely, a neighboring farm, business or residence could have a fault in electrical equipment such as a submersible pump. Current could flow from the faulted equipment through the earth to your dairy and into metal equipment that cows contact. This is rare, fortunately, because it's also often difficult to resolve.

If you suspect stray voltage is impacting your cows, hire a qualified electrician to inspect your electrical system. Have an experienced person take voltage measurements at cow contact areas. If 1 volt or more is measured and the problem can't be traced to an on-farm cause, request your utility conduct a test. With communications and cooperation, most stray voltage incidences can be resolved quickly. ■