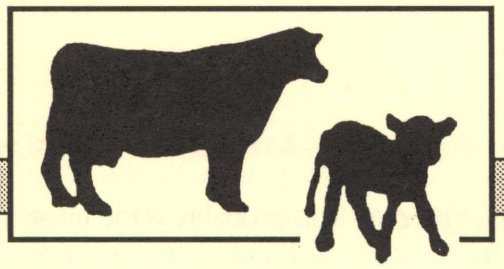
Virginia Cooperative Extension
Virginia Tech • Virginia State

Dairy

REPRINTED 1992

PUBLICATION 404-250



Stray Electricity on Dairy Farms

G. M. Jones, Extension Dairy Scientist, Management
Virginia Tech

In recent years it has become evident that small electrical currents may come in contact with dairy cows and may cause significant losses in milk production as well as certain health problems. This condition may be caused by current existing on the grounded neutrals of the farm electrical system, poor or faulty wiring, improper grounding, or faulty equipment. Surveys in Minnesota and Washington report that approximately 20 percent of all dairy farms have suffiicient current to cause significant effects upon the herd. In Virginia, 25 percent of the herds may be affected. Nebraska reported that over 58 percent of the milking operations or waterers exceeded threshold levels (0.5 volts).

The effect of stray electric current can be severe. Many of the symptoms can be caused by other factors; they are not specific to stray voltage alone.

Effects Upon Milking Herd

1. Altered animal behavior

   a. *Reluctance to enter the parlor* - Cows refuse to enter the parlor and have to be driven in. On occasion, cows that normally enter the parlor without hesitation will start to move back and have to be forced to enter. On other occasions, cows may refuse to cross a metal grate. Also, cows may hurry to leave the parlor.

   b. *Uneasiness in the parlor* - There may be mild to excessive movement of rear feet, cows may dance or step around almost continually; and, in a herringbone parlor, a cow may put her head over an adjacent cow as if avoiding contact with the feeder.

   c. *Reduced feed consumption* - Cows will be reluctant to eat from any feeder where they may become shocked. Parlor feeders, metal stanchions, and automated silage feeders are excellent conductors. Any metal feeder attached to an electric motor should be grounded properly and checked periodically.

   d. *"Lapping" of water or reluctance to drink* - If cows are shocked as they drink, some may lap at the water as if trying to avoid the shock. Also cows may approach waterers with care and even avoid or favor certain water stations. They may choose to drink quickly and more frequently. There does not have to be electrical power to the immediate area. Electric potential differences can exist between water tanks and adjacent ground surfaces. Electrical heaters in water tanks should be checked.

2. Poor milking performance

   a. *Incomplete milking or uneven milk out* - This probably is the most common symptom of stray voltage. Check udders after milking for complete milk out. Some cows don't milk out cleanly or are slow milkers for reasons other than stray voltage. Incomplete milking can be caused by the presence of strangers at milking time, loud noises, fright, equipment malfunction, or improper preparation of the cow for milking.

   b. *Longer milking times* - It takes longer to milk cows who have poor milk let-down. Stray voltage may extend milking time in a 100-cow herd by 30 minutes, especially the afternoon or evening milking.

3. *Reduced milk production* - Production decreases have been estimated at 10 percent or 4 to 6 lb per day or more. The effect can be continuous or occasional. Bulk tank weights may drop sharply for a period of time and then return to near normal. Daily milk production by individual cows may decline dramatically after calving; daily peak level of production for 16,000 to 20,000- lb herds should average between 75 to 93 lbs by older cows and 59 to 78 lbs by first lactation animals. DHI Herd Summaries show average peak test day production for both groups.

   The effect on milk production probably is caused by some of the other factors associated with stray voltage: reduced feed or water intakes, poor milk let-down, or increased somatic cell counts. When a herd's milk production is low, the herdsman should evaluate the nutritional content of the ration and be sure that cows have access to sufficient feed. Proper milking procedures also are important.

4. Poor animal health

   a. *Increased mastitis* - Bacteria present in the udder will multiply in residual milk left by incomplete milking.

   b. *Elevated somatic cell counts in milk* - Bacterial infections of the udder will increase cell counts. If the infection persists for much of the lactation, cell counts may be slow to decrease after the problem has been corrected. Cows with elevated cell counts may have negative results from bacteriological examination of milk samples.

Voltage Levels of Concern

The voltage level at which cows may react has not been scientifically defined. New Zealand studies observed a decline in milk yield when cows were subjected to 3 volts. They detected more than 3 volts on the power earth system in 35 percent of the herds surveyed. Practical experience has indicated that the presence of more than 1 volt is excessive and reason for concern. If the voltage is between 0.5 and 1.0 volt during milking, it should be monitored to determine if higher voltages are present during specific hours, days, seasons of year, or weather conditions. These farms should purchase a good voltmeter and periodically monitor voltage levels. If voltage exceeds 0.5 volt between milking, it should be monitored during milking. Research has shown that cows respond to 0.7-0.8 volt, equivalent to 2-3 milliamps.

The following guidelines for voltage levels were suggested by G. F. Williams (Washington State University).

Voltage	Cow's expected reaction
0-0.5	Normal
0.5-0.75	Suspicious
0.75-1.5	Mild reactions
1.5-5.0	Strong to critical reactions
Above 5.0	Dangerous

Measuring Stray Voltage

Use a voltmeter that has an AC voltage scale which has the capability of reading to the nearest 0.1 volt level at loads between 0 and 5 volts. The voltmeter should not read DC voltage on the AC scale. Test voltmeters by connecting the two voltmeter leads to each terminal of a conventional 1.5-6 volt DC dry cell battery. The voltmeter should have a relatively high input impedance (at least 5,000 ohms per volt AC).

Digital voltmeters are well adapted to the analysis of stray current. In difficult cases or where there is something highly irregular or unusual, recording equipment or a portable oscilloscope may be helpful.

Establish an isolated ground rod at least 25 feet from the milking facility and also 25 feet from any underground pipes, electrical equipment, ground rods, or fencing. Turn off electric fences. The rod should be driven at least 2 feet deep into moistened soil.

Connect one insulated lead of the voltmeter to the isolated ground rod; attach the other insulated lead to the bare ground wire which runs from the barn service entrance box to the ground rod at the barn or parlor.

1. Read and record the voltage at the milking facility.

2. Open the main disconnect at the barn service entrance. No load is operating in the parlor or barn at this time, but the primary neutral has not been disconnected. Any voltage at this time has been transmitted through the primary neutral (main power line) or grounding system and originates somewhere else. Check the current flow (amperage) on the neutral. More than 1 milliampere is excessive.

3. Open the main disconnect to the farm. Be sure any wells are disconnected. Any voltage is due to current on the primary neutral created by loads at other locations on the main power source.

4. Reconnect all services.

5. Check 220-volt loads. Record the voltage as each 220-volt load is added to the previous load. Also read the voltage as each load is turned off in reverse sequence. Be alert for voltage spikes associated with the start of any motors. Any voltage increase could be due to the increased load or to faulty equipment. A primary neutral problem is indicated when the voltage increase is about the same (0.3 volt or higher) with each 220-volt load addition of equal amperage rating. Any amperage increase on the neutral may be due to high resistance on the primary neutral or a ground fault in the equipment.

6. Check 110-volt loads: Record the voltage as each 100-volt load in the milking facility is added to the previous load. Then record the voltage as each load is shut off. Carefully observe the voltage as each load starts and stops. Increases of 0.3 volt may be caused by high neutral resistance created by poor connections, resistance of the wire, or balance of line-to-neutral loads.

7. Milking time checks: Periodically record voltage reading, include peak and steady values. Check all cow contact points: stalls or stanchions, floor grates, electrically driven feeders, and milking machine claws. Also check milking pipeline, milk pump, bulk tank, pulsator grounds, waterers, outside feeders, and entrances into milking parlors. You can continue to use the isolated ground rod but you must not forget that the voltage experienced by the cow is equivalent to the difference between the voltage realized at different locations, and not the actual voltage readings. Check voltage at the barn service entry ground at intervals during milking.

8. Isolated system testing: Repeat these testing procedures in cooperation with the power supplier, after they have temporarily disconnected the bond at the transformer between the primary neutral and the secondary neutral. This disconnection may not be possible with certain transformers. After the bond has been disconnected, there should be no change in the voltage when 220-volt loads are added. Any increase in voltage is due to either an electrical fault in that equipment or the voltage on the primary neutral is feeding onto the farm's secondary neutral through the earth or some other electrical connection, the telephone, or the water supply system.

Many stray voltage problems originate in the barn. Problems with wiring, motor faults, ground rod resistance or double grounds account for over 50 percent of all problems. Have an electrician check the electrical system as soon as the voltage checks have been completed.

On-farm Sources

1. Service entrances - Are all service entrances grounded properly? Loose connections, undersized conductors, or total absence of a ground can result in the presence of voltage within the milking facility.

2. Faulty equipment - These sources include improper grounding or lack of grounding. Voltages can develop if a malfunction or short occurs. Other faults result from deterioration of conductor insulation in circuits or motor windings.

    a. *Milk transfer pumps* - shorted, corroded, or improperly grounded.

    b. *Watering tanks or other watering devices* - Feed and other organic materials often accumulate in waterers. Their decomposition may be associated with DC voltages. They should be cleaned out weekly. Deteriorated insulation and faulty heating elements can develop in electrically heated waterers.

    c. *Parlor feeding systems or silo unloaders* - Dust can accumulate in electrical components, and there can be broken ground wires or other shorts.

    d. Electric fences may be improperly grounded.

VOLTAGE CHECKS

	Barn Service Entry	
	Voltage (AC)	Amperage
1. Establish isolated ground rod		
2. Disconnect barn load		
3. Open main disconnect to farm		
4. Checking 240 v loads		

Load added (* increases over 0.3 v)	On	Off	On	Off
Vacuum pump				
Bulk tank compressor				
Hot water heater				
Silo unloader				
House range				

5. Checking 120 v loads

No load				
Lights				
Ventilation fan or heaters				
Milk pump				
Refrigerator				
Other 120 v motor _____				

6. Milking time

Milk line		
Grate		
Stall		
Feeder		
Pulsators		
Waterers		
Milk pump		

e. Deteriorated wire and corroded or loose terminals on electric pulsators may cause DC voltages.

f. Poorly grounded or shorted telephone service.

g. *Faulty fluorescent lighting ballasts* - Use industrial quality fixtures with waterproof enclosures. Ground all light casings.

3. *Wiring* - Damaged insulation around electrical conductors; broken or short-circuited switches and receptacles; poorly wired plugs and receptacles; electrical wires attached to or parallel to metallic conductors (e.g, electric cow trainers parallel to a stainless steel milk pipeline).

4. *Balance of line to farm neutral loads (110 volt) on the barn service entry during milking* - When 220-volt motors are operated, the electric current flows through both hot wires but not through the neutral. For a 110-volt load (10 amp), current flows through one hot wire and returns through the neutral. If a second 110-volt load (10 amp) is added and flows through the same hot wire, the current from both motors (20 amps) flows through the neutral and increases the potential for "leakage." If the second motor was operated from the second hot wire, current flow would be balanced and would not flow through the secondary load. If 110-volt loads cannot be balanced, the following alternatives may be feasible: minimize the use of 110-volt motors during milking; convert to 220-volt motors if and when possible; or install a larger diameter neutral wire to reduce its resistance. In some cases, an imbalance which is out of phase with the primary neutral will cause the voltage to decrease.

Off-farm Sources

Neutral-to-earth voltages of 1-5 volts are considered standard for some well designed main power line systems. However, these voltages on the primary neutral may contribute to problems with livestock performance. The following steps may be taken by the power supplier:

1. The grounds on the primary neutral along the distribution system can be checked for breaks or corrosion. If grounds are missing, the grounding electrodes on the farmstead will be forced to carry a greater part of the primary neutral current flow.

2. The utility should determine if the load is balanced.

3. If the primary neutral voltage exceeds 3-5 volts, faults may exist on neighboring farms or residences within 2-4 miles. The power supplier can check by disconnecting the jumper on the transformer. An example of this problem is ungrounded submersible water pumps.

Solutions

The presence of stray voltage depends upon a voltage differential created by current flowing between the neutral network and the earth. When coming in contact with the grounded neutral system through piping, feeders, etc., cows bridge the gap between the neutral network and the earth. Identify and correct voltage leakage problems before considering other alternatives.

An *isolation transformer* will isolate the barn neutral from the primary neutral. If possible, it should be installed on the barn service. When isolated from the rest of the farm, the neutral-to-earth voltage at the barn service entry should remain low when electrical loads are added to other farm services. These transformers may cost as much as $2,000. With $14 per cwt milk, a 6-lb decrease in milk production by a 90-cow herd will justify purchase of the transformer; its cost will be recovered in 4 weeks. An isolation transformer should be considered for all new milking facilities. The isolation transformer must be grounded and bonded to the case of the main transformer, but neutrals are not connected.

With an *equipotential plane* in the milking parlor, all cow contact points are at the same potential, including stalls, floors, and all equipment (Figure 1). All new milking parlors should be installed with an equipotential plane or grounding mat. Embed a welded wire mesh (6 x 6, 9 or 10 gauge) in the concrete floor for the cow stalls and operator pit. Cover this grid with a layer of concrete which is less than 2 inches thick. Bond the grid to other conductors -- stalls, floor grates, feeders -- by welding to No. 4 copper wire. Connect the copper wire with stainless steel clamps to stainless steel pipelines and bulk tanks. Copper wire in concrete may deteriorate over a short period of years. Use 3/8 rebar and carry it out the side of the building and to service entrance. Ground to the well casing.

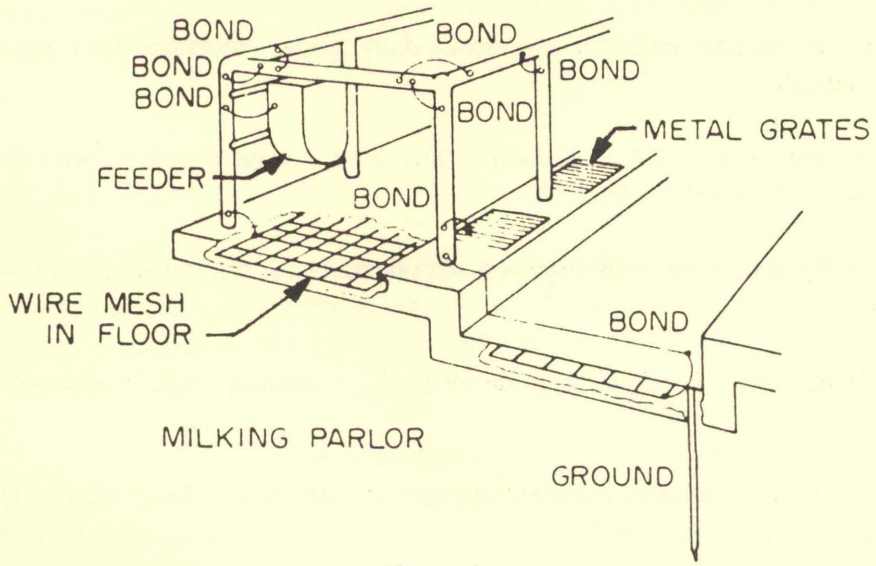


Figure 1

To off-set reluctance by cows to enter the milking parlor from the holding area, extend the wire mesh grid through the holding area.

An equipotential plane may be impractical for *existing milking parlors*, or *stanchion barns*. Cut slots in the floor (1/2 inch deep) and embed 10-gauge, or heavier, bare copper wire into the slots. Grout them over and bond to all metal structures in the parlor and the service entrance ground. In stanchion or milking barns, install a wire mesh grid in the cow platform under the front and rear legs and interconnect all rods to the shanchions and metal stall dividers. A second method is to lay a grid over existing floors and pour a new 1- to 2- inch concrete floor.

Another alternative may be to provide a trenched ground around the perimeter of the milking parlor and holding pen floor area by using No. 4-6 copper wire and bonding to all metal structures.

Grounding System

Do not use single ground rods. Drive three rods spaced equal to the length of the ground rods and connect them. Dig a 3-ft-diameter trench around the rods and fill the trench with magnesium sulfate, copper sulfate, or common rock salt. The chemicals will have to be replaced periodically, but they minimize seasonal variations in resistance. Also run the ground to the well casing if it is on the same service. A separate ground should be driven at each electric waterer or each feed bunk.

References

Appleman, R. D. 1981. Checking for stray voltage. North Central Extension Workshop on Stray Voltage, St. Paul, MN.

Babson Bros., Inc. 1980. Information on the neutral to earth voltage phenomenon. Virginia Dairyman.

Bodman, G. R. 1981. Extraneous voltage on Nebraska dairy farms. Nebraska Dairy Report EC81-220, University of Nebraska, Lincoln.

Cloud, H. A., R. D. Appleman, and R. J. Gustafson. 1980. Stray voltage problems with dairy cows. University of Minnesota Extension Folder 552, St. Paul, MN.

Green S. 1981. Working cooperatively with power suppliers. North Central Extension Workshop on Stray Voltage, St. Paul, MN.

Hutjens, M., and J. Clark. 1980. Feeding: A guide for peak production. Milk Producer's Planner, Dairy Herd Management, 17 (1):4.

Jones, G. M. 1980. The impact of stray electrical voltage on dairy herds. Proc. National Milking Center Design Conf., Rochester, NY, November 20.

Lillmars, L. D. 1980. Wiring methods to reduce stray voltage on farms. Proc. National Milking Center Design Conf., Rochester, NY, November 20.

White, R. P. 1981. Stray electric current: Voltage tolerance levels/Installation of equi-potential planes. Proc. 20th Ann. Meeting; National Mastitis Council, p. 31.

Williams, G. F. 1981. Stray electric current: Economic losses, symptoms, and how it affects cows. Proc. 20th Ann. Meeting, National Mastitis Council, p. 13.