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Neutral-to-Ground Voltage Problems With Dairy Cows

Many Minnesota dairymen may be losing production due to low voltages existing on the grounded neutral of the electrical system. This condition has several names including transient voltage, tingle voltage, stray currents, and neutral-to-ground voltage. Undoubtedly this problem has existed to some degree for many years, but increased loads on rural distribution systems, higher producing dairy herds and increased equipment requirements for modern dairy operations have caused increasing problems and concerns. Knowledge of its cause, symptoms, and means of minimizing its effects has increased but is still in development and quite limited.

SYMPTOMS

Animal reactions will vary widely depending upon the severity of the problem. In many cases they may be mild and not easily observed. Some of the signs are: (a) cows are reluctant to enter the milking parlor or stall, (b) cows are extremely nervous while in the parlor, (c) uneven milk out, (d) longer milking times, (e) reduced feed intake, (f) reluctance to drink water, (g) increased mastitis, (h) high leucocyte counts, and (i) lowered production.

WHAT IS IT?

The most correct terminology is neutral-to-ground (N-G) voltage. The problem is caused by the voltage required to move current through the grounded neutral system. This voltage exists on the grounded neutral conductors which are electrically joined to everything that is grounded such as feeders, waterers, stanchions, stalls, and the bulk tank.

The primary and secondary neutrals together with the grounding system make up a complex electrical circuit. Any electrical current in the grounded neutral system has an associated voltage dependent on the resistance of the system and the current it is carrying. This is probably best visualized as a voltage between the grounded neutral and a true or isolated ground. If the cow makes contact at two points with one at neutral voltage and the other near true ground, it can result in a flow of current through her body.

One point of contact is her feet on the concrete floor. Another point of contact is created when she touches the sides of the stall, eats grain from a metal feeder, or attempts to drink from a water bowl. Some people tend to blame the milking equipment for this phenomena. At first glance, this seems reasonable since so many symptoms are associated with the milking process. Unless there is an electrical fault, the milking equipment should not be the cause.

The neutral-to-ground voltage depends on wire size and length, quality of connections, number of and resistance of ground rods, and the current in the neutral. The variability in the many factors which affect neutral-to-ground voltage partially explains the intermittent "here today, gone tomorrow" nature of the problem.

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The causes of excessive neutral-to-ground voltages are often very difficult to locate. Some factors which will cause excessive voltages are heavily-loaded power lines with the problem frequently at its worst during the evening milking, poor connections, corrosion of switches, frayed insulation and faulty equipment. **Its source may be on the farm, off the farm or both.** In addition, the problem can occur whenever the combination of neutral resistance and current creates a voltage large enough to cause a problem. This can be very frustrating since the condition can exist even with no electrical faults because it may be an inherent characteristic of the electrical system.

In attempting to correct the problem, one of the first things to do is to determine the major source of the voltage. A procedure for doing this is outlined later in this fact sheet.

WHEN CAN IT BE A PROBLEM?

The adverse effect on dairy cattle is created by the neutral-to-ground voltage forcing a small current through their bodies. The current depends on the resistance of the cow's body, her contacts with the concrete or stalls, and the voltage. The milking machine operator will seldom feel these voltages because of the person's body resistance and the insulating material of the operator's boots. But the cows have four bare feet that may be on wet concrete and this, together with their low body resistance, will allow the neutral-to-ground voltage to force enough current through their bodies to create a problem. The question is: How much voltage is necessary to do this?

One volt can create an immediate response and is cause for concern in any dairy operation. Larger voltages will cause increasingly severe problems. If the neutral-to-ground voltage is less than 0.5 volt, there probably is no serious cause for concern. If the voltage is in the range of 0.5 to 1.0 volts, it should be monitored and possibly some corrective measures may have to be taken.

HOW TO MEASURE IT?

Someone familiar with electrical systems, wiring, and equipment should be consulted and, if possible, be there when measurements are being made.

Any AC voltmeter that has a scale of 0 to 2.5, 0 to 5, or 0 to 10 can be used for initial checks on transient voltages. However, most of the standard inexpensive volt-ohm-milliammeters (VOM) will also detect DC voltages when they are on the AC scale. It is best to use a voltmeter that will read only AC voltages. DC voltages can usually be detected at many locations in the dairy parlor but such voltages are generally no cause for concern.

Digital read-out AC meters have proven to be very satisfactory for checking neutral-to-ground voltages. With these meters the technician may be able to observe short period spike voltages that are considerably higher than the normal readings observed frequently on Minnesota dairy farms especially when a motor or other electrical device is started or stopped. Their significance and effect on the cow has not yet been determined.

Of particular concern to the dairy farmer is the voltage between any two points that the cow may touch. These voltages

can be checked by placing the leads of the voltmeter at the contact points. Good electrical contacts are necessary.

To provide a common reference and to standardize measurements, the authors recommend the use of a copper or copper-clad ground rod located 50 feet or more from the barn and isolated from any other component such as water piping. The ground rod should be at least four feet deep and in moist soil. Connect one insulated lead of the voltmeter to this isolated ground rod and the other insulated lead to the bare ground wire leading from the barn entrance box to the ground rod at the barn (service entrance grounding conductor). In this position the voltmeter will read the voltage between the grounded neutral system and an isolated or true ground. This voltage is then monitored as will be discussed later.

Some questions may arise as to why this voltage is measured rather than voltages within the milking parlor itself. The reason is that this voltage is generally the maximum that would be expected between any two locations in the milking parlor unless an electrical fault exists. If this voltage reaches a problem level as discussed earlier, it is possible it exists in the milking parlor or barn and may be difficult to locate.

HOW TO DETERMINE THE SOURCE OF THE PROBLEM (Five-Step Procedure)

1. Record the reading with the voltmeter connected between the isolated ground rod and the service entrance grounding conductor. In addition, it may be desirable to obtain readings between each of several possible cow contact points. Do this in mid-morning or mid-afternoon when the readings are expected to be at their lowest.
2. Turn on several 240-volt electrical devices and repeat the readings. We suggest turning on the hot-water heater, vacuum pump, milk cooler, and any 220-volt appliances such as the house range. Have someone read the voltmeter as each motor is turned on so that the voltage can be recorded both at the time of starting and after continued usage.
3. Repeat the procedure when electrical loads on the entire electrical system are expected to be high. The best time to do this is during the evening milking or around 6 p.m.
4. If no voltages over 0.5 volt are observed in steps 1, 2, and 3, repeat these steps with one lead of the voltmeter on the isolated ground rod and the other lead connected to various pieces of grounded equipment, such as motors, waterers, tanks, feeders, or stanchions, in the milking parlor or barn. If significantly higher voltages are observed in these locations, it is probably caused by faulty equipment, faulty grounding or faulty wiring.
5. **This step must be done in cooperation with the power company because it involves an alteration in their system.** This step repeats the same measurements outlined in steps 1, 2, and 3, after the **power company** has disconnected the bond between the primary neutral and the farm secondary neutral at the transformer.

To determine the source(s) of the problem, compare the recorded results. If the readings are lowered after the secondary neutral has been disconnected, the voltage on the primary neutral is contributing to the problem. See a later section for procedures to follow.

If the readings remain at the same level or are higher when the secondary neutral is isolated, then the problem originates on the farm. Be sure to study the results obtained at varying times of the day and with different local electrical loads. A marked increase in voltages observed may provide a lead to the source of the problem.

WHAT TO DO IF THE PROBLEM ORIGINATES ON THE FARM

1. Establish and maintain good neutral circuits and connections. Heavy use, high humidity, corrosive silage acids, urine and manure make dairy farms poor environments for electrical wiring and equipment.
2. Look for faulty equipment that may have leakage currents to ground by determining the current draw of operating equipment and by checking the currents in the ground and neutral wires. If no faults are observed, better balancing of 120-volt loads on the farm may help minimize the problem.
3. Ground all electrical equipment such as manure pumps, silo unloaders, water heaters and pumps to the service entrance ground. Use large wire, No. 9, 10, or 12. Insulation is not needed. Spot weld or use pressure clamps rather than solder or wrapped connections.
4. Provide adequate power circuits. Too many service entries become overloaded as more and larger equipment is installed.
5. Consider three-phase service. Three-phase motors cost less but considerable expense can be incurred when converting existing single-phase equipment.

WHAT TO DO IF THE PROBLEM ORIGINATES OFF THE FARM

1. Consult with the power company about leaving the farm neutral disconnected from the primary neutral at the transformer. This procedure will provide relief if the problem voltage originates on the primary neutral. **Operation under these conditions must be under the direction of the power company.**
2. In consultation with the power company, install an isolation transformer on the farm. This procedure is used in hospitals where the problem is common. In doing this, the dairyman assumes the responsibility for maintaining proper neutral grounding on the farm.
3. Provide an equi-potential plane. This procedure is practical in milking parlors but is probably impractical in stall-barn operations. If the entire milking parlor including floor, stalls, and feeders is at the same potential, there can be no electrical shock as in the "bird on a wire" phenomena. A 2-inch by 2-inch, 9-gauge galvanized welded wire mesh is imbedded in the concrete floor over the entire milking parlor including cow stalls and operator's pit. Weld or clamp the mesh at all possible locations to other conductors such as stalls, floor grates and feeders. It is important that the complete interior of the milking parlor be electrically connected. Use stainless steel clamps when connecting to stainless steel milk lines.

Installation of an equi-potential grounding mat is highly recommended in all new milking parlors.

This method when installed correctly removes the shock potential for the cow in the stall. It does not prevent a differential voltage from occurring when the cow enters the parlor from the holding corral which is not a part of the equi-potential plane. In these cases, there may still be a reluctance for cows to enter the milking parlor.

LEGAL RESPONSIBILITY

The services and advice of licensed electricians and electrical utility engineers should be used. Leakage on or off the farm may be traced and corrected. In some cases, power can be routed on different lines thus reducing service loads which can correct or reduce the problem.

In the opinion of the authors, the power company has no legal responsibility, only a moral one. There appears to be no regulations concerning quality of electrical distribution other than supply voltages. There may be conditions which are beyond the control of the power company since they have no direct control over the loads of their customers or time of use. So, if a problem exists, the solution is basically the dairyman's responsibility with advice, help, and consultation from the power company.

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