ПРОБЛЕМИ С УТЕЧНОТО НАПРЕЖЕНИЕ В МЛЕКОДОЙНИТЕ ФЕРМИ

STRAY VOLTAGE PROBLEMS IN DAIRY FARM

Erkan GONULOL[1] **Hilmi KUŞÇU**[2]

[1]*Trakya University, Tekirdag Agricultural Faculty, Dept. of Agricultural Mach. 59030 Tekirdag*
[2]*Trakya University, Faculty of Engineering and Architecture, Dept. Of Mechanical Engineering, Edirne*
egonulol@trakya.edu.tr, hilmi@trakya.edu.tr

Abstract

Stray, tingle or neutral to earth voltage has been an important problem for dairy and other livestock herds for approximately twenty years. Stray voltage is a small voltage (less than 10 V) measured between two points that can simultaneously be contacted by cow. A current will flow between these points. The amount of current depends on the voltage and the circuit resistance (impedance).

Potential stray voltage sources are; primary neutral current external to the farm and from on-farm loads, secondary neutral current in farmstead wiring systems, fault current on equipment grounding conductors etc.

The reactions of animals to mild electric shocks caused by stray voltage have been reported to include behavioral changes, changes in milking characteristics of dairy cows and changes in production performance.

Stray voltage problems can be solved by elimination or reduction of sources and active suppression.

In this paper, the effects and sources of stray voltage were described. In addition, the solution methods of stray voltage problems were explained.

Keywords: Stray voltage, Tingle voltage, Neutral to earth

INTRODUCTION

By its nature, livestock production involves numerous variables; nutrition, genetics, infectious disease and environmental factors including stray voltage. As a relatively small element in this complex production system, stray voltage is at least as well researched and understood as other components.

The consumption of electricity in a farm was effected by size of a farm process. There is a linear correlation between the consumption of electricity and stray voltage. Stray voltage has been implicated as a problem for dairy and other livestock herds for approximately twenty years. Stray voltage is known by several names; tingle voltage, neutral-to-earth (N-E) voltage, neutral -to-ground voltage, and extraneous voltage.

Stray voltage is a small voltage (less than 10 V) measured between two points that can be simultaneously contacted by cow. A current will flow between the two points. The amount of current depends on the voltage and the circuit resistance (impedance). This voltage may be caused by poor or faulty wiring, faulty equipment, improper grounding, or they may be result from the small voltages required to move current through the grounded neutral system (Cloud et al., 1987; Warley and Wilson, 2000)

Cows and humans are similarly sensitive to electric current, i.e., both respond similarly to comparable current levels. However, cows are much more susceptible to stray voltages primarily because the body impedance (resistance) of cows are much lower than those of humans (USDA,1991)

Recent research indicates that current levels below 6mA have no direct effect on production, reproduction, or animal health; furthermore, there is no evidence that hormones naturally released during milking and stress are adversely impacted

by elevated current levels. Some moderate behavioral changes are seen in cows exposed to currents of between 3 and 6 mA. If exposure to such currents occurs on -farm, the behavioral changes may require an additional investment of time from the dairy operator. Using the above estimates for impedances, these currents translate to 1.5 to 6.0 V. However, it also appears that the large majority of cows probably do not demonstrate problem behaviors until voltages are above 3.0 to 4.0 V. Direct economic effects including reductions, in milk yield have been shown for a small percentage of cows (7 percent) at cow contact voltages of 4.0 V and above (USDA, 1991; Bray and Shearer, 1993).

SOURCES OF STRAY VOLTAGE

Any electrical condition which creates a large enough voltage between any two animal contact points may create a stray voltage problem. The following are potential stray voltage sources (Cloud et al, 1987):

1. Primary neutral current external to the farm: As the current in the distribution neutral increases due to increased load on other parts of the single phase tab or the imbalance current in three-phase feeder increases, the primary N-E voltage will increase. This can be reflected to a greater or lesser degree to the problem farm through the primary- secondary neutral interconnection at the transformer.
2. Secondary neutral current on-farm loads: As the electrical load on the distribution transformer of the problem farm increases, the increase in primary neutral current will generally result in increased primary N-E voltages which will be reflected to the farmstead grounding system through the interconnection at the transformer.
3. Secondary neutral current in the farmstead wiring systems.
4. Fault currents on equipment grounding conductors.
5. Improper use of neutral conductor as a grounding conductor or interconnection of the neutral and grounding conductor at the equipment grounding separately.
6. Grounding fault currents to earth through faulty insulation on energized conductors or improperly grounded equipment.
7. Induced voltages on electrically isolated conductive equipment.

SYMPTOMS OF STRAY VOLTAGE

The reactions of animals to mild electric shocks caused by stray voltage have been reported to include behavioral changes, changes in milking characteristics of dairy cows and changes in production performance.

Field studies cited previously and personal observations have revealed several behavioral clinical signs in dairy cows associated with stray voltage on dairy farms. These include: elevating heads and holding ears back rigidly; vocalizing (bellowing); trembling; displaying extreme nervousness; constant moving of legs and restlessness ("dancing"); arching of the back; bristling of the hair; increased manure volume (>10% of cows); reluctantly entering the parlor and "stampeding" when exiting; reduced feed intake in the parlor; and failing to drink water (lapping water) (Lefcourt, 1991; Reineman et al., 1997).

Poor milk let-down and incomplete or uneven milk-out; increased milking time; lowered milk production; increased somatic cell counts and incidence of clinical mastitis are common symptoms about milking characteristics and production performance (Lefcourt, 1982; Lefcourt 1991; Reineman et al.,1997)

Many of the above symptoms are not directly caused by stray voltage. For instance, if the stray voltage/current problem is severe enough to affect a cow's behavior, such as kicking off the machine, milk-out may be influenced. This problem will result in increased milking time. Mastitis, whether clinical or subclinical, is the result of an infection, but there is more chance of picking up an infection when the machine is being kicked off. Lowered milk production will result when cows drink less water, consume less feed, or develop mastitis. Whether or not milk production will be adversely affected by stray voltage depends on the extent to which the cows' behavior is altered and how management compensates. On the other hand,

improvements in milk production are not always apparent after a stray voltage problem has been corrected (Appleman and Gustafson, 1985; Bray and Shearer, 1993)

Although stray voltage has not been shown to have a direct physiological effect on cows will complicate management practices. As a result, labor efficiency and profitability may be lowered.

It must be remembered that many of the above symptoms can be caused by factors other than stray voltage. These factors include management, environmental conditions, poor nutrition, mastitis control programs, sanitation, malfunctioning milking equipment and disease.

DETERMINATION OF STRAY VOLTAGE

The following step-by step procedure is intended to help isolate the causes of a stray voltage problem. Forms for recording the data as well as notes on how to interpret the data are included. The tests may take several hours to conduct. However, the entire procedure needs to be completed to determine if a problem exists and what the cause or causes might be. The tests suggest the use of a clamp-on ammeter. The ammeter readings are optional for preliminary screening problems (Rodenburg, 1998).

Table 1. Stray voltage determination procedure

Procedure
Step 1. After establishing an isolated ground rod and connecting the voltmeter between the ground rod and the neutral bar of the service entrance panel, read the N-E voltage at the barn.
Record of Results
Voltmeter Reading (AC volts), Time
Interpretation
The voltmeter will now read the N-E voltage at the barn. This voltage is measured rather than voltages in the milking area itself because generally it is the maximum which would be expected between any two points in the Milking area, unless a fault exists.

Procedure
Step 2. N-E voltage without the barn load: Open the main disconnect at the barn service entrance. If the N-E voltage in Step 2 is low (below 0.25 volt) skip Step 3 and 4 and go to Step 5
Record of Results
Voltmeter Reading
Interpretation
No load is operating in the barn at this time. However, the neutral to the barn is not disconnected. Any voltage in the barn at this time is being transmitted to the barn through the neutral or grounding system and originates somewhere else.

Procedure
Step 3. Removal of loads from other farm buildings. Leaving the main disconnect at the barn open, record the N-E voltage at the barn after opening each of the other service entrances on the farm. Leave the service disconnects open until all have been disconnected.
Record of Results
Service Disconnected, Voltmeter Reading
Interpretation
After each service entrance is disconnected, the N-E voltage at the barn should drop slightly if there are any loads operating on that service entrance. If the voltmeter reading at any step is relatively high (above 0.5 volts) and drops to a much lower value (less than 0.2 volts) when the service entrance is disconnected, the loads on that service entrance should be checked out later.

Procedure
Step 4. Complete removal of farm load. Open the main disconnect to the farm and record the N-E voltage at the barn. Be sure the well is also disconnected if it is powered ahead of the main disconnect. After Step 4 is completed reconnect the main service and all building services.
Record of Results
Voltmeter Reading
Interpretation
The voltage recorded at the barn when all services are open is due to N-E voltage on the

primary neutral created by loads at other locations on the main distribution system. When the main disconnect is opened the voltage reading should be the same as when all building services were disconnected.

Procedure

Step 5. Checking 240-volt loads in the barn: Place a clamp-on ammeter around the neutral to the barn service. Be sure no 120-volt loads are added or dropped during this test. Record the voltmeter and ammeter reading after each of several 240-volt loads are added to the previous load. Also read the voltmeter and ammeter as each load is turned off in reverse sequence.

Record of Results

Load Added, Voltmeter Reading, Ammeter Reading

Interpretation

The increase in neutral-to-earth voltage as each load is added is due either to the increase in primary N-E voltage as a result of the increased load or to faulty equipment on that circuit. If any 240-volt load causes a current flow in the secondary neutral to the barn (as indicated by the clamp-on ammeter) it is a result of interconnected 120-volt loads or ground faults in the equipment. Very slight changes in neutral current may be detected as a result of the increased N-E voltage forcing some current through the electrical system grounds at the barn.

Procedure

Step 6. Checking 120-volt loads in the barn. Open all 120-volt circuits in the barn. Record the voltmeter and ammeter readings as each of the 120-volt circuits is reconnected and the loads on that circuit are operating. Carefully observe the effects of starting and stopping 120-volt motors. They can cause serious N-E voltage when starting.

Record of Results

Circuit Number, Loads, Voltmeter Reading, Ammeter Reading

Interpretation

The secondary neutral current to the barn (read by the clamp-on ammeter) and the N-E voltage readings will increase and decrease as the unbalanced load on the secondary neutral to the barn changes. If the N-E voltage increases significantly (perhaps 0.3 volts or higher) with a maximum unbalanced load on the barn neutral, the voltage drop in the neutral may be causing problems. The problems may be a high neutral resistance created by poor connections or the resistance of the wire itself. Improving connections, better balancing of the line-to-earth loads, and or a larger neutral wire may help relieve the problem.

Step 7. Circuit checks for other farm buildings. If in Step 3 one of more of the other building services seemed to produce an excessive voltage repeat Steps 5 and 6 for that building.

Procedure

Step 8. Milking time monitoring. Have some-one watch the voltmeter throughout the milking time and periodically record the readings, both the peak values and static (steady) values. (You will probably require additional space for recording this data).

Record of Results

Peak, Voltmeter Reading Static, Time

Interpretation

Pay particular attention to major changes in fluctuations in the readings. These may occur rapidly and may last only a short time. Close attention is necessary to observe these changes. Starting of motors is the most common cause of short-term peaks.

Procedure

Step 9. Isolated system testing. Repeat the procedure outlined in cooperation with the power supplier after its employees, under the direction of their supervisors or engineering consultants have disconnected the bond between the primary neutral and the secondary neutral at the transformer. The disconnection of this bond is not possible with single busing transformers in common use today and requires changing transformers. This step requires disconnecting the bond only; it is critical the primary neutral and secondary neutral connections to the transformer remain intact and are not disconnected.

Interpretation

After the bond between the primary and secondary neutrals has been disconnected, there should be no change in the N-E voltage at the barn when the 240-volt loads are operated. If this voltage increases with these loads, there is either an electrical fault in the equipment or the voltage on the primary neutral is feeding back onto the secondary neutral through the earth or some other electrical connection. (Primary and secondary neutral systems have not been isolated).

SOLUTION OF STRAY VOLTAGE

While some knowledge of stray voltage has existed for many years, it was not until about 1982 that the national and worldwide nature of this phenomenon was recognized. Even when problems associated with stray voltage were recognized, early solutions were not always fully effective an or were not always satisfactory to both farmers and power suppliers. One of the challenges for solving stray voltage/current problems has been in persuading everyone involved to work as a team in diagnosing and solving the problems on the basis of a rational understanding of the factors involved. (USDA, 1991)

Approaches for controlling stray voltages fall into three categories (Cloud et al., 1987; Bray and Shearer, 1993).

1. Voltage reduction by either a) elimination of the source (e.g., by removing bad neutral connection, faulty loads, or improving or correcting wiring and loading) or b) by active suppression of the voltage by nulling device.
2. Gradient control by use of equipotential planes and transition zones to maintain the animal's step and touch potentials at an acceptable level.
3. Isolation of portion of the grounding or grounded neutral system from animals.
4. The most suitable approach in any given situation must be based on the available information and constraints of the specific situation.

CONCLUSION

As long as electricity is supplied to farms, the issue of stray voltage will exist. Problems with stray voltage are not widespread but continue to occur due to changes or failures in on-farm and off-farm electrical systems and equipment. We have to understand what levels of stray voltage a threat to dairy farm and to be tested dairy farm by an expert who is trained to test cow contact areas. More consistent tracking of problems and education for farmers, and those serving farmers is recommended. This will result in more timely identification of problems caused by stray voltage or other equipment, management or cow health issues. Proper identification of problems is essential to crafting the appropriate solutions.

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