Stray Voltage Update

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I would like to accomplish three things in this presentation:

1. Make you aware of the nature of stray voltage and its basic sources;
2. Review research on stray voltage presented at the National Stray Voltage Symposium held in October 1984;
3. Bring you up to date on the continuing research in Stray Voltage.

Stray voltage, transient voltage, juice, tingle voltage. The condition which results in current flowing through a cow's body and causes all sorts of grief for both man and animal is called by many names. The terminology which best defines stray voltage, however, is Neutral to Earth Voltage. A normal single-phase 120-240 service which is the most common system for farms originates at a step-down transformer on the power company's pole. The power company's side is called the primary side, while the customer's side is called the secondary service drop. The transformer will have both primary and secondary windings. The secondary windings of the transformer are tapped at each end and in the center. The two end taps are hot wires and connecting between them will give you 240 volts. The center tap is called the neutral wire and is also connected to earth ground by a wire running down the pole and attached to a driven ground. This gives the neutral wire a zero voltage potential relative to earth. Connecting the neutral wire to either one of the hot wires will give you 120 volts. Since the neutral wire is at the same voltage potential (0) as earth ground, any condition which puts a voltage on the neutral wire can cause a neutral to earth voltage. If a cow touches one point which is at the secondary neutral voltage and another which is closer to earth potential, current may flow through her. Since the neutral wire is connected to everything that is grounded, any neutral voltage may show up on stanchions, water pipes, stalls, etc.

There are there basic causes of Neutral to Earth Voltage:

1. Unbalanced 120 loads;
2. Ground faults;
3. Voltage drop on the neutral wire.

Unbalanced load: When 240 volt motors are used on the farm, there is no problem since a 240 load is connected between the two hot wires and there is no connection to neutral. However, when 120 volts are used, the neutral wire is connected to either one of the two hot wires. In this case, current may flow on the neutral. For example, if you had a 20 amp load on one hot wire and a 30 amp load on the other, you would have 10 amps on the neutral.

Ground Fault: Since the secondary neutral is tied in with the grounding system through their common grounds, any piece of electrical equipment which has a ground fault (current leaking to ground) may cause a voltage on the neutral wire. This can happen with 240 as well as 120 loads, thereby setting up a neutral to earth voltage.

Voltage drop: In many systems, the neutral wire from the transformer to the barn is smaller than the two hot wires since it does not carry nearly as much current as they do. However, when the loads are unbalanced and it does carry current, its resistance to the flow of electricity, due to its small size, may be high enough to create a voltage drop between the barn and transformer. This voltage drop will show up as a neutral to earth voltage. Faulty connections (corroded, loose, etc.) on the neutral wire will also create resistance and cause a neutral to earth voltage.

Power suppliers use two main types of distribution systems, the Delta and the Wye. The Delta transformer is an isolation transformer, there being no direct connection between the secondary neutral and the primary wires. In this case most all neutral to earth voltages are from an on-farm source. The Wye transformer has a common neutral with the primary neutral being directly connected to the secondary neutral. The primary neutral is shared with all the users on that system. With a Wye system, neutral to earth voltage sources can be both on-farm as well as off the farm. A ground fault for example on one farm may show up on another as neutral to earth voltage.

It is important to know in investigating neutral to earth voltage that it is current which affects the cow, not voltage. It is possible to have a potential voltage difference between neutral and earth and yet have no current flow. The resistance of cows varies depending on the two contact points (feet to mouth, feet to feet, etc.), environmental conditions (wet versus dry), etc. However, research shows a resistance of between approximately 300 to 1000 ohms. (1) Using a high impedence meter, a resistor and Ohm's law, you can test to see if there is a current flow in a neutral to earth voltage situation. Ohm's law states I = E/R, where I = amps, E = voltage and R = resistance in ohms. Since Amps = Volts divided by Ohms we can very easily figure current flow in

1. Norell, Appleman and Gustafson. Electrical Resistance of Dairy Cattle, presented at the 1982 American Dairy Science Association.

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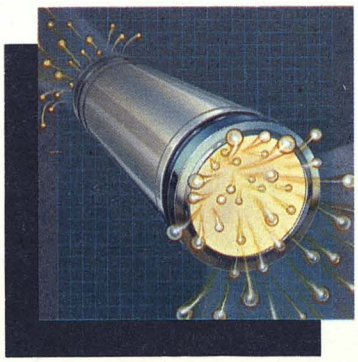

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any neutral to earth voltage situation by looking at the voltage drop across a known resistance. For example, let's use 500 ohms to represent the cow and assume a one volt neutral to earth voltage level. Placing the 500 ohms resistor (cow) in parallel in the meter and dividing the voltage on the meter by 500 will give us the amperage or current flow that the cow will feel. Assuming that the voltage stays at one (1), the cow would be exposed to two (2) milliamps (1 volt divided by 500 = .002 amps). If the voltage drop was one-half a volt, then the cow would be exposed to one (1) milliamp (.500 volts divided by 500 - .001 amps). If the voltage dropped to zero (0) through the resistor, there would be a voltage potential but no current flow.

Now let us address the Stray Voltage Symposium which covers animal sensitivity to current flow.

In October 1984, a National Stray Voltage Symposium was held in Syracuse, NY. At this symposium, which was coordinated by the Stray Voltage Research Council, results of two years of study on stray voltage at Cornell University, Michigan State University and the University of Minnesota were reported. Also included in this symposium, although not a part of the coordinated research, was a presentation by Dr. John Kirk, a veterinarian from Michigan State University, and A. M. Lefcourt, Biomedical Engineer at USDA-ARS, Beltsville, Maryland. This symposium covered three main areas: 1) Animal Sensitivity, 2) Electrical System Characteristics and Source Identification, and 3) Mitigation and Protection. Following is a brief synopsis on what was reported on Animal Sensitivity.

There were two papers on this subject from Cornell University by Gorewit, Drenkard and Scott. The first one dealt with the physiological effects of electrical current on dairy cows. In this particular study the cows were exposed to zero, four and eight milliamps of current before and during milking. Blood samples were taken and tested for cortisol, oxytocin, and prolactin. Heart rate, blood pressure and the flow of blood through the udder was monitored. From this, it was determined that current applications of eight milliamps increased the cortisol output and delayed the oxytocin release. Current applications of four milliamps did not seem to interfere with milk ejection or cause any changes in blood flow to the udder. The heart rate, blood pressure and mammary blood flow at four milliamps increased appreciably but then it returned to normal after 60 seconds. It was concluded that current levels of 1 to 5 volts did not inhibit milk ejection, did not influence mastitis or any other diseases, and that it was doubtful that 1 to 5 volts of extraneous current could be a direct cause of lost milk production on a properly managed farm.

The second study looked at the behavioral effects of electrical current on cows. Behavior, milking and the threshold of sensitivity were observed to determine when a cow would react to current, and the effects of that current during milking upon her milk production and milk composition. They reported that cows show a behavior change between 2 and 4 milliamps of current but they appear to adapt rather rapidly. Milk production and composition were not affected by current applications of: 1) eight milliamps applied before and during milking; and 2) four milliamps every four hours up to 96 hours.

Appleman and Gustafson from the University of Minnesota reported on behavioral experiments to animal sensitivity, both to AC and DC currents, observing three things: 1) Aversion to Learned Response—determining current levels that alter a learned response such as food acquiring response; 2) Learned Escape Response—determining current level applications required for an animal to exhibit an escape response (front hoof pick-up would terminate the shock); and 3) Grid Crossing Response—determining cow reactions when stepping from one grid to another of different voltage potential between the prep stall and milking stall.[1] They found: 1) three to four milliamps were necessary to suppress the learned behavior, 2) Current levels over 4 milliamps caused an escape response in excess of 90% of the animals tested, and 3) cows exhibited inhibited grid-crossing behavior, but milk yield and machine-on time were not affected. It was concluded that further research is needed.

A. M. Lefcourt from USDA-ARS, Beltsville, Maryland, reported on the physiological stress responses to electrical shock. Using the medical definition of stress, he concluded that although dairy cows exhibit a behavioral change, the physiological evidence to stress was minimal. He came to the conclusion that the cows are not stressed by electric shock, according to the medical definition of stress. He said that the associated behavior responses could result in a management problem. However, milk yield could probably be maintained in the presence of stray voltage or stray current with good management practices.

John Kirk, D.V.M., reported on the possible causes of stray voltage-like signs in dairy cattle. He concludes that since there are many other possible causes of responses in dairy cattle, a complete study of the dairy operation should be undertaken before assuming that stray voltage is a problem. To quote him exactly: "The message to be passed on is that there are many causes of the signs attributed to stray voltage exposure of dairy cows and before stray voltage is blamed as the sole cause, an exhaustive study of the entire dairy operation to include management, feeding practices, nutrition, mastitis control measures, milking machine function, sanitation and cow handling methods should be undertaken."[1] His presentation summed up the section on Animal Response to stray voltage indicating that

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1. Appleman, R. D., Gustafson, R. J. Behavioral Experiments Quantifying Animal Sensitivity to AC and DC Currents. Stray Voltage: Proceedings of the National Stray Voltage Symposium, October 10-12, 1984.

1. John H. Kirk, D.V.M., Possible Causes of Stray Voltage-Like Signs in Dairy Cows, Stray Voltage: Proceedings of the National Stray Voltage Symposium, October 10-12, 1984.

although cows show a behavioral change when subjected to stray voltage, there is no evidence to show that it affects milk production, incidences of mastitis, or physiologically stresses the cows. This does not mean to say that stray voltage is never a problem, but rather that present research fails to substantiate it.

So where are we now? Well, obviously there needs to be more research.

In Canada the Ontario Ministry of Agriculture, the Ontario Milk Marketing Board and Ontario Hydro are working in a Cooperative effort on this issue. The Canadian Electrical Association has also instituted a study of its own on stray voltage as it affects dairy cattle.

Minnesota and Michigan are both continuing their stray voltage research.

At Cornell, Dr. Gorewit, whose papers were discussed earlier, is beginning a three-year study. The first two years will determine the voltage level needed to affect milk production, milk composition, animal health and animal behavior. Voltages will be administered through the water cup, stanchion, parlor stall, and/or milking machine. The third year the study will be devoted to the effects of long-term application of AC voltage, both constant and transient. A 24-cow herd will be used in this experiment, it will be divided into three treatment groups and followed through a whole lactation. Reproductive performance will also be evaluated. At the present time there is no data available for publication, however preliminary results are very interesting.

The Agricultural Engineering Department at Cornell University has a proposal not yet funded to establish a New York State Voltage Program. This proposal would establish a clearing house in NYS for all stray voltage enquiries. It would also develop and distribute technical information concerning stray voltage. In addition, workshops would be conducted in conjunction with Cooperative Extension and technical assistance provided where necessary.

The Electrical Power Research Institute has reports available on the effects of high tension transmission lines on plants, honey bees, and embryo and chick development.[1] They are involved in present research continuing their study on high tension transmission lines.

The New York State Health Department also has an ongoing study of the field effects of high tension transmission lines. This is a five year project, with two years remaining. They are studying the effects of high tension transmission lines on plants and animals which live in close proximity of the lines.

Quality Milk Promotion Services (a/k/a NYS Mastitis Control Program), Cornell University, has received partial funding to study the prevalence of neutral to earth voltage on NYS dairy farms. Farms will be chosen randomly from our client list and at the time of our regular survey the field technician and/or veterinarian will perform simple tests to determine the presence of neutral to earth voltage. They will also leave a recording volt meter for 4-7 days. These results will be given to me and I will visit any farm which has a voltage level over ½ of a volt. I will confirm the voltage level and determine the source, using more sophisticated equipment. When possible and if necessary, I will be assisted in this endeavor by someone from the Agricultural Engineering Department at Cornell. Test procedures will be developed in cooperation with the major power suppliers and Agricultural Engineering. We hope to start this study by January 1, 1986.

The issue of stray voltage is still very much alive and we're still learning. Hopefully the projects mentioned above will answer some of the many questions we still have concerning stray voltage.

1. EPRI - Research Report Center, P.O. Box 50490, Palo Alto, Calif. 94303.

References

1. Cloud, H.A., Appleman, R.D., and Gustafson, R.J. Stray voltage problems with dairy cows. North Central Regional Extension Publication 125, University of Minnesota. 2. Gustafson, Robert J. Fundamentals of electricity for agriculture 1980, AVI Publishing Co., Inc., Westport, Connecticut. 3. McCurdy, J.A. Neutral-to-ground voltage problems with dairy cows, fact sheet EPP-36, Pa. State Univ. 4. Norell, R.J., Appleman, R.D., Gustafson, R.J. Electrical resistance of dairy cattle, Presented at the 1982 annual meeting, Animal Dairy Science Association, University Park, Pa. P-223. 5. Stray Voltage: Proceedings of the National Stray Voltage Symposium, October 10-12, 1984. Published by American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, MI. 49085-9659. 6. Surbrook, T.C., and Reese, N.D. 1981. Stray voltage on farms. ASAE Paper No. 81-3512. Am. Soc. Agric. Eng., St. Joseph, Mi.