

When we consider today's realities, EHS is taking a greater and greater toll on humanity and the cellular systems and other high frequency sources are the fastest growing industries in the world, our greatest effort should involve these two issues. As we consider these two issues, it is important to deal with the means by which these electromagnetic energies can reach living organism, and possible mechanisms for the observed biological and health effects. At the same time we must recognize the possibility of additive and synergistic effects associated with the mixture of frequencies.

One area in which I have worked involves the sources of electromagnetic energies and how they reach the human population. I will provide some information offered to the MN legislature regarding the potential impact electromagnetic energies that move in the earth and on the surface of the earth. These can include high frequency, low frequency, or direct currents. Although the term "Stray Voltage" has been mainly associated with the 60 Hz power frequency, the currents in the earth and the electromagnetic energies reaching people and animals are a complex mixture of numerous frequencies. Therefore, we ought not exclude this exposure mechanism.

### STRAY VOLTAGE SUMMARY

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The following is a brief summary of my understanding of the so-called "stray voltage" problem, and of legislation for mitigating the problem suggested by dairy farmers. Even though the term stray voltage does not accurately describe the problem experienced by dairy farmers, it continues to be used. As I discuss the problem, I will also use the term stray voltage.

Historically, universities, researchers and electric utility personnel have chosen to use the shock model in describing the potential effects of electricity on dairy animals. The shock model assumes that when a dairy animal touches something metallic that is at a different electrical potential than its feet, it experiences a shock. The size of the current going through the body of the animal determines whether or not it feels an electrical shock. If the current is sufficiently large the animal demonstrates a reaction, and that reaction may or may not affect its behavior, health and production. As universities have performed their research using this model, they have not been able to definitively replicate the set of effects recorded by dairy farmers.

Before university people became involved in research related to the stray voltage problem, dairy farmers and their electricians had discovered that a ground fault on or near the farm could produce the effects associated with stray voltage. A ground fault is simply an electric current entering the earth from a current-carrying wire because of an electrical connection error or a wire that has lost its insulation. Approximately 60 years ago, when this was discovered and much less electricity was being used than is used today, the problem could be quickly solved by eliminating the ground fault.

In the mid 1930's a decision was made to ground one of the two wires of the electric distribution system for the purpose of using the earth as a pathway for some of current to return to substations, and that wire is identified as the neutral. After that time the neutral wires for most electrical distribution and some transmission lines were connected to the earth at certain intervals. Another decision was made to connect the utility neutral wire directly to the

consumer's neutral wire. Although this connection is not necessary for the appropriate operation of the electrical systems, the utility industry claimed it was a precautionary procedure in the event of a lightning strike in the consumer's system. Upon further investigation, another reason became more evident. Because the consumer's electrical system usually has a lower resistance to ground in their grounding system, this neutral connection allows more electric current to return to the substation directly through the earth instead of on the neutral wire. Measurements that have been provided recently show that at least two-thirds of the neutral current is in the earth and only one-third on the neutral wire itself. As the use of electrical energy has increased, so has the quantity of electric current flowing through the earth from the grounding of the neutral wire. Considering the quantity of electricity used today, one could describe the intensive grounding of the utility neutral as causing something like a perpetual ground fault.

Many forms of electricity are necessary for the healthy functioning of all living organisms, and consequently extraneous currents have the potential of disrupting the health of the living organism. Quantifying the electric potentials and currents that can cause effects is a difficult task. For many reasons, including complexities in measurements, individual differences in animals and differences in farm conditions, dairy farmers anticipate that many years would be required to obtain any results. Some observations have been made, however. Veterinarians who have worked on stray voltage dairy farms find that the immune system of the dairy animal has been compromised, and in addition dairy farmers observe that the animals are continuously affected by some external stimulus. Intermittent shock, on the other hand, appears to have little effect on the health and production of the dairy animals.

University researchers have attempted to identify a level of shock voltage that appears to be sensed by dairy animals, although thus far in this work there has been no consistency in the level of concern. On stray voltage dairy farms, however, shock voltage does not necessarily correlate with the problems that have been observed by dairy operators. As an additional concern, university research has dealt primarily with pure 60Hz electric currents, whereas the currents in the earth have a very complex wave form. The animals are exposed to whatever electric current is in the earth. The following two reports provide a good summary of university work:

LEFCOURT, A. M., ed. 1991, EFFECTS OF ELECTRICAL VOLTAGE/CURRENT ON FARM ANIMALS, USDA No. 696.

PROCEEDINGS FROM CONFERENCE ON "STRAY VOLTAGE AND DAIRY FARMS, Camp Hill, PA., April 9-11.

I have written a number of papers summarizing information collected from my work and from dairy farmers and veterinarians working with the stray voltage problems, much of which presents a different picture of what is happening on dairy farms from that presented in the papers above. One report contains a critique of the 1991 report, as well. Two are included as attachments.

University researchers have recommended procedures for mitigating stray voltage problems. Separating the utility's neutral and the consumer's neutral with an isolation device was

recommended, and then ultimately the equipotential plane. These mitigation devices were based on the assumption that the shock voltage was the cause of the problems. They were indeed effective in reducing the shock voltage, but not necessarily the problems in the behavior, health, and production of the animals. Unfortunately separation of neutrals was in general helpful only for short period of time, and the equipotential plane most often caused an increase in the behavioral, health, and production problems. Especially because of the negative results in the use of the equipotential plane, dairy farmers had to conclude that electric shock was not the primary cause of their stray voltage problems.

Dairy farmers dealing with stray voltage problems began their own mitigation procedures. They began by checking for and correcting any ground faults and eliminating unnecessary grounding on their farms. If the problems remained their mitigations were directed toward the utility grounding. The most important experimental evidence gathered was associated with the reduction of electric current going into the earth on the utility system. For some dairy farmers disconnecting a certain group of grounding wires on the utility system made it possible to milk their cows again.

In April 1998, Attorney General Frank J. Kelley, for and on behalf of the State of Michigan, the People of the State of Michigan, and all energy customers of Consumers Energy Company (Consumers), filed a complaint against Consumers. The complaint was filed with the Public Service Commission (PSC). In this complaint the Attorney General respectfully requests an order requiring Consumers to cease and desist from allowing any stray voltage or current flowing from its electric system (poles, lines, substations, and other facilities) into the earth and onto private property, and an order requiring Consumers to upgrade and improve its distribution system and to operate and maintain this distribution system so as to eliminate all stray voltage or current from flowing from the utility's distribution system into the earth and onto private property.

In a news release from his office, Kelly stated: "Stray voltage has been linked directly and indirectly to reduction in milk production; stillborn calves; birth defects in livestock; and erratic behavior in livestock." Kelly also said: "Consumers' record with its rural customers, especially farmers, is abysmal. Over one-third of the dairy farms in Michigan have been driven out of business due in part to stray voltage;" and "I find it ironic that Consumers often touts research, that the company paid for, stating that there is no real problem on dairy farms with stray voltage. It reminds me of the same convoluted research done by the tobacco industry to show that smoking does not adversely affect a person's health. Just as the facts show the harmful impact of tobacco, the same can be said of the damage being done by stray voltage." Unfortunately the Michigan PSC did not carry out this order, and no changes were made in Consumers' system.

In Minnesota three studies were done in the 1980's and 90's. Each was described as having the purpose of testing the ground current model, and each demonstrated an association between ground currents and stray voltage problems. How one selects to interpret the data determines the conclusions, however. The conclusions drawn from the EQB and PUC studies differed widely. The electric utilities and the State Agencies selected information from the EQB and PUC studies for their conclusions and found no conclusive evidence that ground currents

from the utility systems were causing the stray voltage problems. Dairy farmers and their consultants also selected information from these studies and concluded that the studies provided sufficient evidence that the ground currents from the utility systems indeed correlated with the behavior, health, and production problems on dairy farms. Unfortunately dairy farmers and their consultants were not permitted to see some of the raw data from the studies to support their conclusions.

I provide this information because in my discussions with dairy farmers, they say that further study is not helpful for them. Hundreds of hours of electrical testing, experimentation, and observation by farmers and consultants have provided significant documentation that the quantity of electric current entering the ground is directly associated with the observed negative effects on behavior, health, and production of dairy herds. In addition, their experiences with studies undertaken in Michigan and Minnesota convince them that those performing the studies were not willing to take seriously the information provided by the dairy farmers. Dairy farmers also feel that university researchers do not listen to them. They are convinced from their experience, and the results of the studies already completed, that any proposed legislation must deal with the reduction in the use of the earth to carry current, rather than launching further studies. In addition, they strongly urge legislation that eliminates the requirement of the installation of an equipotential plane in construction of dairy facilities. In my work with dairy farmers, I am not aware of a single farm where the installation of an equipotential plane has improved the behavior, health, and production of dairy animals. In fact on most farms it was necessary to disconnect the equipotential plane in order to milk the cows. When the equipotential plane is installed at the time of construction of the barn, it is more difficult to determine the effectiveness of the plane unless it becomes necessary to disconnect the plane because of behavior, health, and production problems in the dairy herd.

Of course there are questions concerning mechanisms and it is not clear if one electrical component of the current in the ground, for example, such as power frequency direct currents or transients, is the primary cause of the stray voltage problems, or if a combination of all components is at work. For dairy farmers, knowing specifically what the exact mechanism or component is could be valuable information, but it won't help their dairy operations now. The realization among dairy farmers is that whatever the components and whatever the mechanisms, at the present time the only clear correlation is between stray voltage problems and the use of the earth to carry electric current. Answering questions dealing with mechanisms and electric components would require years of extensive research. Dairy farmers cannot wait if they are going to survive and have a profitable operation.

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