STRAY VOLTAGE SYMPTOMS COMMON IN DAIRY CATTLE

ELIMINATED BY ON-FARM NEUTRAL ISOLATION

by

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ABSTRACT

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Dairy farmers with stray voltage symptoms in their cattle often spend thousands of dollars to do neutral isolation, which isolates the primary neutral of the electricity provider from the farm neutral to suppress stray voltage from off-farm sources without knowing what results to expect. Dairy cows exposed to stray voltage exhibit behavioral symptoms, milking and production characteristics that are detrimental to their ability to produce milk. This study determined the effects of neutral isolation on these three general classifications of stray voltage symptoms in dairy cattle.

A survey of sixty-three dairy farms throughout Wisconsin was done to determine what stray voltage symptoms in dairy cattle were eliminated on these dairy farms that have neutral isolation. This study will serve as a resource for dairymen, agriculture

educators, and consultants who deal with the problems and symptoms associated with stray voltage in dairy cattle.

To answer the questions of this study, dairy farmers who installed neutral isolation devices to correct the problems associated with stray voltage were sent a mail-back survey. They were asked what common stray voltage symptoms were present on their dairy farms prior to isolation, compared to what symptoms were eliminated by neutral isolation. Questions about type of milking facility, milk production, and cost of isolation were asked. Comments were requested to illicit opinions and comments from participants in the study.

The subjects selected for this study were a convenience sample taken from the customer list of Concept Electric Inc., Appleton, Wisconsin. This company specializes in stray voltage testing and neutral isolation. Sixty-three dairy farms throughout Wisconsin that were tested for stray voltage and installed neutral isolation devices to correct stray voltage problems in their dairy cattle were surveyed. Thirty-seven surveys were returned. No follow up survey was sent to the non-respondents because it was an anonymous survey, with no identifiers used.

A major finding of this stray voltage study, was that the average increase in milk production was 14.03 pounds of milk per cow per day after neutral isolation on the thirty seven farms that responded to the survey. The mean daily milk production per cow before isolation was 53.97 pounds. The median was 55 pounds of milk with a standard deviation of 11.38 pounds. The mean daily milk production per cow after isolation was 68 pounds. The median after isolation was 70 pounds of milk with a standard deviation

of 9.61. Forty-three percent of the respondents spent between $20,000 and $30,000 to install neutral isolation devices to eliminate stray voltage problems on their dairy farms. Another 18.9% spent over $50,000 to correct the problems associated with stray voltage on their farms.

To answer the research questions of this study, dairy farmers who installed neutral isolation devices to correct the problems associated with stray voltage were asked what common stray voltage symptoms were present on their dairy farms before isolation, compared to what symptoms were eliminated after neutral isolation. This study found that the percentage of behavioral symptoms reported by the respondents as always present was zero percent after neutral isolation. Both milking parlor and stall barn facilities had the same results. The milking characteristics of milk letdown and milking time were improved by neutral isolation. Two production performance characteristics were surveyed, somatic cell count and incidence of clinical mastitis. Even though increased somatic cell count and clinical mastitis is not caused by stray voltage, the incidence of each was reduced in the findings of this study. Neutral isolation improved the cows' behavior and milking performance, resulting in a decrease of somatic cell count and incidence of clinical mastitis.

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Chapter I

INTRODUCTION OF THE STUDY

Stray voltages are causing serious problems in certain dairy operations. Dairymen are losing milk production and are experiencing cow behavior and cow health problems due to small electrical currents passing through the cows' bodies. The stray voltages are known by several different names, including tingle voltage, neutral-to-earth voltage, neutral-to-ground voltage, and extraneous voltage.

The definition of stray voltage in the United States Department of Agriculture handbook is:

> "Stray voltage is a small voltage (less than 10 volts) measured between two points that can be simultaneously contacted by an animal. Because animals respond to the current produced by a voltage and not to the voltage directly, the source of the voltage must be able to produce current flow greater than the threshold current needed to elicit a response from an animal when an animal, or an equivalent electrical load, contact both points."(Lefcourt, 1991)

This definition accurately describes the stray voltage phenomena. In other words, stray voltage is a small voltage that is measured between two points that livestock can simultaneously touch. If these points are simultaneously contacted by an animal, a current will flow through the animal.

Cows can sense voltages at approximately one-tenth the level that humans can. Humans have inherently higher body resistance than cows and generally have shoes or

boots on when working in barns, which increase resistance. Consequently, humans do not feel what animals feel. Both controlled research and observation on problem farms show that animals subjected to stray voltages are likely to exhibit symptoms related to three general classifications: 1) behavioral problems, 2) milking characteristics, 3) production performance.

Some studies estimate that twenty percent of all American dairy farms have stray voltage. Dairymen can eliminate or decrease stray voltage symptoms in their dairy cattle by neutral isolation, which involves the installation of an isolation transformer by a certified electrician. It can cost several thousand dollars to do a whole-farm isolation.

Farm Business and Production Management instructors for the Wisconsin Technical College system are often ask by student and non-student dairy farmers whether to do whole-farm isolation to correct symptoms and problems associated with stray voltage in their dairy cattle. This study will survey dairy farmers who have done neutral isolation to determine which symptoms in the three general classifications were eliminated.

Statement of Problem

Dairy farmers with stray voltage symptoms in their cattle often spend thousands of dollars to do a neutral isolation. This isolates the primary neutral of the electricity provider from the farm neutral to suppress stray voltage from off-farm sources. This study of stray voltage symptoms in dairy cattle will determine the effects of neutral isolation on the three general symptom classifications: behavioral problems, milking characteristics, and production performance.

Purpose of the Study

The purpose of this study is to determine what stray voltage symptoms in dairy cattle were eliminated on dairy farms that have neutral isolation. Dairy cows exposed to stray voltage exhibit behavioral symptoms, milking and production characteristics that are detrimental to their ability to produce milk. This study will give a clear understanding of what symptoms are eliminated by neutral isolation. This study will serve as a resource for dairymen, agriculture educators, and consultants who deal with the problems and symptoms associated with stray voltage in dairy cattle.

Questions to be Answered

This study will answer the following questions:

1. What stray voltage behavioral problems in dairy cattle were eliminated on dairy farms when neutral isolation was installed.
2. What stray voltage milking characteristic symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed.
3. What stray voltage production performance symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed.

Significance of the Study

The results of this study will be used by dairy farmers with stray voltage

symptoms in their dairy cattle to make informed decisions about neutral isolation as a possible solution to correct these symptoms. This study will show what stray voltage symptoms were eliminated by neutral isolation, allowing dairy farmers to better understand the option of neutral isolation to correct their stray voltage symptoms. The findings will be used by agricultural educators, extension personnel, and farm consultants to inform dairy farmers of what results to expect if neutral isolation is done on their farms to correct stray voltage symptoms.

Limitations of the Study

The limitations of this study were found as follows:

1. The survey instrument may be limited because it was designed by the author which does not guarantee its reliability and validity.
2. The population sampled was taken from the customer list of Concept Electric Inc., Appleton, Wisconsin, a company specializing in neutral isolation. This sample may not represent a cross section of Wisconsin dairy farmers who have neutral isolation.
3. Because of limited time and resources, all dairy farmers with neutral isolation could not be surveyed.

Definition of Terms

The following terms are defined, as used in this study, for clarity of reading:

Behavioral Problems: Changes in behavior that can be associated with novel or objectionable stimuli or events. Changes range from mild or moderate (i.e., flinching or becoming vocal) to distinct (i.e., raising a leg or kicking).

Circuit: An electrical pathway, consisting of conductors, loads, and sources, through which electric current flows.

Current: The flow of electrons through a pathway, due to a difference in electric potential (voltage).

Grounded: Connected to earth or to a conducting body that connects to earth.

Isolation: Separation of all or part of a farmstead's grounded conductors from the grounded conductor of the distribution systems.

Isolation Transformer: A transformer used to separate the grounded primary side from the grounded secondary, enabling the establishment of an isolated grounded neutral system for a farmstead.

Neutral: The common (shared) conductor in a wiring system.

Primary neutral conductor: The grounded neutral conductor on the power supplier side of the distribution transformer.

Resistance: The properties of a material that impedes the flow of current in a electric circuit.

Secondary: In reference to the complete electric system, the electrical wiring on the customer side of the distribution transformer.

Secondary neutral conductor: The grounded neutral conductor on the customer side of the distribution transformer.

Step potential: The voltage between hooves as an animal stands or moves on a surface.

Stray voltage: A difference in voltage measured between two surfaces that may be contacted simultaneously by an animal.

Voltage: A difference in electric potential between two points.

Chapter II

REVIEW OF LITERATURE

Introduction

This chapter will begin with the history of stray voltage, describing when this phenomenon was first recognized throughout the world and began to appear in North America. Current research from Minnesota and Wisconsin will be discussed. The December 10, 1998 Wisconsin stray voltage summit and resulting Wisconsin Public Service Corporation farm rewiring program will be reviewed. The most common stray voltage symptoms reported in field observations and surveyed in this study will be explained.

History of Stray Voltage

While some knowledge of stray voltage has existed for many years, it was not until about 1982 that the global nature of this phenomenon was recognized. Even when livestock problems were recognized, early solutions were not always effective and were not always satisfactory to both farmers and power suppliers. These problems often caused frustration, since many dairy farmers have little understanding of electrical distribution and farmstead wiring. At the same time, few electrical workers understood the behavioral and physiological responses of animals to small electrical currents.

In 1948, an Australian researcher implied that current resulting from electrical equipment in the milking area may have affected cows negatively (Churchwood

1948). Similar statements were published in New Zealand in 1962 (Phillips 1962). The first cases of stray voltage problems in North America were reported in Washington State In 1969 (Craine et al. 1969). Canadians reported incidences of stray voltage problems in 1975 (Feistman and White 1975). These cases received little attention because they were thought to be a localized problem.

Starting in 1980, problems from stray voltage began to surface throughout much of the United States and Canada. Some researchers estimated that twenty percent of all American and Canadian dairy farms are affected by stray voltage. Numerous articles concerning stray voltage were published. Hoard's Dairyman, a popular magazine for dairy farmers, published at least twelve articles or references to stray voltage between 1980 and 1983. National awareness of stray voltage and extensive research projects started at this time. In 1984, a national stray voltage symposium was held in Syracuse, New York; the proceedings were published in 1985 by the American Society of Agriculture Engineers (Majerus et al. 1985).

Current Research

Appleman et al. (1987) researched dairy farms in west-central Minnesota. One hundred twenty-one dairy farms were isolated at the electricity distribution transformer. These farms had dairy herd improvement milk production data available for twenty-four months prior and twelve months after isolation. The general criterion for isolation was a stray voltage at the barn electricity service panel above one volt, with an indication that the principal source of stray voltage was off-farm and that animals were able to access the stray voltage. Assessment of the dairy herd

improvement rolling herd averages showed that milk production per cow during the twelve months after isolation was 16,030 pounds of milk. This was significantly greater than milk production recorded twelve months prior to isolation, which was 15,185 pounds of milk. Thirty-one percent of the herds isolated showed a marked improvement in milk production of over seven pounds more milk per cow daily. With milk priced at $11.50 per hundred weight, lost milk in a fifty cow herd was valued at nearly $12,500 annually.

The Public Service Commission of Wisconsin collected data from seventeen hundred Wisconsin farms at which stray voltage problems were suspected and summarized the data in "Stray voltage: the Wisconsin experience." (Dasho et al, 1995). Of these farms, the Public Service Commission of Wisconsin found that seventy percent had stray voltage of less than one-half volt. Ninety percent had stray voltage of less than one volt. Ten percent had stray voltage over the one volt. The United States Department of Agriculture has found that the level of stray voltage to elicit the first stray voltage symptoms is one volt (Lefcourt, 1991). Farmers are recommended to continuously monitor and measure stray voltage when it reaches the one-half volt level. A reasonable and attainable goal on farms needing correction would be to maintain stray voltages on the farms grounding system below 0.35 volt (Cloud et al, 1987). This research shows there is a potential stray voltage problem on dairy farms in Wisconsin.

The Public Service Commission of Wisconsin data also shows that stray voltage is dependent on many physical factors stemming from both on-farm and off-

farm electrical power systems. Herd problems caused by stray voltage often can be difficult to diagnose. If stray voltage is suspected, the only way to know if it is a problem is to have the farm tested. "It is not possible to tell with any accuracy if a farm has stray voltage or not without appropriate electrical testing," according to John Roberts, D.V.M., of the Wisconsin Department of Agriculture, Trade, and Consumer Protection.

The importance of this stray voltage issue to dairy farmers in Wisconsin was brought to the public's attention when Wisconsin Secretary of Agriculture, Ben Brancel, called for a stray voltage summit to be held December 10, 1998 in Mosinee, Wisconsin. The summit was moderated by State Representative Al Ott from Brillion, Wisconsin, who is chairman of the Assembly Agriculture Committee. The goal of the summit was to share information and improve lines of communication between the various sides of the stray voltage issue. More than four hundred people, with about half being dairy farmers, attended the day long meeting. The attendance alone sent a clear signal that stray voltage remains a widespread concern on Wisconsin dairy farms.

The morning program featured an eleven member panel of dairy industry representatives, including a veterinarian, a lawyer, electrical engineers, a dairy farmer, a member of the state agriculture board, and others. They answered and discussed prepared questions related to stray voltage issues in Wisconsin. The answers reported by Dan Natzke in the December 17, 1998 Agri-View newspaper, were often inconclusive or of opposite opinions, which shows the complexity of this stray

voltage problem. The afternoon breakout sessions included three Wisconsin dairy farmers who described their experiences and steps to overcome stray voltage problems on their own farms. The one thing that came out of the summit was that people realized the importance of working together to solve stray voltage problems in Wisconsin.

One result of this summit was that Wisconsin Public Service Corporation, a Green Bay based investor owned utility, has introduced a new farm rewiring program. The program addresses three important goals: farm safety, energy efficiency, and the reduction of stray voltage. To participate, farms must be inspected by a state certified electrical inspector and let the utility do a detailed stray voltage test. The farmer then gets competitive bids from qualified electricians on what it will take to upgrade the farm's electrical system to meet the requirements of the National Electric Code. The goals of the program are reached by cleaning up old and eroded wiring conditions and installing energy efficient lighting on participating farms. The program provides reimbursement grants up to $10,000 per customer. In addition, Wisconsin Public Service offers to finance the remaining balance of the project cost at a three percent interest rate for up to five years. A maximum of $15,000 may be borrowed through this program. Wisconsin Public Service is doing more than just dealing with something that is causing stray voltage on a farm, they are also looking at safety and energy efficiency.

This study will survey dairy farms that were tested and had stray voltage measurements exceeding the one volt level the United States Department of

Agriculture has found as a serious enough problem to warrant isolation from the utility.

Symptoms Surveyed

The concept of stray voltage is relatively simple electrically, though the sources can be varied and complex. These voltages may be caused by poor or faulty wiring, faulty equipment, improper grounding , or they may result from small voltages moving through the grounded neutral system of the farm. As farm operations increase in size and sophistication, as electrical wiring systems become obsolete or deteriorate, and as electrical loads on rural distribution systems increase, it is likely that stray voltage problems will continue to exist. With a good understanding of the sensitivity of animals to stray voltage, its problems can be analyzed and corrected in existing facilities and prevented in new constructions.

Reactions of animals subject to stray voltage vary, depending on the pathway through the animals and the magnitude of the voltage. Many factors other than stray voltages may cause herd behavior or health and production problems. These factors include management and cow handling methods, nutritional disorders, mastitis control methods, sanitation, and disease. A careful analysis of all possible causes is necessary if proper corrective procedures are to be found.

The three general classifications of stray voltage symptoms in dairy cattle researched in this study are: 1) behavior symptoms, 2) milking characteristics, and 3) production performance.

Behavior Symptoms

Both controlled research and observation on problem farms shows that animals subjected to stray voltage are likely to exhibit a change in behavior. The following are the most common symptoms.

1. Cows excessively or unusually nervous in the milking parlor or stall barn.

This trait often is characterized by cows dancing or stepping around while in the stall. If this behavior is caused by stray voltage, it is usually due to a voltage between the stall pipes, which the cow touches, and the concrete floor on which the cow is standing.

2. Reluctance to enter and eagerness to leave the milking parlor or stall barn.

When cows are subjected to stray voltage in the milking parlor or stall barn, they soon become reluctant to enter the parlor or stall barn. In extreme cases, nearly all cows have to be forced into the parlor or stall barn and they may have a tendency to stampede out upon release.

3. Increased frequency of defecation and urination in milking parlor or stall barn.

Stray voltage causes cattle to become nervous and excrete body waste more frequently.

4. Reluctance of animals to consume water or feed.

Reduced intake of water and feed due to stray voltage problems may occur in cattle. The problem may be general throughout the farmstead, or only to a specific water or feeding location. Generally, higher voltages are required to limit water or feed consumption than to alter the other behavioral symptoms discussed previously.

A rather specific symptom indicative of a stray voltage problem is the uncharacteristic lapping of water during the animals' attempts to meet their needs for water.

Milking Characteristics

Poor milk letdown, incomplete milkout, and increased milking time are common symptoms expressed by dairy farmers having stray voltage problems. The mechanism of how this occurs is not fully understood. Researchers have not been successful in identifying any significant hormonal changes.

1. Poor, incomplete, or uneven milk letdown.

The number of cows affected by and severity of milk letdown problems appear to be dependent on the level of stray voltage present. When it is high enough to cause the cows to move or step about during the milking process, it is difficult to keep the milking unit properly aligned and adjusted to provide an even weight distribution necessary to promote fast, effective milkout.

2. Increased milking time.

If the stray voltage problem is severe enough to affect cows' behavior, such as kicking off the machine, milkout may be influenced. This problem can result in additional time needed for milking.

Production Performance

Although stray voltage has not been shown to have a direct physiological effect on cows, severe behavioral responses can affect production performance. Milk production may be lowered, along with increased somatic cell counts and clinical mastitis cases. As a result, labor efficiency and profitability may be lowered.

1. Increased somatic cell count and clinical mastitis.

Mastitis, whether clinical or subclinical, is the result of a bacterial infection of the mammary gland. Such infections are not directly caused by stray voltages. However, if cows' behavior is modified, and if the milking routine is altered because of the change in cows' behavior, what may result is less satisfactory milking performance, increased somatic cell counts, and more clinical mastitis.

2. Lowered milk production.

If cows drink less water, consume less food, or become more mastitic, they are likely to produce less milk. 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.

Summary

Stray voltage problems alter animal behavior, and may influence milking characteristics or affect milking production. This phenomenon is recognized world wide and is significant to dairy farmers in the state of Wisconsin who have symptoms of stray voltage appear in their cattle. The purpose of this study is to determine what stray voltage symptoms in dairy cattle were eliminated on dairy farms that have neutral isolation.

Chapter III

METHODS AND PROCEDURES

The methods and procedures used in this study of stray voltage symptoms in dairy cattle eliminated by on-farm neutral isolation are explained in this chapter under the headings of: 1) research design, 2) sample selection, 3) survey instrumentation, 4) procedures followed, and 5) data analysis.

Research Design

This study used a descriptive research design to answer the following questions:

1. What stray voltage behavioral problems in dairy cattle were eliminated on dairy farms when neutral isolation was installed.
2. What stray voltage milking characteristic symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed.
3. What stray voltage production performance symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed.

To answer the questions of this study, dairy farmers who installed neutral isolation devices to correct the problems associated with stray voltage were asked what common stray voltage symptoms were present on their dairy farms prior to isolation, compared to what symptoms were eliminated by neutral isolation. The dairy farmers surveyed had to have tested their dairy facilities and found levels of stray voltage measurements exceeding the one volt level which is significant enough to cause problems in their dairy cattle. The three main components of the survey, which included the first eleven

responses, were developed from the three general classifications of stray voltage symptoms discussed in Chapter II: 1) behavior symptoms, 2) milking characteristics, and 3) production performance. A complete copy of the survey is in the appendix of this research study.

Sample Selection

The subjects selected for this study were a convenience sample from the customer list of Concept Electric Inc., Appleton, Wisconsin. This company specializes in stray voltage testing and neutral isolation. Sixty-three dairy farms throughout Wisconsin were selected and surveyed to answer the questions of this study. These farms contracted Concept Electric Inc., Appleton, Wisconsin to test for stray voltage and installed neutral isolation devices to correct stray voltage problems in their dairy cattle.

Instrumentation

A mail-back stray voltage survey was developed by the researcher based on the three most common stray voltage symptom classifications: 1) behavior symptoms, 2) milking characteristics, and 3) production performance. Subjects were asked to respond to eleven statements, and indicate if the symptom was present in their dairy cattle before isolation by checking if the symptom was always, sometimes, or never present in column A. In column B respondents indicated if the symptom was present in their dairy cattle after isolation by checking if the symptom was always, sometimes, or never present after isolation. The first six statements referred to behavior symptoms of stray voltage. Statements seven and eight were about milking characteristics. Statements nine, ten, and eleven were about production performance problems that are a result of stray voltage.

Question twelve was, What type of milking facility do you have? The answers were either milking parlor or stall barn, which allowed the results of the stray voltage symptom statements to be cross referenced with the type of milking system.

Question thirteen asked for the approximate cost of isolation. This data will give farmers, agriculture educators, farm consultants, and researchers who read this study an idea of what dollar amounts are involved with neutral isolation.

Questions fourteen and fifteen ask what the daily milk production per cow was before and after isolation. This information will show what type of production performance can be expected with neutral isolation.

Questions sixteen and seventeen were designed to illicit opinions and comments from the participants in the study.

Procedures Followed

To obtain a list of subjects to survey, this researcher contacted Concept Electric Inc., Appleton, Wisconsin. This company specializes in testing for stray voltage and correcting the problem by installing neutral isolators. They agreed to provide their customer list of dairy farmers who tested for stray voltage and installed neutral isolators. The survey instrument was mailed to sixty-three dairy farmers during October 1999 with a cover letter indicating the purpose of the survey, the request for a prompt response, and the voluntary nature of the survey. Thirty-seven surveys were returned during November 1999. The percent return rate was fifty-nine percent, which was adequate to not warrant another mailing. No follow up survey was sent to the non-respondents because it was an anonymous survey, with no identifiers used.

Data Analysis

The survey data was analyzed at the Computer Center, University of Wisconsin-Stout. Frequency counts and percentages on statements 1-11, column A, before isolation, and column B, after isolation, were determined. Cross tabulation of frequency counts and percentages between column A and column B, for statements 1-11 were analyzed. Cross tabulation of frequency counts and percentages between question twelve, type of milking facility, and statements 1-11, columns A and B were completed. The t-test was utilized for the total group comparison between the before and after isolation average daily milk production per cow, in questions fourteen and fifteen.

Chapter IV

RESULTS

The results of this study determined what stray voltage symptoms in dairy cattle were eliminated on dairy farms that have neutral isolation. The study was performed utilizing a mail back survey sent to sixty-three dairy farms throughout Wisconsin who installed neutral isolation devices to correct stray voltage problems in their dairy cattle. Thirty-seven respondents returned surveys which answered this study's following questions:

1. What stray voltage behavioral problems in dairy cattle were eliminated on dairy farms when neutral isolation was installed.
2. What stray voltage milking characteristic symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed.
3. What stray voltage production performance symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed.

Survey Results

The symptom statement results presented are based on cross tabulation of frequency counts and percentages determined by which type of milking facility the respondents have. Twenty-one reported having a milking parlor and sixteen respondents milk in a stall barn.

The initial results presented for each symptom statement indicate if the symptom was present in the respondent's dairy cows before isolation. The second set of results

presented indicate if the stray voltage symptom was present in the respondent's dairy cows after isolation.

Behavior Symptoms

The results of research question number one which was, "What stray voltage behavioral problems in dairy cattle were eliminated on dairy farms when neutral isolation was installed," are as follows.

1. Excessive or unusual nervousness in milking parlor or stall barn **before** isolation:

   Milking parlor - Always 57.9%, Sometimes 36.8%, Never 5.3%

   Stall barn - Always 62.5%, Sometimes 31.3%, Never 6.3%

   Excessive or unusual nervousness in milking parlor or stall barn **after** isolation:

   Milking parlor - Always 0, Sometimes 57.9%, Never 42.1%

   Stall barn - Always 0, Sometimes 37.5%, Never 62.5%

   This trait often is characterized by cows dancing or stepping around while in the stall. If this behavior is caused by stray voltage, it is usually due to a voltage between the stall pipes, which the cow touches, and the concrete floor on which the cow is standing. Three respondents stated that after isolation their cows were more comfortable and content. A definite improvement in the nervousness of cows was seen after isolation.

2. Reluctance to enter milking parlor or stall barn **before** isolation:

   Milking parlor - Always 73.7%, Sometimes 21.1%, Never 5.3%

   Stall barn - Always 31.3%, Sometimes 37.5%, Never 31.3%

Reluctance to enter milking parlor or stall barn **after** isolation:

Milking parlor - Always 0, Sometimes 57.9%, Never 42.1%

Stall barn - Always 0, Sometimes 18.8%, Never 81.3%

When cows are subjected to stray voltage in the milking parlor or stall barn, they soon become reluctant to enter the parlor or stall barn. The cows want to avoid this area and the stray voltage shock they receive when they enter. In extreme cases, nearly all cows have to be forced into the parlor or stall barn. There were no comments regarding this symptom. There was a significant change in milking parlors. The symptom was always present 73.7% before isolation and went to zero percent after isolation.

3. Eagerness to flee milking parlor or stall barn **before** isolation:

Milking parlor - Always 31.6%, Sometimes 42.1%, Never 26.3%

Stall barn - Always 18.8%, Sometimes 50.0%, Never 31.3%

Eagerness to flee milking parlor or stall barn **after** isolation:

Milking parlor - Always 0, Sometimes 33.3%, Never 66.7%

Stall barn - Always 0, Sometimes 26.7%, Never 73.3%

When cows are subjected to stray voltage in the milking parlor or stall barn, they soon become eager to leave the parlor or stall barn. In extreme cases, nearly all cows may have a tendency to stampede out upon release to exit this area of stray voltage. There were no comments regarding this symptom. The results show a significant change of always being present 31.6% in milking parlors and 18.8% in stall barns to zero percent after isolation.

4. Increased frequency of defecation and urination in milking parlor or stall barn **before** isolation:

    Milking parlor - Always 52.6%, Sometimes 42.1%, Never 5.3%

    Stall barn - Always 42.9%, Sometimes 42.9%, Never 14.3%

    Increased frequency of defecation and urination in milking parlor or stall barn **after** isolation:

    Milking parlor - Always 0, Sometimes 73.7%, Never 26.3%

    Stall barn - Always 0, Sometimes 40.0%, Never 60.0%

    Stray voltage causes cattle to become nervous and excrete body waste more frequently. After isolation the respondents reported much less frequent defecation and urination. The results show the symptom always present 52.6% in milking parlors and 42.9% in stall barns before isolation and zero percent after isolation.

5. Reluctance to consume water **before** isolation:

    Milking parlor - Always 66.7%, Sometimes 16.7%, Never 16.7%

    Stall barn - Always 62.5%, Sometimes 25.0%, Never 12.5%

    Reluctance to consume water **after** isolation:

    Milking parlor - Always 0, Sometimes 33.3%, Never 66.7%

    Stall barn - Always 0, Sometimes 6.3%, Never 93.8%

    Reduced intake of water due to stray voltage problems may occur in cattle. The problem may be general throughout the farmstead, or only to a specific water location. One dairy farmer responded that a water meter to measure the gallons of water consumed per cow each day should be the first thing installed. Another dairy farmer stated that his

cows went up from sixteen gallons of water per day to twenty-six gallons per day and increased ten pounds of milk per day after isolation. Another respondent commented, "With stray voltage cows will not drink enough water and therefore feed consumption will be low," which is the next symptom surveyed.

6. Reluctance to consume feed **before** isolation:

    Milking parlor - Always 47.4%, Sometimes 36.8%, Never 15.8%

    Stall barn - Always 37.5%, Sometimes 50.0%, Never 12.5%

Reluctance to consume feed **after** isolation:

    Milking parlor - Always 0, Sometimes 36.8%, Never 63.2%

    Stall barn - Always 0, Sometimes 37.5%, Never 62.5%

Reduced intake of feed due to stray voltage problems may occur in cattle. The problem may be general throughout the farmstead, or only to a specific feeding location. Cattle will avoid feeding areas and consume less feed if stray voltage is present in these areas, according to the results of this survey symptom.

Milking Characteristics

The results of research question number two which was, "What stray voltage milking characteristics in dairy cattle were eliminated on dairy farms when neutral isolation was installed," are as follows.

7. Poor, incomplete, or uneven milk letdown **before** isolation:

    Milking parlor - Always 52.6%, Sometimes 36.8%, Never 10.5%

    Stall barn - Always 62.5%, Sometimes 37.5%, Never 0

Poor, incomplete, or uneven milk letdown **after** isolation:

Milking parlor - Always 5.3%, Sometimes 42.1%, Never 52.6%

Stall barn - Always 0, Sometimes 43.8%, Never 56.3%

Scientific research shows that the number of cows affected by stray voltage and the severity of milk letdown problems appear to be dependent on the level of stray voltage present. When it is high enough to cause the cows to move or step about during the milking process, it is difficult to keep the milking unit properly aligned and adjusted to provide an even weight distribution necessary to promote fast, effective milkout. The results of this study showed a significant improvement in milk letdown. Before isolation the symptom was always present 52.6% in milking parlors and 5.3% after isolation. In stall barns the symptom was present 62.5% before isolation and was zero percent after isolation.

8. Increased milking time **before** isolation:

Milking parlor - Always 50.0%, Sometimes 44.4%, Never 5.6%

Stall barn - Always 75.0%, Sometimes 12.5%, Never 12.5%

Increased milking time **after** isolation:

Milking parlor - Always 5.6%, Sometimes 50.0%, Never 44.4%

Stall barn - Always 6.3%, Sometimes 31.3%, Never 62.5%

If the stray voltage problem is severe enough to affect cows' behavior, such as kicking off the machine, milkout may be influenced. This problem can result in additional time needed for milking. A respondent stated immediately before isolation it took three people two and one quarter hours to milk. Even with three people, over one

third of the cows knocked the milking units to the floor. Within one month after isolation two people milked the same number of cows in one and three quarter hours with the same number of milking units. Less than ten percent of the cows kicked off the milking units.

Improved milking time was achieved by isolation according to the results of this study. The symptom was always present in milking parlors 50.0% and in stall barns 75.0% before isolation. After isolation the results show the symptom was 5.6% in milking parlors and 6.3% in stall barns after isolation.

Production Performance

The results of research question number three which was, "What stray voltage production performance symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed," are as follows.

9. Increased somatic cell count **before** isolation:

    Milking parlor - Always 68.4%, Sometimes 31.6%, Never 0

    Stall barn - Always 68.8%, Sometimes 31.3%, Never 0

    Increased somatic cell count **after** isolation:

    Milking parlor - Always 5.3%, Sometimes 78.9%, Never 15.8%

    Stall barn - Always 0, Sometimes 56.3%, Never 43.8%

10. Increased incidence of clinical mastitis **before** isolation:

    Milking parlor - Always 73.7%, Sometimes 26.3%, Never 0

    Stall barn - Always 75.0%, Sometimes 25.0%, Never 0

Increased incidence of clinical mastitis **after**:

Milking parlor - Always 5.3%, Sometimes 78.9%, Never 15.8%

Stall barn - Always 0, Sometimes 56.3%, Never 43.8%

Mastitis, whether clinical or subclinical, is the result of a bacterial infection of the mammary gland and is measured by the somatic cell count test. This test measures the number of white blood cells in a milliliter of milk. The cow's body sends white blood cells to the mammary gland to fight off infections. So the higher the somatic cell count the more serious the bacterial infection. Most dairy farmers have a goal of producing milk with a somatic cell count below 100,000. These bacterial infections are not directly caused by stray voltages. However, if cows' behavior is modified, and if the milking routine is altered because of the change in cows' behavior, what may result is less satisfactory milking performance, increased somatic cell counts, and more clinical mastitis.

The results of these production performance symptom statements were confirmed by the comments of a few respondents. One dairy farmer said, "I was going through one or two boxes of mastitis tubes a day before isolation, and in the last year and a half I treated four cows for mastitis. My somatic cell count went from between 500,000 - 700,000 to 110,000 - 180,000." A respondent said his somatic cell count went from 600,000 to 150,000 and another stated his somatic cell count dropped from 350,000 to 175,000. Another stated that his cows are not flaring up with mastitis all the time. Yet another farmer reported, "I feel isolation helped with herd health, but we still have a somatic cell problem. We had to sell many cows with high somatic cell counts."

11. Lowered milk production **before** isolation:

Milking parlor - Always 84.2%, Sometimes 10.5%, Never 5.3%

Stall barn - Always 75.0%, Sometimes 25.0%, Never 0

Lowered milk production **after** isolation:

Milking parlor - Always 15.8%, Sometimes 42.1%, Never 42.1%

Stall barn - Always 0, Sometimes 37.5%, Never 62.5%

If cows drink less water, consume less food, or become more mastitic, they are likely to produce less milk. Whether or not milk production will be adversely affected by stray voltage depends on the extent to which the cows' behavior is altered. The results of this symptom statement show that milk production was increased by isolation. Lowered milk production was reported as being present 84.2% on dairy farms with milking parlors and 75.0% on farms with stall barns before isolation. After isolation farms with milking parlors reported lowered milk production 15.8% and farms with stall barns report lowered milk production zero percent. How much milk production increased was answered by the results of survey questions fourteen and fifteen.

14. What was the average daily milk production per cow **before** isolation? _____ lbs.

Mean - 53.97 lbs., Median - 55.00 lbs., Standard deviation - 11.38 lbs.

15. What was the average daily milk production per cow **after** isolation? _____ lbs.

Mean - 68.00 lbs., Median - 70.00 lbs., Standard deviation - 9.61 lbs.

The average increase in daily milk production after isolation was 14.03 pounds of milk per cow per day. Thirty-five of the thirty-seven respondents reported an increase in milk production after isolation. One dairy farmer reported no increase in milk production

after isolation and another had a decrease of three pounds of milk per day, but he stated, "I think isolation is a good investment and an insurance policy. Unfortunately it did not work for us. We have two transmission lines that run through our farm and we feel these are the culprit."

An increase in milk production is one way to pay for the cost of isolation. Question thirteen addresses the cost of isolation with the following responses.

13. What was the approximate cost of isolation on your farm?

	Frequency	Percent
1. Under $10,000	1	2.7
2. $10,000 to $20,000	5	13.5
3. $20,000 to $30,000	16	43.2
4. $30,000 to $40,000	5	13.5
5. $40,000 to $50,000	3	8.1
6. Over $50,000	7	18.9
Total	37	100.0

Forty-three percent of the respondents reported spending between twenty and thirty-thousand dollars on isolation and nearly nineteen percent spent over fifty-thousand dollars. Several hundred thousands of dollars are being spent by dairy farmers to correct stray voltage symptoms in their dairy cattle, but is it worth it? Question sixteen addressed this issue.

16. Do you feel isolation was a good investment? Please comment.

Thirty-five of the thirty-seven respondents stated in some form that isolation was a good investment. Six farmers said they would be out of business without isolation. Many commented about the increased milk production, lower somatic cell counts, and fewer clinical cases of mastitis. Another topic that was commented on, but not

researched in this study, was the improvement of herd health after isolation. Nineteen respondents made comments regarding this issue. After isolation, they saw lower death loss, less sore feet and swollen legs, and an improved immune system for fighting off disease. Improved reproductive performance was observed and measured with better heat detection and conception rates. Two respondents reported that their veterinary bills were reduced by fifty percent because of fewer sick cows.

Two respondents said isolation was not a good investment because it did not solve their stray voltage problems or show any improvement in the stray voltage symptoms on their farms.

The results of this study showed that isolation eliminated or greatly reduced the stray voltage symptoms in cattle on dairy farms surveyed in this study. One dairy farmer summed it up best. He said, “Milking cows is an every day thing and isolation became a pay back every milking. It is an investment that I recommend everyone to do on their original or new-farm investment.”

Chapter V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter will begin with an analysis and summary of the information gathered in this study. Conclusions will then be drawn, resulting in an answer to each of the three research questions, followed by recommendations for the future.

Summary

Stray voltages are causing serious problems in certain dairy operations. Dairymen are losing milk production and are experiencing cow behavior and cow health problems due to small electrical currents passing through the cows' bodies. Cows can sense voltages at approximately one-tenth the level that humans can. Both controlled research and observation on problem farms show that animals subjected to stray voltages are likely to exhibit symptoms related to three general classifications: 1) behavioral problems, 2) milking characteristics, 3) production performance.

Dairy farmers with stray voltage symptoms in their cattle often spend thousands of dollars to do a neutral isolation. This isolates the primary neutral of the electricity provider from the farm neutral to suppress stray voltage from off-farm sources. The purpose of this study is to determine what stray voltage symptoms in dairy cattle were eliminated on dairy farms that have neutral isolation by answering the following questions:

1. What stray voltage behavioral problems in dairy cattle were eliminated on dairy farms when neutral isolation was installed.

2. What stray voltage milking characteristic symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed.
3. What stray voltage production performance symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed.

To answer the questions of this study, dairy farmers who installed neutral isolation devices to correct the problems associated with stray voltage were sent a mail-back survey. They were asked what common stray voltage symptoms were present on their dairy farms prior to isolation, compared to what symptoms were eliminated by neutral isolation. Questions about type of milking facility, milk production, and cost of isolation were asked. Comments were requested to illicit opinions and comments from the participants in the study.

The subjects selected for this study were a convenience sample taken from the customer list of Concept Electric Inc., Appleton, Wisconsin. This company specializes in stray voltage testing and neutral isolation. Sixty-three dairy farms throughout Wisconsin that were tested for stray voltage and installed neutral isolation devices to correct stray voltage problems in their dairy cattle were surveyed. Thirty-seven surveys were returned. No follow up survey was sent to the non-respondents because it was an anonymous survey, with no identifiers used.

Statistical analyses using cross tabulation, frequency counts, and percentages were utilized. The t-test was used for total group comparison of milk production before and after neutral isolation.

A major finding of this stray voltage study, was that the average increase in milk production was 14.03 pounds of milk per cow per day after neutral isolation on the thirty seven farms that responded to the survey. The mean daily milk production per cow before isolation was 53.97 pounds. The median was 55 pounds of milk with a standard deviation of 11.38 pounds. The mean daily milk production per cow after isolation was 68 pounds. The median after isolation was 70 pounds of milk with a standard deviation of 9.61. This increase in milk production contributes to the pay back of the cost of neutral isolation. Forty-three percent of the respondents spent between $20,000 and $30,000 to install neutral isolation devices to eliminate stray voltage problems on their dairy farms. Another 18.9% spent over $50,000 to correct the problems associated with stray voltage on their farms.

To answer the research questions of this study, dairy farmers who installed neutral isolation devices to correct the problems associated with stray voltage were asked what common stray voltage symptoms were present on their dairy farms before isolation, compared to what symptoms were eliminated after neutral isolation. Subjects were asked to respond to eleven statements, and indicate if the symptom was present in their dairy cattle before isolation by checking if the symptom was always, sometimes, or never present. The respondents indicated if the symptom was present in their dairy cattle after isolation by checking if the symptom was always, sometimes, or never present after isolation. The results were cross tabulated with the type of milking system they had, either milking parlor or stall barn.

Conclusions

Research question #1 was to determine what stray voltage behavioral problems in dairy cattle were eliminated on dairy farms when neutral isolation was installed. Six behavioral symptom statements were listed in the survey. This study found that the percentage of behavioral symptoms reported by the respondents as always present was zero percent after neutral isolation. Both milking parlor and stall barn facilities had the same results. These six behavioral symptoms were eliminated from always being present after neutral isolation.

Behavioral problems were not completely eliminated by neutral isolation. For every behavioral symptom statement the results show that every symptom was still sometimes present on farms. The percentage of respondents reporting that the symptom was never present after neutral isolation increased for every symptom statement. This researcher concludes that neutral isolation eliminated all of the behavioral problems associated with stray voltage from always being present to only sometimes and never being present.

Research question #2 was to determine what stray voltage milking characteristic symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed. Two milking characteristic symptoms were surveyed, milk letdown and milking time.

Milk letdown was improved by neutral isolation. Before isolation, 52.6% with milking parlors and 62.5% with stall barns always had milk letdown problems. After isolation, 52.6% milking parlor and 56.3% stall barn reported never having milk letdown problems because of stray voltage.

Milking time was also improved by neutral isolation. Before isolation, 50.0% with milking parlors and 75.0% with stall barns had increased milking time because of stray voltage. After isolation, 44.4% with milking parlors and 62.5% with stall barns reported never having increased milking time because of stray voltage.

Research question #3 was to determine what stray voltage production performance symptoms in dairy cattle were eliminated on dairy farms when neutral isolation was installed. Two production performance characteristics were surveyed, somatic cell count and incidence of clinical mastitis.

Before isolation, increased somatic cell count was always present on 68.4% of the farms with milking parlors and 68.8% with stall barns. After isolation these percentages went to 5.3% for milking parlors and 0% for stall barns.

Before isolation, increased incidence of clinical mastitis was always present on 73.7% of the farms with milking parlors and 75.0% with stall barns. After isolation these percentages went to 5.3% for milking parlors and 0% for stall barns.

Even though increased somatic cell count and clinical mastitis is not caused by stray voltage, the incidence of each was reduced in the findings of this study. Neutral isolation improved the cows' behavior and milking performance, resulting in a decrease of somatic cell count and incidence of clinical mastitis.

The conclusions of this study showed significant improvement because of neutral isolation in the three general stray voltage symptom areas: behavioral problems, milking characteristics, and production performance.

Recommendations

The results of this study can be used by dairy farmers with stray voltage symptoms in their dairy cattle to make informed decisions about neutral isolation as a possible solution to correct these symptoms. This study identified what stray voltage symptoms were eliminated by neutral isolation. The average milk production increase and cost of installing neutral isolation were determined. This information allows dairy farmers to better understand the option of neutral isolation to correct stray voltage symptoms in their dairy cattle. The findings can be used by agricultural educators, extension personnel, and farm consultants to inform dairy farmers of what results to expect if neutral isolation is done on their farms to correct stray voltage symptoms.

Further research on this subject could expand the size of the sample surveyed and repeat the study. Other electric companies offer dairy farmers neutral isolation services and more dairy farmers will continue to install neutral isolation devices to correct problems in their dairy cattle caused by stray voltage. A larger survey sample would validate the results of this study more accurately.

This study researched the results of neutral isolation on farms with either milking parlors or stall barn facilities. Future research may look at why there was significant differences in the results for some of the symptom statements between milking parlors and stall barn facilities after neutral isolation.

Many respondents commented about the improved herd health of their cattle after neutral isolation. Improved immune systems allowed dairy cattle to fight off disease and infection better. Lower herd death loss and culling rates were expressed as benefits of neutral isolation. Future research could include these areas of study.

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Martin Nackers
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Hector Cruz
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Dear Dairymen,

As a Farm Business and Production Management instructor at Northeast Wisconsin Technical College in Green Bay, I have worked with dairymen who have isolated their farms from the utility company. This was done because their dairy cattle suffered symptoms caused by stray voltage.

To meet a requirement of my Masters Degree in Vocational Education at the University of Wisconsin-Stout, I must complete a research project. I have chosen to research the topic of stray voltage, and specifically what common stray voltage symptoms were present on dairy farms prior to isolation compared to what symptoms were eliminated by isolation.

I would sincerely appreciate your cooperation in completing the attached survey. It should only require a few minutes to complete. Please circle or check the appropriate response and return it in the enclosed self-addressed, stamped envelope within ten days.

This survey is voluntary with no identifiers used. The information is being sought in such a way that confidentiality is guaranteed. By returning this survey you are consenting to be a volunteer in this study. Any concerns should be addressed to myself or to Hector Cruz, my research advisor.

Your responses will contribute to the completion of my research project. I greatly appreciate you taking the time out of your busy schedule to help me. Thank you.

Sincerely,

Martin Nackers

Hector Cruz
Research Advisor

STRAY VOLTAGE SURVEY

DIRECTIONS: Use your experience as a farm owner/operator as the basis for answering the following survey. Read each statement concerning a symptom attributed to stray voltage and respond two times to each statement. In column A, indicate if the symptom was present in your dairy cows before isolation. In column B, indicate if the symptom was present in your dairy cattle after isolation.

Use the following responses:

A. Symptoms before isolation
1 = A = Always
2 = S = Sometimes
3 = N = Never

B. Symptoms after isolation
1 = A = Always
2 = S = Sometimes
3 = N = Never

SYMPTOM STATEMENT	A. Before isolation A S N 1 2 3	B. After isolation A S N 1 2 3
Behavior Symptoms		
1. Excessive or unusual nervousness in milking parlor or stall barn……..	1 2 3	1 2 3
2. Reluctance to enter milking parlor or stall barn……..	1 2 3	1 2 3
3. Eagerness to flee milking parlor or stall barn……..	1 2 3	1 2 3
4. Increased frequency of defecation and/or urination in milking parlor or stall barn…	1 2 3	1 2 3
5. Reluctance to consume water……	1 2 3	1 2 3
6. Reluctance to consume feed……..	1 2 3	1 2 3
Milking Characteristics		
7. Poor, incomplete, or uneven milk letdown.	1 2 3	1 2 3
8. Increased milking time……	1 2 3	1 2 3

SYMPTOM STATEMENT	A. Before isolation A S N 1 2 3	B. After isolation A S N 1 2 3
Production Performance		
9. Increased somatic cell count……	1 2 3	1 2 3
10. Increased incidence of clinical mastitis…	1 2 3	1 2 3
11. Lowered milk production…….	1 2 3	1 2 3

Some demographic information:

12. What type of milking facility do you have?
    _____1. Milking parlor
    _____2. Stall barn

13. What was the approximate cost of isolation on your farm?
    _____1. Under $10,000
    _____2. $10,000 to $20,000
    _____3. $20,000 to $30,000
    _____4. $30,000 to $40,000
    _____5. $40,000 to $50,000
    _____6. Over $50,000

14. What was the average daily milk production per cow **before** isolation? _____ lbs.

15. What was the average daily milk production per cow **after** isolation? _____lbs.

16. Do you feel isolation was a good investment? Please comment.

17. Are there any other comments you would like to add? Thank you.