

Michigan Stray Voltage Protocols

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Professionals who work directly with livestock producers are frequently asked questions that extend beyond the bounds of their primary training. Questions about electrical issues and stray voltage may be an example. Dairy field inspectors are generally aware of stray voltage and the effects that can result from livestock exposed to excessive levels, but few have training to understand the sources and measurement techniques. A few years ago an electric power supplier representative in Michigan was discussing the stray voltage issue with agricultural leaders and the need for producers awareness and early detection to prevent adverse conditions from developing on a farm. Since conditions can arise both on-the-farm as well as off-the-farm that can lead to voltage conditions that may be adverse to livestock, there is always a need for electrical awareness. Dairy field inspector interest to help in the identification of electrical problems on farms was expressed to the Michigan Agricultural Electric Council which worked with the Michigan Department of Agriculture Food and Dairy Division field inspectors to develop and implement a dairy farm electrical safety check program.

Electrical Safety Check Program Objectives

The objective of the dairy farm electrical safety check program was to take advantage of the field inspectors being on farms and in a position to help identify potential electrical safety problems. Stray voltage was one, but not the only, electrical problem this program would seek to identify. The program would also make the dairy producer aware of sources of assistance in dealing with an electrical safety problem or an electrical safety concern. This was to be a program to assist the dairy producer and not for the purpose of gathering electrical data on dairy farms. The program was set up to preserve the anonymity of the dairy producer outside of the dairy field inspection organization. Voltage measurements were provided for analysis on a county basis, but specific producers were not identified. This was not a mandatory activity, and individual producers were given the option of participating. To prevent this program from being burdensome to field inspectors, the electrical measurement at the farm could not be time consuming. Measurements had to be easy to make and give reliable results.

Program Operation

Field inspectors for the Food and Dairy Division of the Michigan Department of Agriculture during their regular farm inspections make a voltage measurement that can reveal electrical safety problems. The electrical safety check program consists of a single ac voltage measurement from the milk bulk tank to the milkhouse floor drain or the concrete floor adjacent to the drain. A dairy field inspector is shown in Figure 1 making an electrical safety check measurement. The person making the measurement is standing on a 4 inch diameter copper plate placed on the wet floor. Ideally the desired measurement is from the electrical panel neutral in the milking facility to a reference ground located outside the building. Such a measurement requires extra equipment and should only be done by trained electrical personnel. Generally a voltage measurement from a milk tank to the milkhouse floor is a good approximation of a neutral-to-reference ground voltage measurement. It is recognized that a voltage measurement between the milk tank and the floor may not be reliable, but experience has shown the chances for error are low. If there is an equipotential plane in the floor (metal in the floor bonded to the electrical system ground), the measurement between the milk tank and the floor will be near zero. Field inspectors were made aware of this condition and why a zero reading would be obtained if there was an equipotential plane in the milkhouse floor. When a zero or nearly zero measurement occurred, the field inspector was encouraged to verify the reading by making alternate measurements around the milking area to other equipment. If a

higher measurement was obtained, the higher voltage was to be recorded.



Figure 1 The electrical safety check program involved an open circuit voltage measurement from the milk tank to the concrete floor or floor drain.

It is also recognized that a single voltage measurement taken under unspecified conditions is not necessarily representative of conditions that may exist on the farm. Some electrical safety conditions will exist only when certain equipment is in operation. Dairy producers are instructed to be aware of abnormal livestock behavior that may be caused by an electrical condition and how to request assistance in investigating the situation. Regardless of some shortcomings, with little effort, this voltage measurement program has a good chance of identifying potential electrical safety problems on farms.

The field inspectors were provided with equipment for making the electrical safety checks. The cost of providing the digital voltmeter, 4 inch diameter copper floor plate, and lead wires was paid by the Michigan Agricultural Electric Council. A leaflet was developed that briefly explained the program and showed how to make the voltage measurement (Tinsey, 2001). Space was provided on the form to record the measurement. Based upon a thorough review of literature (Fick, 1996), it was decided the level for taking action would be a steady 2 volts ac or greater. The date and voltage reading would be recorded on the leaflet and if a reading of 2 volts or greater was measured, the dairy producer was encouraged to call the electric power supplier for a follow-up evaluation. Telephone numbers for each power supplier serving dairy producers in Michigan are provided on the leaflet. A measurement of 10 volts or greater was considered to be cause for immediate action and the producer was informed that a call should be made immediately to a licensed electrician and the electric power supplier.

Before the electrical safety check program was started in 1996, training on how to proceed was provided to the dairy field inspectors. They were also provided with measurement

equipment and printed leaflets on the safety check program as well as on the stray voltage issue. The field inspector reported the results of the electrical safety check to the dairy producer. In cases where the measurement was 2 volts or more, the producer was informed and encouraged to seek assistance. Because anonymity for the dairy producer was to be maintained, there was no follow-up provision to determine if a specific dairy producer acted upon the information provided. Once a contact was made to an electric power supplier, that power supplier worked with the dairy producer to conduct an evaluation, identify both on-farm and off-farm conditions that may require corrective action, and conduct a follow-up evaluation to determine if the condition had been corrected. It was also recognized that voltage measurements may indicate a potential safety problem when one did not exist. This can happen when voltage measurements are taken by personnel with little electrical training. The electric power suppliers participating in this program were willing to deal with such cases in order to err on the side of caution to make sure all possible conditions that may pose a safety hazard or a stray voltage concern were resolved.

The voltage measurements taken between the milk tank and the floor in the milkhouse were open circuit voltage measurements. It is a common practice at times to take a neutral-to-earth voltage measurement with a resistor with a value of approximately 500 ohms across the input of the voltmeter (shunt resistor). Taking neutral-to-earth voltage readings using a shunt resistor requires special training and can lead to measurement errors. All of the voltage readings taken as a part of the electrical safety check program are open circuit voltage measurements without the use of a shunt resistor. Open circuit voltage measurements are equal to or higher than measurements taken at the same location using a shunt resistor. A high open circuit voltage does not necessarily mean there is a safety problem, but this type of measurement is highly reliable at finding problems when they do exist.

Program Operation

In 1996 the objectives of the electrical safety check program were explained to dairy field inspectors. They were provided with test kits, including a digital voltmeter, and provided training in making measurements on the farm. For personnel who may not be familiar with neutral-to-earth voltage conditions, making a measurement from a metal milk tank to the adjacent concrete floor can seem strange. It was explained that since the milk tank is connected to the neutral terminal in the electrical panel, this measurement is an approximation of the neutral-to-earth voltage that exists on the farm at that time. It was also explained that a small level of voltage from the milk tank to the floor is normal. It was explained that the source of this voltage can be due to normal or abnormal conditions in the wiring on-the-farm or the electrical distribution system supplying the farm.

After the initial training in 1996, the field inspectors were asked to make an electrical safety check as a part of their farm inspection. The program continued in this manner until the summer of 2000. Periodically repairs were made to the equipment and training provided to the field inspectors. The dairy inspectors would record the measurement on their farm inspection tally sheets which were compiled at the central office according to county. Starting in 2001 it was decided to conduct the electrical safety checks over a two month period of time where all dairy field inspectors would be required to make measurements on all farms inspected unless the dairy operator requested to be excluded. During any two month period, the field inspectors will visit 25% or more of the dairy farms in Michigan. The program is now designed so that over a four year period, a safety check can be conducted at every dairy farm in Michigan. Each year the testing would be scheduled during a different season. The field inspectors were free to make electrical safety checks throughout the year, but it was not required as a part of an organized activity. Farm operators can request a safety check to be conducted at any time during the year, and the serving electric power supplier will provide a detailed follow-up evaluation if requested.

Results

During the period of 1996 to 2000 the total number of dairy farms where electrical safety checks were conducted was 3072. Some of these dairy farms were checked several times for a total number of 6766 safety checks. There were 26 different inspectors involved in the program from 1996 to 2000. There were 86 measurements at 2 volts or above. In each case the dairy producer was encouraged to request a detailed evaluation. Because of the maintenance of anonymity of the individual farms it was not possible to determine if follow-up evaluations were conducted. In 2001 electrical safety checks were conducted by 20 field inspectors for a total of 980 dairy farms out of a possible 3104 dairy farms in Michigan. Eleven farms had a voltage measurement of at least 2 volts. Table 1 is a summary of the electrical safety check voltage measurements for the entire state with the average and median measurements. The last column of Table 1 indicates that 50% of the safety check voltages measured did not exceed 0.1 volts. Measurements were made at different times of the day. Some measurements were made during milking and some were at times when little farm electrical equipment was operating.

Table 1 Summary of the electrical safety check voltage measurements made in Michigan between 1996 and 2001.

Check period	Safety checks	2 volts or greater	2 volts or greater	Average voltage	Median voltage
1996 - 2000	6766	86	1.3%	0.26	0.09
2001	980	11	1.1%	0.34	0.10

The distribution of dairy farms in Michigan is contained in Table 2. Upper Michigan consists of the entire Upper Peninsula and the Northern three tiers of counties in the Lower Peninsula. Southeastern and Southwestern Michigan consists of the lower three tiers of counties split in the middle of the state. The Saginaw Bay region includes counties bordering the Saginaw Bay except Huron County and it does include Genesee County. The farms with voltages measured at or above 2 volts were distributed throughout Michigan. Table 2 shows the number of total dairy farms and the number of farms with measurements at or above 2 volts for the State subdivided into seven regions. In 2001 the safety check program was operated for a two month period and safety check measurements were made on 32% of the total farms.

Table 2 Distribution throughout Michigan of safety check measurements of 2 volts or above.

Region	Total dairy farms*	Safety checks 2 volts or above 1996 to 2000	Safety checks 2 volts or above 2001
Upper Mich	453	15	2
West Mich	715	23	1
Saginaw Bay	172	3	1
Central	432	12	1
Southeast	374	0	0
Thumb	517	19	5
Southwest	441	14	1
Totals	3104	86	11

* Totals based upon 2001 statistics. Numbers approximately the same for 1996-2000

Future Activities

Interest in participating in the farm safety check program has increased, and two organizations that previously were conducting neutral-to-earth voltage evaluations on farms also asked for assistance in participating in a safety check program. Instrumentation being used by field inspectors for the Michigan Dairy Farmers of America and the Michigan Milk Producers Association were collected for maintenance and calibration. The Michigan Agricultural Electric Council provided maintenance on the test kits and replaced any voltmeters, parts and materials that were either damaged or missing. Test kits were provided to field inspectors who previously did not have this equipment. These field inspectors requested equipment that could also be used to make livestock contact measurements. A resistor and a switch (Figure 2) was assembled as a part of a double banana plug to allow a quick and easy method of taking an open circuit voltage at livestock contact as well as a measurement with a resistor placed across the voltmeter input leads. In May 2002 a one day training session was conducted for field inspectors to discuss the basic safety check program and to give the inspectors actual field experience. At that time the test kits were returned to the field inspectors. A special leaflet was prepared for the field inspectors for the Dairy Farmers of America and the Michigan Milk Producers Association that provided a space to record an animal contact voltage measured with and without a 500 ohm shunt resistor (Tinsey, 2002). Space was also provided for recording the basic safety check measurement to the milk tank. These differences between this program and the Michigan Department of Agriculture program were made at the request of the dairy field inspectors. There is no formal data reporting taking place for the measurements made by the field inspectors of the Dairy Farmers of America and the Michigan Milk Producers Association. These field inspectors also advise the dairy producer to request a follow-up evaluation in cases where any voltage measurement equals or exceeds 2 volts. The Michigan Agricultural Electric Council provides a detained neutral-to-earth voltage evaluators training program on an annual basis that is available to any person desiring training. Later in 2003 feedback will be gathered to determine if the procedures followed are beneficial. It is the intention of the Michigan Agricultural Electric Council to provide technical assistance and training to professional agricultural personnel when requested.

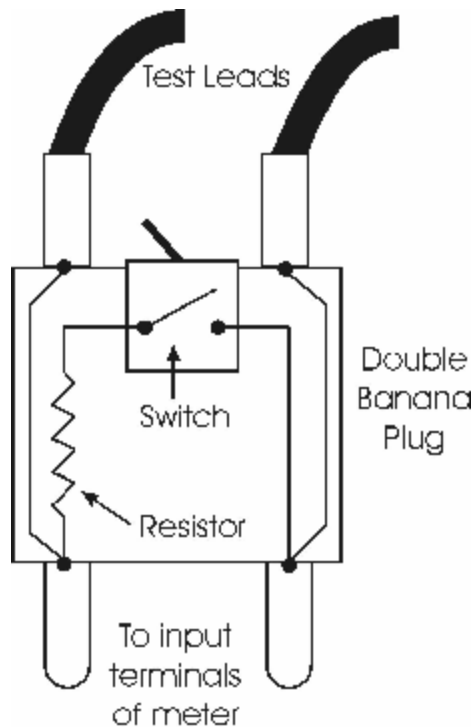


Figure 2 A double banana plug can be fitted with a 500 ohm resistor and a switch to make it easy to take an open circuit voltage and a shunted voltage reading at a livestock contact location.

Summary

Electric power suppliers conducting follow-up evaluations found the typical causes of the elevated voltage level to be ground faults or high resistance in neutral conductors on the farm, or a condition with the primary neutral circuit. Some measurements were found to be in error and a condition that required correction did not exist. Of the on-farm sources, the causes were either high resistance in a neutral supplying a building or a ground fault in equipment. Not enough data was collected and documented from the follow-up evaluations to form overall conclusions except the types of problems that were found were consistent with previous research. It was concluded by the electric power suppliers participating in the safety check program that enough problems were identified to justify continuation of the program. Problems with an electrical system are normal and can occur at any time, thus requiring continued vigilance and maintenance of electrical systems.

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www.egr.mus.edu/age/ and click on Michigan Agricultural Electric Council to view copies of publications listed in this paper.

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