THE PHILIPPINE AGRICULTURAL SCIENTIST
Vol. 91 No. 4, 251-260
December 2008

ISSN 0031-7454

Stray Voltage Problems in Dairy Farms and Effects on Animal Behavior

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Stray voltage is a small voltage measured between two points that can simultaneously be contacted by a cow. A current will flow between these points. The amount of current depends on the voltage and the resistance of the animal. Reactions of animals to mild electric shocks caused by stray voltage have been reported to include behavioral changes, changes in milking characteristics of dairy cows and changes in production performance. This study evaluated the presence or absence of stray voltage on dairy farms. Questionnaires related to the history of the situation and animal reactions were also used in the study. Experiments were carried out on 51 dairy farms in Turkey. All farms had more than 30 milking cows which are milked by using pipe line milking systems. Stray voltage problems were found on 12 farms (23%). The relationship between the presence of stray voltage and behavioral change on the dairy farms was statistically significant (P=0,002). Based on the results, stray voltage sources on the farms were mostly attributed to faulty wiring, faulty equipment and improper grounding.

Key Words: stray voltage, neutral to earth, behavioral change, animal reaction

INTRODUCTION

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

Stray voltage is a small (usually less than 10 volt) potential measured between two points that can be contacted by a cow (Cloud et al. 1987; Worley and Wilson 2000). Cows and humans are similarly sensitive to electric current, i.e., both respond similarly to comparable current levels. However, cows are more susceptible to stray voltages primarily because their body impedance (resistance) is much lower than that of humans (USDA 1991). Dairy cattle may be sensitive to 0.5 volt AC or about 2.5 milliamperes. Cows react to the current, not the voltage. The dairy cow's resistance is about 250–400 ohms, or about 0.1 that of humans. That is why cows may feel the electrical current when the dairyman does not (Bray and Shearer 1993).

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

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

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

Many of the above symptoms are not directly caused by stray voltage. For instance, if the stray voltage/current problem is severe enough to affect a cow's behavior, such as kicking off the machine, milk-out may be influenced.

This problem will result in increased milking time. Mastitis, whether clinical or subclinical, is the result of an infection, but there is more chance of picking up an infection when the machine is kicked off. Lowered milk production will result when cows drink less water, consume less feed, or develop mastitis (Appleman and Gustafson 1985; Bray and Shearer 1993).

This study evaluated the presence or absence of stray voltage on dairy farms. Behavioral changes as a result of stray voltage, which were noticed by farmers, were also evaluated and compared.

MATERIALS AND METHODS

Trials were performed in the Trakya Region of Turkey. There were about 60 farms that had more than 30 milking cows in this area. Experiments were carried out in 51 large-scale dairy farms. Other farms were not available for the experiments. All farms had more than 30 milking cows that were milked by using pipe line milking systems.

Before checking stray voltage on farms, a questionnaire was used to look into the situation and the reactions of the animals. Questions for the farmer included "What symptoms of the problem have been noticed?" Symptoms mentioned in the questionnaire consisted of: cows were extremely nervous while in the parlor, cows were reluctant to enter the parlor or drink water, increase in manure deposition in the parlor, reduced feed intake in the parlor, incomplete or uneven milk out, more mastitis or lowered milk production (Cloud et al. 1987). Symptoms mentioned by farmers were marked as behavioral change in the questionnaire.

Standardized procedures for stray voltage measurement have been developed by many researchers. Experimental procedures of this study were developed according to Cloud et al. (1987) and Gustafson (1983). Some of the procedures in these studies were adapted in order to fit the conditions of the farms in this study.

The main devices used in the test were a multimeter, a continuous recorder multimeter and a ground rod. Some of the general specifications of the multimeter and the continuous recorder multimeter are presented in Table 1. The ground rod was 1.5 m copper clad with a connecting clamp.

A reference ground rod was provided at least 15 m (25 feet) from the barn and isolated from any metallic objects. An insulated lead was connected from the rod to the multimeter. The other lead of the voltmeter was connected to the grounded neutral system at the selected point and cow contact points which are mentioned below.

The following step-by-step procedure was done for checking stray voltage problem. The scheme of procedures is presented in Figure 1.

Table 1. General specifications of multimeter and continuous recorder multimeter.

	Multimeter	Continuous Recorder Multimeter
Measuring	AC and DC (digital)	AC and DC (digital)
Accuracy	0.5 %	0.5 %
Update rate	0.33 s	0.2 s
Data hold	-	5400
Measuring range	0.1 Ω – 40M Ω	0.1 Ω – 50M Ω
	DCA 0.1μA-20A	DCA 0.1μA-20A
	ACA 0.1 μA-20A	ACA 0.1μA-20A
	DCV 0.1mV-1000 V	DCV 0.01 mV-1000 V
	ACV 0.1mV-1000 V	ACV 0.01 mV-1000 V

Step 1: A multimeter was connected to the main service entrance (transformer) ground and N-E (neutral to earth) voltage was read with all electrical devices turned off. Readings were continued as each load was turned on. Primary wiring system was checked in this step.

Step 2: A multimeter was connected to the barn service entrance to check the secondary wiring system. Voltage was recorded with all loads turned off in the barn. Similar to step 1, voltages were read as each load was turned on.

Step 3: A continuous recorder multimeter was connected at the barn service entrance where step 2 was done. Voltage reading was recorded throughout milking time (loads on). Peak values and steady values in this term were determined by using the software of the recorder.

Step 4: Voltages at potential cow contact points were read during milking time in this step. Potential cow contact points were stall pipes, metal feeder, watering bowl and the floor.

Any voltage value over 0.5 Volt in each step was evaluated as a potential stray voltage problem on the farm.

The relationship between the independent variables of stray voltage and behavioral change were evaluated statistically by using chi square test. Analyses were performed with SPSS version 10.0.

RESULTS AND DISCUSSION

Stray voltage values (Volt) on the dairy farms and symptoms which were obtained from the questionnaire are given in Table 2. Only farms where voltages over 0.5 V were found or where any of the symptoms were noted are shown in the table. Values are the maximum reading values for each step measurement.

The relationship between present stray voltage and behavioral change on the farms was significant (Chi-Sq=8.747, DF=1 and P=0,002). A stray voltage problem was

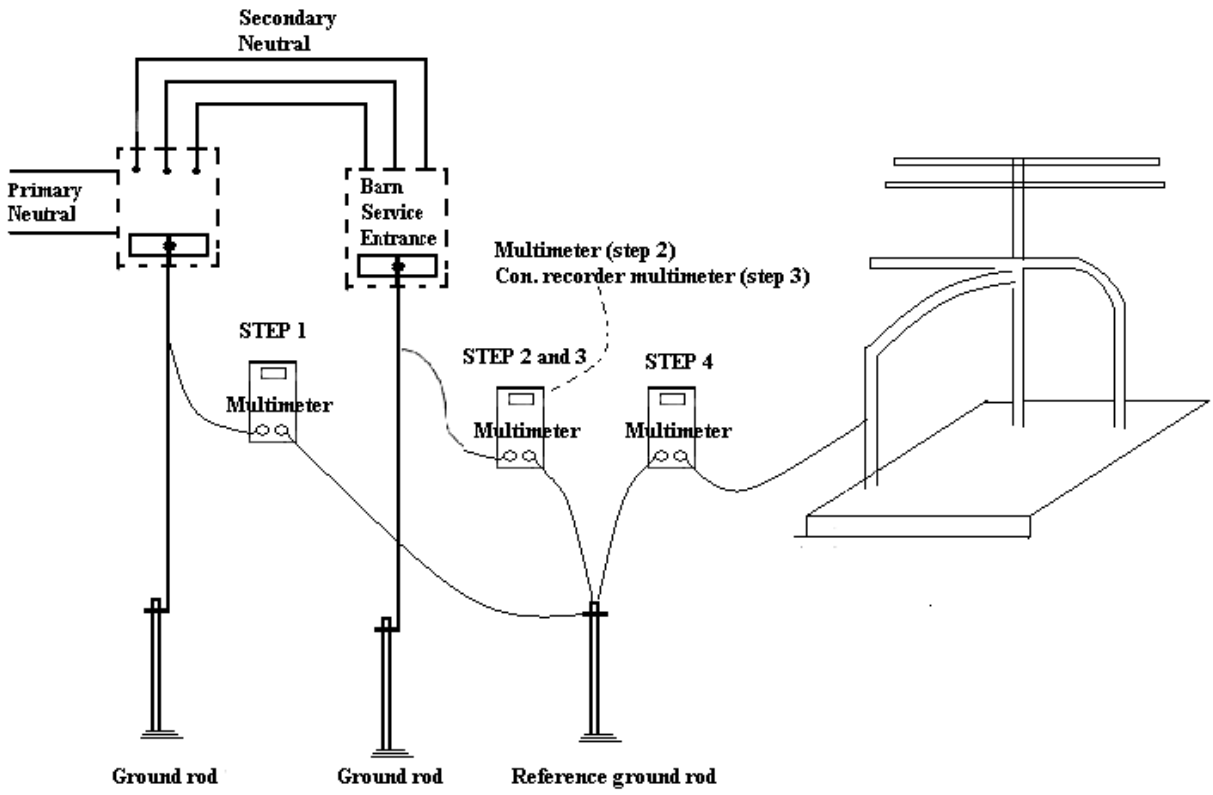

Fig. 1. The scheme of procedures for determining stray voltage.

found in 12 farms (24%) of the 51 farms. Nineteen of them (37%) identified any of the symptoms of stray voltage on the questionnaire. Voltage levels over 0.5 were found on 83.3% of farms reporting symptoms while these voltage levels were only found on 16.6% of the farms not reporting symptoms (Table 2). Some detailed results are given below:

No voltage readings above 0.5 V were measured during step 1 while all loads were turned off. This situation may be explained by the fact that all primary wiring systems on the farms were sufficient. But, as loads were turned on, stray voltages were determined in Farms 12, 17, 26 and 40. Stray voltage also appeared during the other steps on these farms. Symptoms of reluctance to enter the milking parlor and extreme nervousness while in the parlor were predominantly observed at these farms.

Voltages over 0.5V were found on Farms 12, 17, 20, 26, 40 and 46 during step 2. The reason for stray voltage on Farms 12, 17, 26 and 40 can thus be attributed to the secondary wiring systems in the milking areas. No stray voltage was found on Farm 20 or Farm 46 at step 2 with loads turned off, but voltages over 0.5 V were read when the vacuum pump started on Farm 20 and when the milk delivery pump started on Farm 40 in this step. The vacuum pump and the milk delivery pump were found to be sources of stray voltage on these farms. Symptoms reported on Farms 20 and 40 were reluctance of the cows to enter the parlor and increased manure deposition in the parlor. Similar results of steps 1 and 2 were observed by Reinemann et al. (1999) who studied behavioral reactions of dairy cows during transient voltages and found that facial activity was the most sensitive and repeatable behavioral indicator of response.

While stray voltage sometimes could not be measured using instantaneous measuring systems (steps 1, 2 and 4), it was observed in step 3 when a continuous recorder multimeter was used. Voltages over 0.5 V were found for the first time at Farms 8, 13, 28 and 34 in this step. The cause of stray voltage was found to be a water pump for Farm 8 (Fig. 2) and Farm 34. The milking parlor lighting system was the cause of stray voltage for Farms 13 and 28. There were no symptoms given by the farmer for Farm 8 whereas more cases of decreased milk production due to mastitis and extreme nervousness while in the parlor were mentioned for Farms 13, 28 and 34. In their study on aversion to transient and steady state stray voltage applied to water bowls, LeMire et al. (1997) found that different amounts of water

Table 2. Stray voltage values (Volt) in the dairy farms and symptoms of cows.

Farms	Step 1		Step 2		Step 3	Step 4	Symptoms
	Loads Off	Loads On	Loads Off	Loads On			
1	0.311	0.338	0.297	0.319	0.340	0.227	More mastitis, Lowered milk production
3	0.120	0.262	0.116	0.159	0.298	0.303	Reluctant to enter parlor
5*	0.116	0.228	0.176	0,189	0,294	**0.522**	Reluctant to enter parlor Incomplete or uneven milkout
8*	0.320	0.402	0.392	0.451	**1.682**	**0.868**	
9	0.269	0.380	0.259	0.401	0.427	0.421	More mastitis Lowered milk production
12*	0.461	**0.817**	**0.877**	**0.978**	**0.969**	**0.822**	Reluctant to enter parlor Extremely nervous while in parlor
13*	0.372	0.475	0.406	0.469	**0.518**	**0.535**	More mastitis Lowered milk production
15	0.290	0.375	0.364	0.374	0.399	0.220	Reluctant to enter parlor
17*	0.384	**0.688**	**0.872**	**1.020**	**1.686**	**1.258**	Reluctant to enter parlor Extremely nervous while in parlor
20*	0.265	0.370	0.351	**0.510**	**0.697**	**0.652**	Reluctant to enter parlor Increased manure deposition in parlor
24	0.174	0.260	0.171	0.221	0.281	0.251	Reluctant to enter parlor
26*	0.392	**1.232**	**0.685**	**1.478**	**1.861**	**1.911**	Reluctant to enter parlor Extremely nervous while in parlor
28*	0.372	0.385	0.406	0.398	**1,864**	**2,345**	Extremely nervous while in parlor
31	0.115	0.179	2.125	1.748	2.754	2.049	More mastitis Lowered milk production
34*	0.287	0.386	0.275	0.358	**2,022**	**1.362**	More mastitis Lowered milk production
39	0.118	0.174	0.154	0.862	0.252	0.263	More mastitis Lowered milk production
40*	0.384	**2.422**	**1.662**	**2.485**	**2.226**	**2.311**	Reluctant to enter parlor
42	0.262	0.243	0.262	0.344	0.388	0.273	More mastitis Lowered milk production
46*	0.265	0.370	0.351	**1.610**	**1.350**	**0.781**	Reluctant to enter parlor
48*	0.206	0.312	0.215	0.256	0.365	**2.457**	Reluctant to enter parlor Incomplete or uneven milkout

*Farms where stray voltage (over 0.5 Volt) were determined.

consumption may presumably result from different contact times and exposure risk.

Unlike Farms 5 and 48, similar results were found during step 4 on farms where stray voltages were determined at the above steps. The reason why stray voltage could not be determined before step 4 for Farms 5 and 48 is not clear. Reluctance to enter the parlor and incomplete or uneven milk out were indicated for Farm 5.

Stray voltage sources in the 12 farms could be caused by faulty wiring, faulty equipment and improper grounding. Similar results were found by Appleman and Gustafson (1985), Cloud et al. (1987), Lefcourt (1982), and Worley and Wilson (2000).

The symptoms reported herein may be caused by factors other than stray voltage. These factors include management, environmental conditions, poor nutrition, mastitis control programs, sanitation, malfunctioning milking equipment and disease. For this reason, symptoms were mentioned for some of the farms (Farms 1, 3, 9, 15, 24, 31, 39 and 42) where stray voltage was not found. The symptom of reluctance to enter the milking parlor on Farms 3, 15 and 24 may have other possible explanations. New milking systems were in place on Farms 3 and 24, and most of the cows were on first lactation for Farm 15. It is also possible that there was stray voltage on some of these farms, but that it did not occur during our investigation.

CONCLUSION

The presence or absence of stray voltage on dairy farms was evaluated and the reactions of animals to stray voltage were investigated. A stray voltage problem was found on 12 farms (23%) and behavioral changes in dairy cows

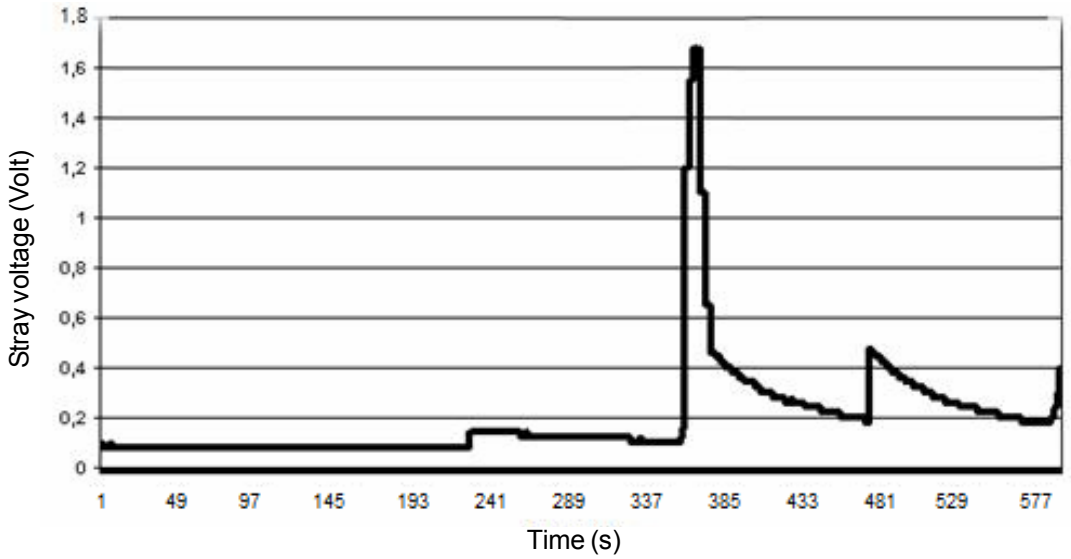

Fig. 2. Output of continuous recorder multimeter in Farm 8.

were observed on 19 farms (37%). A significantly higher relationship was found between independent variables of dairy farms that present stray voltage and behavioral changes (P=0,002). Based on the results, stray voltage sources on the farms were usually caused by faulty wiring, faulty equipment and/or improper grounding.

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