CowContacttm
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Making cow contact measurements

At this point you have all your instrumentation installed at the selected cow contact points, you are reading AC voltages with or without a resistor and you need to decide what to do next.

If you have purchased a logging voltmeter you can record measurements and note the times the CC voltage peaks. Using the charting software provided with your meter, identify the time periods the peak voltages occur.

Before we get started I am including a technical description of the capabilities of the Fluke 189 meter I will be using. If it seems to technical, don't worry, the meter is simple to use and I will be using as many default settings in the meter as possible. For the technical types, this should answer most of your questions.

This data and more can be obtained at:
http://www.fluke.com/download/electricalpower/eventlog.pdf

Some safety hints to be considered and measurement techniques suggested by the Midwest Rural Energy Council

I am also including a handout from the Midwest Rural Energy Council [formerly the Wisconsin Farm Electric Council]. This group is a non-profit organization formed by utilities based in Minnesota and Wisconsin. The council was founded in 1954 as a cooperative program between the investor-owned utilities, rural electric cooperatives, and the University of Wisconsin Agricultural Engineering Department. In December 1997, the board approved the merger with utilities in Minnesota and the University of Minnesota.
The MREC website can be reviewed at

http://www.mrec.org/

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Fluke 89-IV & 189 Event Logging

FlukeView Forms Technical Note

One of the major features of the Fluke 89-IV & 189 meters are their ability to "do logging". This technical note explains what kind of logging the Fluke 89-IV & 189 meters can perform, how to use the event logging feature and the information that can be provide to you. This note also discusses briefly how the FlukeView Forms PC software is used as a key element to increase the functionality of the logging feature. There are other application notes that explain in more detail how to use the FlukeView Forms PC software to enhance the Fluke 89-IV & 189 event logging feature.

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Differences between Fluke 89-IV & 189 and Data Logger

First and foremost, the Fluke 89/189 were not built to do data logging in the traditional sense like a data logger would. Typically, the goal of a data logger is to sample an input signal at a rate sufficient enough to be able to track something of interest that you expect to be contained within the signal. This often means that it is desirable to sample the signal as fast as possible so you "don't miss anything." The problem with this approach is you need a large storage place for the fast data sampling that is taking place. You can also end up with a lot of redundant data that is considered "normal" and not of interest. You must wade through the normal data to find the exceptional data (or lack thereof) that you are interested in seeing.

With the Fluke 89-IV / 189 meters, there is not a large memory to store large amounts of data. Yet, it can still do an effective job of monitoring and logging data for an input signal in order to detect when and if a

system is operating normally or abnormally. This is accomplished by something we call *event logging*.

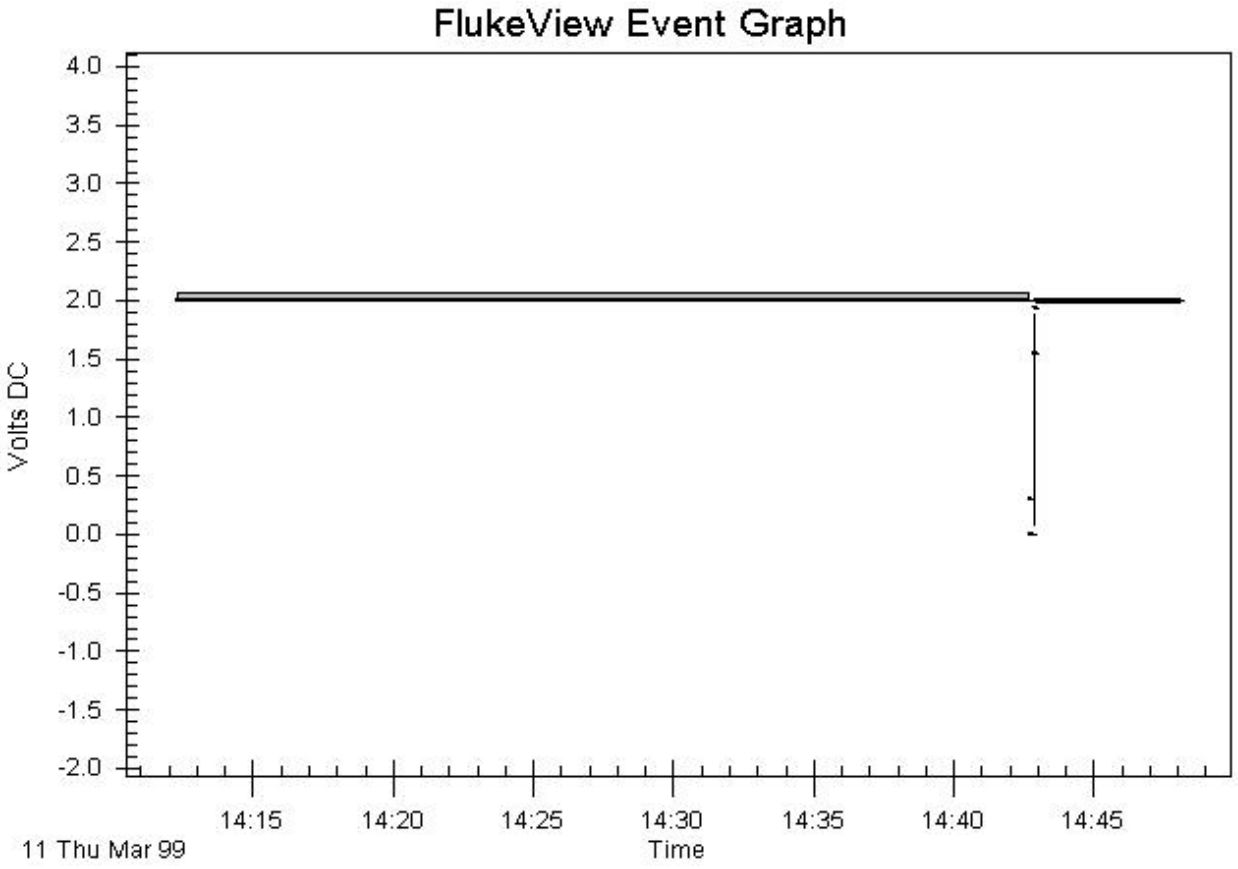
Introduction to Event Logging, Stable Period, Unstable Period, and Event Data

Event Logging can be thought of as an extension of the "Touch Hold" feature of the original Fluke 87. (Touch Hold is now called "Auto Hold" in the model 87/89, series IV & model 187/189.) When the Touch Hold feature works is activated, the meter will wait until a period of stability has been reached, then it will beep and freeze (hold) a stable reading on the display for the user to see. If the input changes to the point that it is no longer stable, then becomes stable again, the meter will beep a second time and hold a new reading on the display.

Event logging encompasses a similar scheme. When the Fluke 89-IV/189 is logging it is looking for periods of stability. Obviously, while waiting for a stable signal, there are periods of instability as well. What happens during the logging process is that as each period of stability or instability ends the meter will log information about that period to its internal memory. The information that is logged for each of stable or unstable period is a start time, stop time; and between that period of time the maximum reading, minimum reading, and average reading. The approach with event logging is to only store enough information to describe *changes* (i.e., events) that have happened to the input signal (if any). Thus, the term "event logging" was coined. The goal is to focus on catching and recording transition events as opposed to trying to record an entire input signal. The information recorded for the transition events is referred to as event data.

An Example - Viewing what Event Logging Data Looks Like

The Fluke 89 / 189 excels at performing the logging of transition events, but does not have a large graphical display needed to view the event data. This is where the FlukeView Forms software comes into the picture. The only way to view event data is to load it into the FlukeView Forms application (from the meter you can only view interval data, which is explained later). FlukeView Forms is able to display the data in table or graph form. An example is shown below:



Logged Readings Table

	Start Time	Duration	High	Average	Low	Description	Stop Time
1	3/11/99 2:12:17 PM	0:30:27.3	2.0625 V DC	1.9962 V DC	1.9898 V DC	Stable	3/11/99 2:42:44 PM
2	3/11/99 2:42:44 PM	0:00:00.9	1.8022 V DC	0.3092 V DC	0.0058 V DC	Unstable	3/11/99 2:42:45 PM
3	3/11/99 2:42:45 PM	0:00:07.6	0.0050 V DC	-0.0000 V DC	-0.0005 V DC	Stable	3/11/99 2:42:53 PM
4	3/11/99 2:42:53 PM	0:00:01.3	1.8836 V DC	1.5379 V DC	0.0600 V DC	Unstable	3/11/99 2:42:54 PM
5	3/11/99 2:42:54 PM	0:00:01.1	1.9625 V DC	1.9319 V DC	1.8865 V DC	Stable	3/11/99 2:42:55 PM
6	3/11/99 2:42:55 PM	0:05:10.7	1.9986 V DC	1.9974 V DC	1.9642 V DC	Logging Stop	3/11/99 2:48:06 PM
7							

Looking at this data, you can see that the logging session started at 2:12:17 PM and ended at 2:48:06 PM with an elapsed time around 36 minutes. You can also see that signal being measured was stable at 2 volts for most of the logging session. However, there were 2 occurrences of instability detected by the meter during a 11 second period just before 2:43 PM. The graph gives a visual indication of what happened around that time. What is interesting about this example is that the table of data shows that only 6 "events" needed to be stored in the meter memory over the entire 36 minutes of logging to capture the essence of what happened.

What this illustration shows is that with event logging, only a very small amount of memory was needed to store the information. To capture the same data using traditional data logging would require a 1 second sample rate over the entire 36 minutes which would have produced 2160 records of data. Compare this with the fact that the Fluke 89-IV / 189 only has room for 995 logged readings. It becomes clear why event logging makes sense for a handheld meter with limited memory.

Definition of a Stable and Unstable Signal

So what determines if a signal is stable or unstable? The original Touch Hold feature of the Fluke 87 that was mentioned earlier uses the criteria: "if the input signal changed more than 4% of the current measurement range" then a period of instability would be started. Once the input signal settles to within that 4% window for at least 1 second, then a period of stability begins again.

For event logging, a similar approach is taken, but percent of reading is used instead of percent of range. This event stability window defaults to 4% . While this value can be modified with the FlukeView Forms software (version 1.5 or later), we will continue to refer to the default value in this document.

A stable period will continue to be stable if the input signal does not vary more than ± 4% from the input signal amplitude at the beginning of a stable period. If during this time the input signal jumps or drifts outside the ± 4% window and is detected by the meter as being outside the window, the meter will end that stable period and log (record) the input signal's high, low and average values for that stable period of time. The meter will then attempt to start another stable period. If the meter finds the input signal can not stay within the ± 4% window after trying to start a new stable period, it then defines a period of time as unstable.

Minimum Event Duration Time

If the input signal jumps outside of the ± 4% window and then quickly returns back into the window, the duration of the event may be too short for the Fluke 89 / 189 to detect. There is a minimum amount of time an event must exist outside of the 4% window before the meter will detect and record the event. The table below shows some typical minimum event duration times for the various input functions.

Input Function	Minimum Detectable Event
VAC, mVAC, VDC, mVDC, Ohms, Continuity, Diode, AAC, mAAC, µ AAC, ADC, mADC, and µ ADC	50 ms
Exceptions: 50 mVDC, 500 Ohms, 5A DC, 50mA DC, 500 µ ADC	100 ms
AC+DC V, AC+DC mV, AC+DC A, AC+DC mA, AC+DC µ A	1.5 sec
Exception: AC+DC 5V	3 sec
Conductance	250 ms
Capacitance (1 µF is 6.7 samples per second)	300 ms
Temperature	500 ms
Frequency while in: VAC, mVAC, VDC, mVDC, Ohms, Continuity, Diode, AAC, mAAC, µ AAC, ADC, mADC, and µ ADC	50 ms
Frequency while in: 50 mVDC, 500 Ohms, 5A DC, 50mA DC, 500 µ ADC	100 ms

Logging Interval - An additional Twist (only if you need it)

If you have already looked at the Fluke 89 / 189 logging feature somewhat, you are probably aware that the meter has a *Logging Interval* setting. This is a time value that can be set in the meter setup function. The meter will allow you to set the value anywhere from 0:00 to 99:59 (hours:minutes). The factory default value is 15 minutes. The logging interval value is very similar to a sample rate that you might set for a traditional data logging session. Where in traditional data logging one reading would be saved at the sample interval, event logging stores the minimum, maximum, and average values seen during interval of time in its memory. This is done in addition to event logging! So if you use a logging interval, plan on seeing a mixture of data within the logging session - some generated from the event logging, and some generated from using the interval (see How Events and Intervals Blend Together). There is nothing wrong with this, but it is helpful to be aware of it.

Keep in mind that using the logging interval is optional. Setting it to 00:00 will mean that no logging interval will be used and the meter will do pure event logging only. This may be a useful feature if you use FlukeView Forms software to view logging data. But keep in mind that only the interval average is viewable from the front panel of the meter. Setting the logging interval to 00:00 will mean that you can not view any logging data on the front panel of the meter.

Most of the time you probably will have some sort of logging interval set. Here is an example of what happens when this is the case. If the logging interval is 15 minutes, the meter would record a minimum, maximum, and average value based on all the readings encountered during each 15-minute period of time. The meter will always reserve 288 of its 995 memory locations for data resulting from these intervals. That leaves 707 memory locations to store event logging data. One thing to keep in mind, if more than 288 memory locations are needed for interval data, the meter will start using up any of the unused 707 event logging data memory locations. Once the 995 memory locations become full, logging is automatically turned off.

Calculating what Logging Interval to Use

While the logging interval acts similar to a data logging sample rate, it should be thought about in a little different way. Instead of thinking about how small you should set the interval, it is often better to determine how large you need to set it. For example, say you want to monitor for three days or 72 hours. You want to be certain you have some logging data over the entire 72 hours regardless of how stable or unstable your signal is. Calculate the necessary interval as follow:

[Length of Test] divided by 288 = Minimum logging interval

For 3 days or 72 hours this works out as: 4320 minutes / 288 memory locations = 15 minutes
where
4320 minutes = 3 days X 24 hours per day X 60 minutes per hour and
288 is the number of memory locations reserved for interval data

This result shows that a 15 minute or greater interval is needed to guarantee that there will be enough interval data storage for the full 72 hours. If you believe your signal is going to be mostly stable and therefore generating only a few logging events, you could make the logging interval smaller. You can do this because some of the 707 event logging memory locations will not be used up for recording events and will therefore be available for recording interval data instead. This trick of lowering the logging interval only works if you know those events will not fill up the other 707 event logging memory locations first. But keep in mind, even with the longer logging intervals, the Fluke 89 / 189 will catch events each time the input signal jumps outside the ± 4% stability window.

You should also be aware of the following: each automatic range change will eat up two logging interval

memory locations. A few range changes will be okay, but if there could be a lot, then you should place the meter into manual range. Select the input range needed to measure the highest expected signal.

Cases where a Smaller Logging Interval is Valuable

For most uses, the factory default value of 15 minutes for the logging interval is sufficient to provide some logging data regardless of what happens with the event logging portion of the logging process. There are some times however, when it may be desirable to use a smaller interval:

- You need to have definite minimum, maximum, and average values "on paper" for set intervals that are less than 15 minutes in length
- You have a slow changing signal and want more detail about what is happening within the 4% stability window
- Your logging session will not be very long in duration and you know that the meter will be able to hold all the interval data you plan to log
- If you don't have FlukeView Forms software. If this is the case, you will not have a way to see the event data. The only logging data you can see on the meter is the average value and stop time of each interval. So if your logging application allows, it might be advantageous to use a smaller interval so more data can be collected that is viewable on the meter

Cases where a Larger Logging Interval is Valuable

In some instances, you may want the logging interval to be longer than the 15 minute factory default:

- You need to have definite minimum, maximum, and average values "on paper" at set intervals that are more than 15 minutes in length
- You want minimal interference between the interval data and any event data, but aren't willing to turn off the logging interval by setting it to 00:00. That is, you want some readings at intervals once in a great while for feedback over the course of the logging session, but you are mainly focused on capturing transition data from the event logging process

Starting and Stopping a Logging Session from Meter

Starting a logging session on the meter is pretty simple. Once you select the desired meter input function, you start the logging function by pressing the LOGGING key (the yellow Shift button followed by the REL button). If there is already some logging data in the meter memory, the meter will prompt with a message of "CLR?" in order to ask if it is OK to clear this out. Press the YES button (up arrow) if this is OK, or the NO button (down arrow or let timeout) to cancel the logging session. Once memory is cleared, logging will begin. The display will show the LOG annunciator at the top, the elapsed time of the logging session will appear in the lower right corner, and the index number of the interval in progress appears in the lower left corner. There will also be a small flashing MEM symbol just above the index number to show that logging data is going into the meter memory. The index number begins at 001 and increments at the start of each new interval (or range change). Note that the index number will not increment when events are detected.

To stop logging, press CANCEL (the yellow Shift button followed by the Hz button) or press LOGGING (yellow Shift button followed by the REL button). Turning the rotary switch will halt the logging session as well, but this is not recommended since it is possible for stray readings to be logged while the rotary switch is being moved.

The logging session will also stop if the battery becomes low or if the memory becomes full. If the memory does fill up, the word "End" will appear in place of the index number in the lower left corner of the display.

Viewing Logging Data using the Meter

After a logging session is complete, you have two choices on how to view the logging data. You can transfer the data to the FlukeView Forms software, or you can choose to view a limited portion of the data directly on the meter display. Keep in mind that the meter is not able to show any of the event data that was collected or the minimum and maximum value for interval data. What you can view is the average reading for each logging interval. To do this, turn the rotary switch to the VIEW MEM position, then press Logging (press the yellow button followed by the REL button).

The meter will begin by showing the average reading during the first interval. The index number in the lower left corner will read 001 to indicate this fact. The time that the interval concluded is shown in the lower right corner. This is a time of day value with a format of hour and minute. Since seconds are not shown, you would see the same time for more than one interval if the logging interval was set to less than one minute.

To see the average of the next interval, press the Up-arrow button. The index number will change to 002. If you want to move backwards through the data, press the Down-arrow button. When you reach the end of the data, the up button will wrap the data around to show the beginning again. Likewise, when you are at the beginning of the data, the down button will show you the last interval.

If one or more overloads happen during an interval, an OL will be displayed in the secondary reading area of the display. Overload readings are ignored in calculation of the average for the interval with the overload.

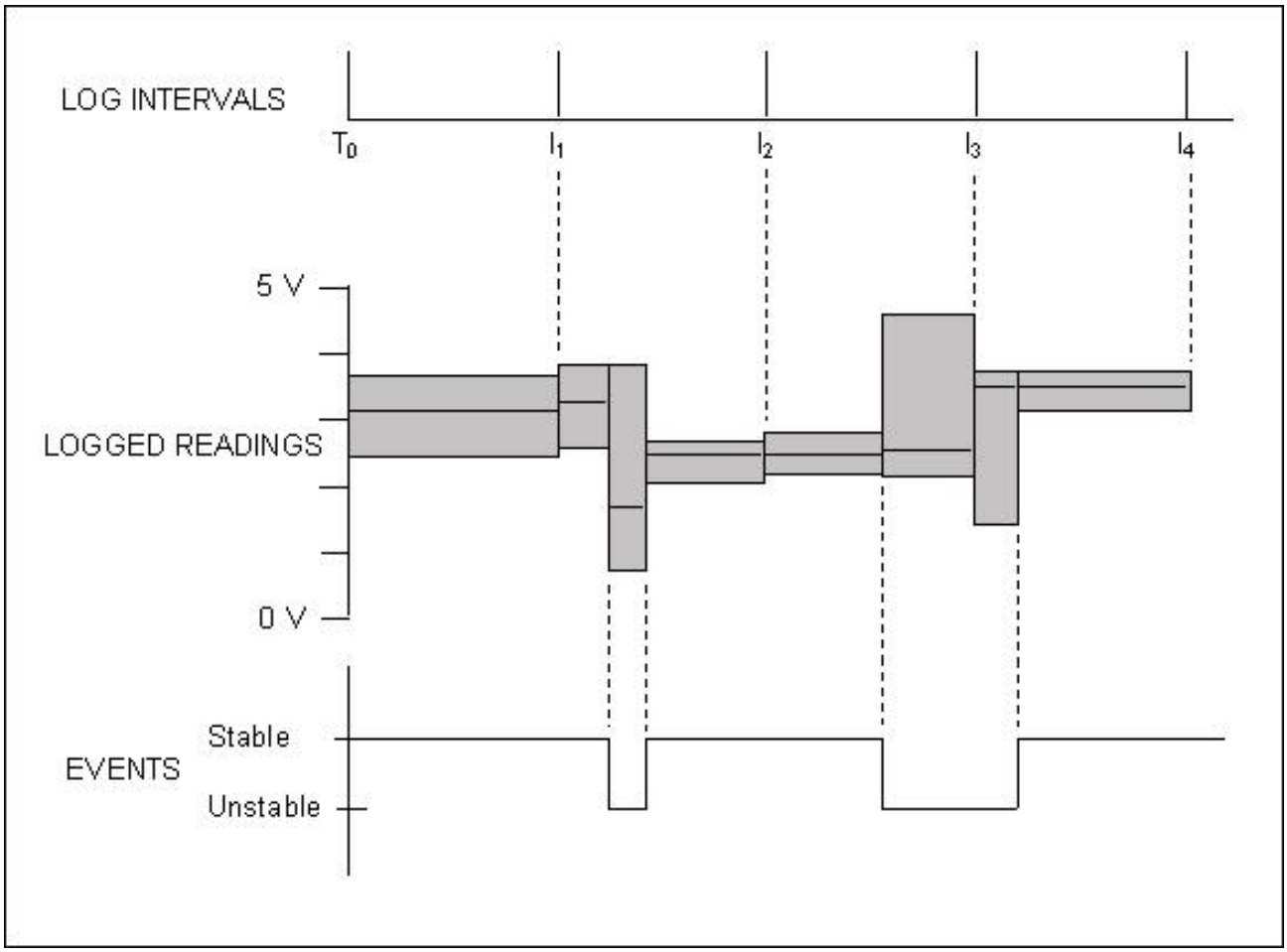
If a range change happens during an interval, the meter will record the data for the portion of the interval spent in each range. In such a case, the meter will display the average reading for each portion - the time of day reading will have reflect the partial interval. This is a side effect of using Auto Range during a logging session. When a range change is logged it will occupy one of the 288 reserved interval locations. If this is a concern you can set the meter in manual range before beginning a logging session.

Viewing Logging Data using FlukeView Forms PC Software

If you want additional viewing capabilities for your logging data, you can use the FlukeView Forms software to transfer the data from the meter memory into a PC. FlukeView Forms has various ways to view the data in graphical and tabular form (see An Example - Viewing what Event Logging Data Looks Like). An important feature is the ability to "zoom in" on graphs containing event data to get more visual detail of what took place. The data can also be saved in a database on the PC or printed for later review. There are online application notes that explain how to use FlukeView Forms and how to create your custom form.

How Events and Intervals Blend Together

One of the main points emphasized in this article: The Fluke 89/ 189 will log event data in addition to interval data at regular time intervals. Since two types of data are being logged, it can be confusing to think about how both of these mix together to make up the logging session as a whole. FlukeView Forms enables you to see all this data obtained during a logging session. The following diagram illustrates how the meter ends up storing this mixture of data and how it will appear graphically in the FlukeView Forms software:



At the top of the diagram is a time line indicating when the end of one logging interval takes place and the start of another logging interval begins. The logging session starts at time T0. Intervals are shown ending at times I1, I2, I3, and I4. At the bottom of the diagram is a time line showing when the meter is logging a stable or unstable signals. The logging session starts with a stable signal, then shows 2 periods of an unstable signal occurring.

In the center of the diagram, an event graph is depicted which looks like an Event Graph in the FlukeView Forms software. The dashed lines indicate when the Fluke 89 / 189 will log for the preceding time period the high, low, and average measurement and the ending time stamp. The FlukeView Forms software constructs a box, whose vertical height represents the high and low measurements for a given logging period and whose horizontal length represents the period duration. The average for that period is shown as a straight line through the box. An explanation for each box in the above diagram follows:

Box #	Explanation
1	The first box is generated because a logging interval (I1) came to an end.
2	A stable signal went unstable, the box will represent the stable period that has come to a close.
3	The signal became stable again, data is logged about the unstable period.
4	A second logging interval (I2) has expired. (This interval has been split into 3 pieces because of some events.)
5	A stable signal went unstable.
6	The third logging interval (I3) expired.
7	The unstable period ended.

8	A fourth logging interval (I4) has ended.

Looking at this diagram shows that the logging intervals get added to the logging results at regular periods of time. The events also get added to the logging results whenever a transition to or from a stable state occurs. Note that when an interval expires, it will "split up" any period of stability (or instability) and cause a new logging period (box) to be started. FlukeView Forms logged readings table and logged readings graph have the capability to show just the interval data or just the event data if this is preferred. You can do this by placing the mouse pointer over the Logged Readings Table, clicking the right mouse key and selecting show data. While you are doing this, you also might want to try right clicking while the mouse pointer in over one of the Event Graphs and selecting View.

Real Time Event Logging using the FlukeView Forms PC Software

FlukeView Forms software 1.5 and higher support event logging on the PC even when the meter does not offer internal logging. (previous versions of Fluke View Forms software supported online logging only with the Fluke 89 /189).

When used with the Fluke 89 / 189, you have an option to let the meter determine the events, or use let the PC determine the events.

> If you choose to have the meter determine the events, you maintain the best time resolution (minimum detection time) for detecting and recording events. The meter has a temporary buffer of 10 memory locations that FlukeView Forms reads, so that short events are not lost.
>
> If you choose to have the PC determine the events, you have a slower detection time, but gain the ability to log both the primary and secondary display's data as well as choosing either a fixed threshold (stable window) size, or a relative threshold and set both the threshold % and a minimum threshold size.

FlukeView Forms also allows you to specify different levels of compression above or below some values when real time logging. For instance, you might specify that you only want interval data for reading between 100 and 130 VAC, but want interval and input data above the 130V limit, and minimum data (combine interval and input data) below the 100V limit.

Real time event logging with Fluke View Forms is discussed in another tech data.

Fluke View Forms (1.5) allows you to change the meter's stored 'event stability window size' parameter. This allows you to specify the amount of change you consider significant for your application.

A SELF-HELP GUIDE

Stray Voltage Detection

Table of Contents

Introduction

For a number of years, stray voltage has been a concern among livestock farmers, particularly those with dairy herds.

This booklet has been prepared to give you a basic understanding of stray voltage, some of its common causes, how to determine if it exists on your farm at levels that may be harmful, and when to call for assistance to minimize it.

"A Self-Help Guide To Stray Voltage Detection" is not intended to make anyone a stray voltage expert, but should provide you with the information necessary to safely determine whether or not a significant level of stray voltage is present on your farm at locations that are accessible to your livestock.

This booklet is specifically oriented toward the dairy farmer; however, most of the information provided is applicable to all livestock operations.

The **Farmers' Stray Voltage Checklist,** located on **page 9**, is included to assist you in visually inspecting your farm's electrical system and noting potential stray voltage sources. A **Stray Voltage Data Sheet,** located on **page 10**, is included to help you record milkhouse and barn area voltage measurements.

In addition, this booklet tells you how to use or install your own voltmeter to monitor stray voltage levels–a practice that is strongly recommended for all livestock operations.

What is Stray Voltage?

WHAT IS STRAY VOLTAGE?

Low levels of AC (Alternating Current) voltage on the grounded conductors of a farm wiring system are a normal and unavoidable consequence of operating electrical farm equipment. These voltages are termed "stray voltage" when they can be measured between two objects which may be simultaneously contacted by animals. Occasionally, stray voltage is significant enough to be felt by you as a "tingling" sensation, particularly if you have a cut at the point of contact.

This booklet concentrates exclusively on measuring and minimizing AC voltages. Small levels of DC (Direct Current) voltage also may be present on farms but are generally not a concern.

REPORTED SYMPTOMS

Symptoms reportedly attributed to significant levels of stray voltage include uneven milkout, decreased milk production, and increased incidence of mastitis. Cows may be reluctant to enter the barn or milking parlor, may be nervous and "dance" in their stall. They also may be reluctant to eat or drink, and feed consumption may be inconsistent for no apparent reason.

It is important to note, however, that these same symptoms can be the result of numerous other non-electrical farm factors. As a farm manager, you should investigate all possibilities, including stray voltage, when attempting to resolve a production, mastitis, or behavioral problem.

TYPES OF VOLTAGE ENCOUNTERED

It is important to make a distinction between low-level stray voltage and the more hazardous voltages which produce a painful shock.

Personal shock

If you experience a painful personal shock when you touch a metal object in the barn, you are not feeling stray voltage. Personal shocks usually indicate defective wiring or equipment. Since these conditions are hazardous and could start a fire, call an electrician or your local utility immediately.

Tingle shock

If you feel low-voltage "tingling" when you're in the barn, it is possible that your livestock may be experiencing a similar sensation.

Tingle shocks felt when touching electrical devices may indicate an internal short in the equipment. If this happens, you should call your electrician. Tingle shock from non-electrical metal objects frequently can be eliminated through better bonding (electrically interconnecting metal objects) and grounding. It is recommended that you continue to take voltage measurements after improving bonding and grounding. Continuing measurements will assure that these changes have reduced the voltage that animals may experience to an acceptable level.

Symptoms present, but no tingle shock sensation

Livestock may feel voltages not sensed by humans because an animal's body resistance is less than that of a human.

Voltage measurements should be taken whenever livestock exhibit symptoms which reportedly have been attributed to stray voltage.

You may take your own voltage measurements to determine the presence, or level, of stray voltage and whether corrective action might be required. If you are unsure how to take these measurements, you can ask for assistance from your local utility office.

CAUSES OF STRAY VOLTAGE

Stray voltage on a farm is typically the result of several voltage sources acting simultaneously. Both on-farm and off-farm sources may contribute to the level of stray voltage present. A common on-farm source of stray voltage is the result of the interconnection of equipment grounding conductors with the neutral conductors of the farm wiring system. The grounding conductor is used to ground metal equipment and should never be one of the conductors used to supply power. The neutral, or other conductor supplying power, should never be connected to the metal case of equipment or be interconnected with the grounding conductor at any point other than the main electric service panel for the building.

Other on-farm sources of stray voltage are electrical shorts in

equipment, defective underground cable, unbalanced 120-volt loads including loads in the house that cause voltage drop on neutral conductors, corroded bonding connections, corroded neutral conductor connections, and missing or inadequate grounding systems.

The normal operation of electrical equipment (such as welders, motors, pumps and conveyors) in remote areas of the barn or other buildings may also result in stray voltage within animal confinement areas. The degree to which these sources contribute to stray voltage levels depends upon many factors including the layout of the farm wiring system.

A visual inspection checklist of potential on-farm problems **(Farmers' Stray Voltage Checklist)** is included in this booklet on **page 9.**

Correction of on-farm deficiencies will normally require the services of a qualified electrician.

Off-farm voltage sources may also be present on your farm. If requested, your local utility will conduct an investigation utilizing controlled, standardized test procedures to determine to what extent electrical distribution facilities or other off-farm sources contribute to stray voltage levels. If an abnormal contribution is found, your local utility will take action to help reduce the level of stray voltage on your farm. Even if the off-farm contribution is found to be normal, they may make minor system modifications to help reduce stray voltage levels.

DETECTION OF STRAY VOLTAGE USING VOLTMETERS

You can detect the presence of stray voltage on your farm safely and easily by using a voltmeter to measure the voltage between two points that may be simultaneously contacted by livestock.

CAUTION: For your own safety, do not attempt to make electrical measurements on electrical wiring or within electrical boxes or cabinets unless qualified to do so.

SUITABLE VOLTMETER

Many of the voltmeters in use today can give you misleading readings because of the manner in which they are constructed. A suitable voltmeter must not be affected by DC voltage when operating on the AC scale. The meter should also "screen out" weak voltage sources which are incapable of affecting your livestock. A shunt resistor is used for this purpose.

In order to accurately measure the stray voltage that livestock may feel, a shunt resistor, approximately equal to the resistance of a cow (about 500 ohms), should be connected across the voltmeter leads. *(Refer to Figures 1 and 2 on page 7.)* A two-watt, flameproof resistor of approximately 500-ohms is recommended as a meter shunt for measuring stray voltage.

NOTE: The shunt resistor should be removed from the meter before making any measurements other than stray voltage (cow-contact measurements).

CAUTION: The shunt resistor MUST be removed from the meter before using the meter to measure energized conductors.

You may use either a digital voltmeter or an analog (needle-type) voltmeter to measure stray voltage. However, you must understand the limitations of each in order to ensure accurate and meaningful measurements.

Digital voltmeter

A digital voltmeter **with** a 500-ohm shunt resistor is easy to read and ideal for monitoring stray voltage levels.

A digital voltmeter **without** a shunt resistor has an extremely high input resistance (several million ohms compared to 10,000 to 25,000 ohms for an analog voltmeter). This high-input resistance makes it very sensitive to weak voltage sources. Weak voltage sources, however, do not have the ability to affect your animals.

In order to accurately measure voltages which your livestock may feel, you must make your voltmeter "look" like a cow (electrically) by connecting a 500-ohm shunt resistor across the voltmeter leads. *(See Figure 1.)* (This type of resistor is available at most electronics parts stores.)

Analog Voltmeter

The digital voltmeter is the preferred method of monitoring stray voltage. However, if you use an analog

voltmeter, it must have a voltage scale sensitive enough to accurately display voltages less than 1.0 volt AC. A meter with a full-scale reading of 2.5 volts AC is ideal. A full-scale reading of 5.0 volts AC is normally acceptable. Any full-scale reading greater than 5.0 volts AC is generally not sensitive enough for stray voltage measurements.

Your analog voltmeter also must be capable of measuring only AC voltage. Some analog voltmeters will not discriminate between DC and AC voltage and may provide you with misleading information.

An analog voltmeter can be tested by setting the meter on the AC scale and touching the leads to the ends of a 1.5 volt battery. The leads should then be reversed and the procedure repeated. If the meter's indicating needle initially "jumps" and then settles to a steady reading of 0.0 volts, the meter is acceptable.

The use of an analog voltmeter with a 500-ohm shunt resistor will result in an accurate measurement of the stray voltage which may be perceived by your livestock.

MAKING ELECTRICAL MEASUREMENTS

CAUTION: For your own safety, do not open or attempt to measure voltage inside electrical devices or equipment or on any other electrical wiring unless qualified to do so.

There are two basic measurement methods for diagnosing stray voltage situations: the point-to-point method and the point-to-reference ground method.

Point-to-point measurement method

The point-to-point method allows you to determine the levels of voltage which may potentially affect the animals. This is the most important measurement and it simply means taking voltage measurements between two points which may simultaneously be touched by livestock. Usually this will be from metal equipment, such as drinking cups, water pipes and stanchions, to the floor.

The meter lead in contact with the floor must be in a wet location with good contact pressure to ensure electrical contact. Attaching the lead to a copper plate placed on the wet concrete floor is the recommended method. However, from a practical standpoint, other alternatives such as standing on the voltmeter probe or clamp, or attaching the clamp to a wet barn cleaner may work satisfactorily in many cases.

When you take the measurements, twist or scrape the clamp when attaching it to make sure that there is good electrical contact.

The point-to-point measurement method, which uses a copper plate on the floor in the rear-hoof area and a 500-ohm shunt resistor across the leads of a digital voltmeter, most accurately represents the actual voltage which may come in contact with livestock.

Point-to-reference ground measurement method

The point-to-reference ground method of testing is used to help the investigator diagnose the sources of stray voltage and involves the use of a remote ground probe as a reference.

For reliable accuracy, the remote ground probe should consist of a metal stake or rod driven into moist soil and located at least 30 feet away from any electrical grounds, water pipes or grounded metal equipment. An insulated wire (no. 18 is adequate) should then be used to connect the ground probe to the common terminal of the voltmeter. The other voltmeter probe is used to contact the metal objects within the animal confinement area. The 500-ohm shunt resistor is not used.

This method of measuring usually results in higher voltage readings than the point-to-point method. However, it is not a measurement of animal exposure because an animal cannot simultaneously contact these two points and, therefore, cannot be harmed by the measured voltage.

Practical suggestions

Most voltmeter leads are too short to make point-to-point voltage measurements. You may want to use a set of light-duty car battery jumper cables to extend the length of the voltmeter leads when making measurements to the various metal contact points. They also may be used as temporary bonding jumpers to determine the effect of additional bonding.

When you measure voltages on outside equipment, such as feeders or stock waterers, you may use a metal rod driven 12 to 18 inches into

the ground approximately six feet from the equipment being measured. This is an adequate method of determining if a voltage is present on the device being checked. A more thorough investigation may be required to accurately measure animal-contact voltage levels.

RECORDING VOLTAGE DATA

Normally, stray voltage should be measured during milking, when the highest electrical loads are present and highest voltage levels will occur. It is recommended that you take voltage measurements at several animal contact locations to determine where the voltage is greatest.

Use the data sheet on page 10 for recording voltage measurements. The date and time that measurements were taken should be included. This information may serve as a future reference to detect any changes in your farm electrical system.

INTERPRETING VOLTAGE DATA

Research regarding the levels of stray voltage that should cause concern is continuing at several universities. At the present time, the majority of the animal experts involved maintain that corrective action is not necessary for values below 1.0 volt AC. Some electric utilities have taken a conservative approach and recommend a stray voltage investigation whenever voltages of 0.5 volts AC or greater are measured across cow-contact points using the point-to-point measurement method described.

WHAT SHOULD YOU DO

If point-to-point voltage measurements, taken during milking or at any other time of day, do not exceed 1.0 volt AC, research indicates that the voltage is too small to affect your livestock. Under these circumstances, it is recommended that you use a voltmeter in your barn to regularly monitor the level of stray voltage present.

POINT-TO-POINT VOLTAGE GREATER THAN 1.0 VOLT AC

If point-to-point voltages exceed 1.0 volt AC, call your local utility office to request assistance in conducting a stray voltage investigation. You should have the voltage measurements from the **Stray Voltage Data Sheet** (page 10) available.

Arrangements may be made for knowledgeable personnel to conduct a detailed investigation to determine the sources of stray voltage on your farm.

Finding the sources of stray voltage can be difficult and time consuming. It requires knowing where and what to measure, knowing what type of sources to look for, being familiar with the nature of electricity, and having the ability to perform controlled tests using suitable measuring instruments.

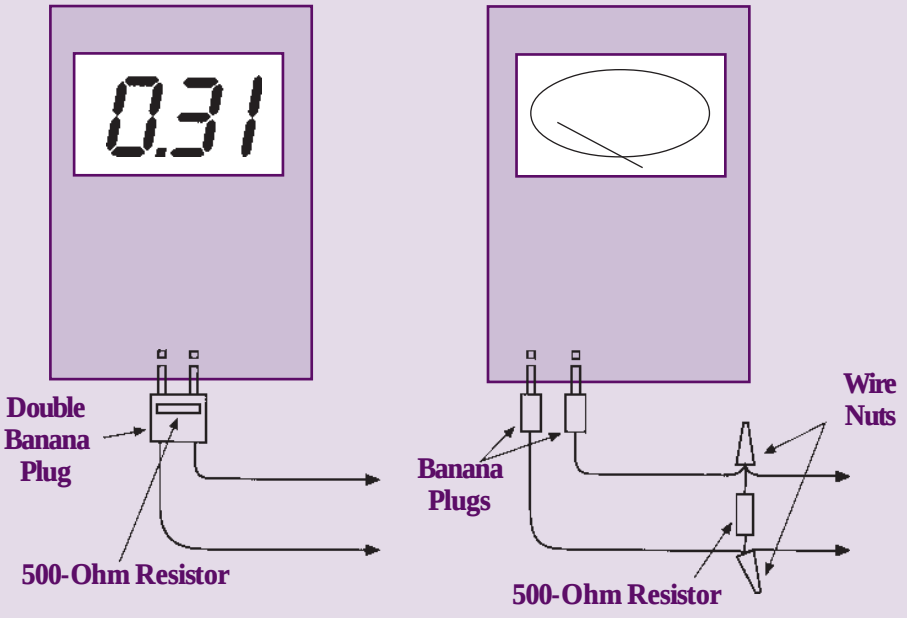


FIGURE 1: Digital Voltmeter with 500-ohm, two-watt, Flameproof Resistor

FIGURE 2: Analog Voltmeter with 500-ohm, two-watt, Flameproof Resistor

NOTE: the shunt resistor should be removed from the meter before making any measurements other than stray voltage (cow-contact measurements).
CAUTION: The shunt resistor must be removed from the meter before using the meter to measure energized conductors.

Monitoring Stray Voltage

Where practical, your electric utility will identify on-farm sources of stray voltage for you. A qualified electrician may be required to perform work necessary to reduce contributions from these on-farm sources.

Your utility may also conduct an investigation using controlled, standardized test procedures to determine to what extent electrical distribution facilities or other off-farm sources are contributing to stray voltage levels. If an abnormal contribution is found, they will take action to help reduce stray voltage levels on your farm. Even if the off-farm contribution is found to be normal, some utilities may make minor system modifications to help reduce stray voltage levels.

MONITORING STRAY VOLTAGE

You should install your own voltmeter in the barn and regularly monitor the level of stray voltage present. Through regular observation, you can quickly become aware of any voltage increase, possibly due to equipment or wiring shorts, which otherwise may go unnoticed. Figure 3, below, indicates typical voltmeter connections.

The voltmeter should be installed in a dry location where it can be conveniently read during milking time.

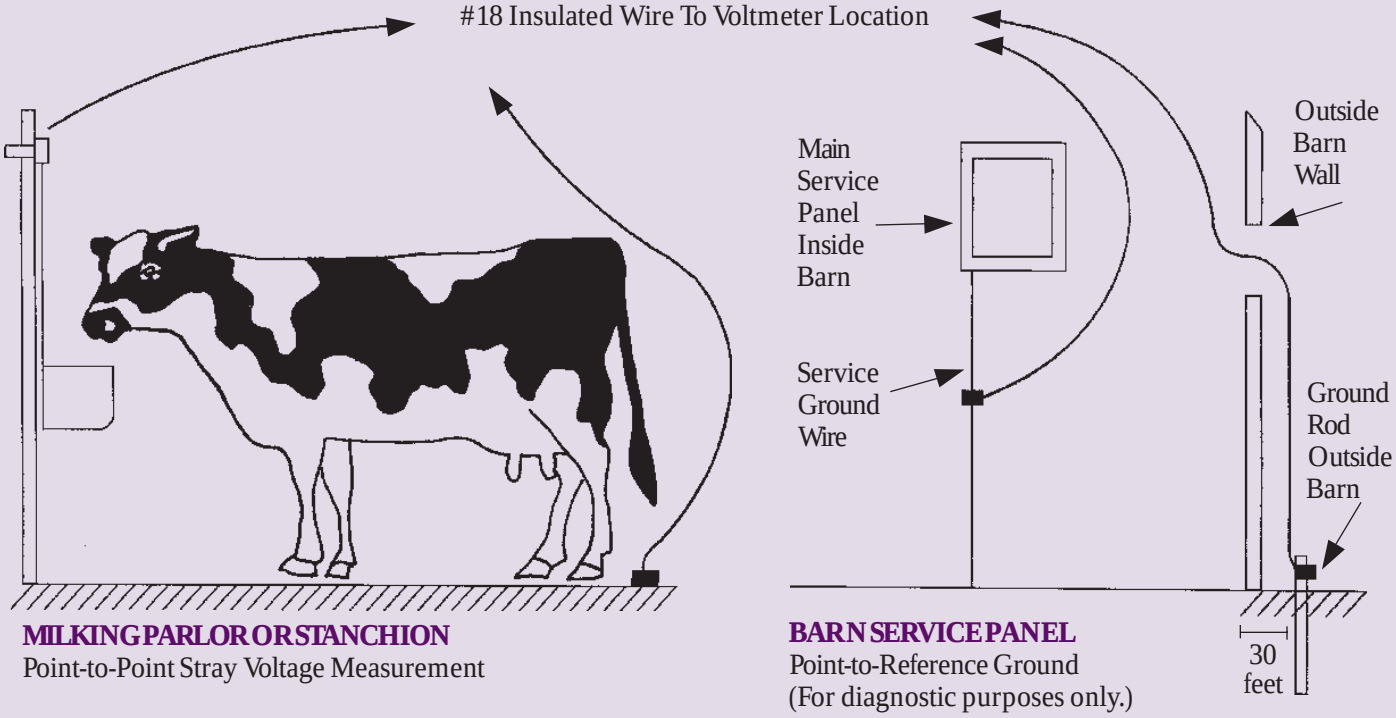
Accurate and easy-to-read digital voltmeters are available for less than $100. Analog (needle-type) voltmeters with an acceptable scale are frequently available for less than $50.

Not all voltmeters are suitable for constant exposure to the damp environment found in many locations in a barn. You must carefully choose the right meter and the proper installation location.

FOR MORE INFORMATION

For more information about stray voltage or its detection, call your local utility for assistance. Or, call your electrical contractor or milking machine supplier. All can assist you in determining if stray voltage is present, and more importantly, how excessive levels of stray voltage can be minimized.

FIGURE 3: Typical Voltmeter Connections



MILKING PARLOR OR STANCHION
Point-to-Point Stray Voltage Measurement

BARN SERVICE PANEL
Point-to-Reference Ground
(For diagnostic purposes only.)

Farmers' Stray Voltage Checklist

This checklist will assist farmers in visually inspecting their electrical systems and noting potential stray voltage sources. A check mark placed in the "yes" column indicates a potential problem. In most instances, a qualified electrician should be contacted for the repair or replacement of electrical equipment or wiring that may be needed.

	Yes	No
MAIN FARM SERVICE		
Connection to the ground rod - loose, corroded	___	___
Ground rod(s) missing at the service entrance	___	___
BARN SERVICE ENTRANCE		
Ground rod(s) missing at the service entrance	___	___
Connection to ground rod(s) - loose, corroded	___	___
Large accumulation of feed dust or other debris on service box	___	___
Corroded or loose neutral connection	___	___
Panel cover missing or removed	___	___
MILKHOUSE		
Wires sitting in water	___	___
Electric portable heaters on bulk tank	___	___
Broken or missing bonding strap for milkline	___	___
Damaged or missing seals on electrical fixtures, switches, outlets, lights, etc.	___	___
Corrosion of electrical fixtures	___	___
IN THE PARLOR OR AROUND THE BARN		
Pulsator wiring		
–Pinched wires	___	___
–Loose, hanging wires, stripped screws	___	___
–Scrapes, breaks or cracks in insulation exposing the conductors	___	___
–Broken stall cocks	___	___
Wires lying in damp or wet areas	___	___
Loose, hanging wires	___	___
Broken or bent conduit		
Energized open wires taped or untaped and extending from ceiling or wall, not in a junction box	___	___
120-volt non-polarized or non-grounded appliances used in barn (clocks, heaters, radios, stereos, etc.)	___	___
Cow trainer insulators *broken, missing, dirty* or covered with whitewash	___	___
TYPICAL PROBLEMS WHICH MAY INDICATE OR RESULT IN STRAY VOLTAGE		
Light dimming when motors start	___	___
Lights seem too bright	___	___
Electrical shocks from any equipment	___	___
Wires, electrical boxes or motors in wet or damp areas	___	___
Frequent fuse blowing	___	___
Electric fence or cow trainer ground connected to farm electric system ground	___	___
Electric fence or cow trainer ground connected to water or milk lines or stanchions	___	___
Bent or broken conduit	___	___
Damaged wire insulation exposing conductors	___	___
Insulated wires wrapped around metal pipes	___	___
Damaged or frayed extension cords	___	___
Motors, operating irregularly under load, sparking, etc.	___	___
Electrical outlets not properly grounded to accept a three-prong plug	___	___

Stray Voltage Data Sheet

This sheet should be used to record milkhouse and barn area voltage measurements. *If any of the voltages recorded in B below are greater than 1.0 volts AC, you may want to call your local utility office and request assistance in conducting a more thorough stray voltage investigation.*

NAME: _____

ADDRESS: _____

PHONE: _____

VOLTAGE MEASUREMENTS DATE _____ _____
TIME _____ _____

A. Diagnostic Measurements (taken without 500-ohm resistor)

CONTACT POINTS FROM	TO	VOLTS (AC)	VOLTS (AC)
Bulk Tank	Milkhouse Floor Drain		
Milk Pipeline	Milkhouse Floor Drain		
Water Pipe	Milkhouse Floor Drain		
Barn Entrance Panel	Remote Reference Ground		
Water Bowl	Remote Reference Ground		
Stanchion	Remote Reference Ground		

B. Stray Voltage Measurements (all measurements should be taken with and without 500-ohm resistor to make sure your electrical connections are good)
Record voltages at several locations in barn while milking equipment is running. Note which equipment is running during measurements.

		1ST MEASUREMENT		2ND MEASUREMENT	
COW CONTACT POINTS FROM	TO	VOLTS (AC) (with 500-ohm resistor)	VOLTS (AC) (without resistor)	VOLTS (AC) (with 500-ohm resistor)	VOLTS (AC) (without resistor)
Drinking Cup	Floor				
Stanchion	Floor				
Waterer	Floor				
Drinking Cup	Floor				
Stanchion	Floor				
Waterer	Floor				
Drinking Cup	Floor				
Stanchion	Floor				
Waterer	Floor				

Mission Statement

This publication was developed by the Wisconsin Farm Electric Council.

The mission of the WFEC is to initiate, develop, support, and coordinate education, research, and communication programs on significant and emerging rural energy issues for the consumer, energy suppliers, and allied industries through cooperative efforts of council members.

Related Publications from the Wisconsin Farm Electric Council

Farming Safely and Efficiently with Electricity
Equipotential Planes for Stray Voltage Reduction
Planning Electrical Systems For Dairy Expansions

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