

A SELF-HELP GUIDE

Stray Voltage Detection



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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?

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 pro-

duction, 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 10 VOLT AC

If point-to-point voltages exceed 1.0 volt AC, call your local utility office to request assis-

tance 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.

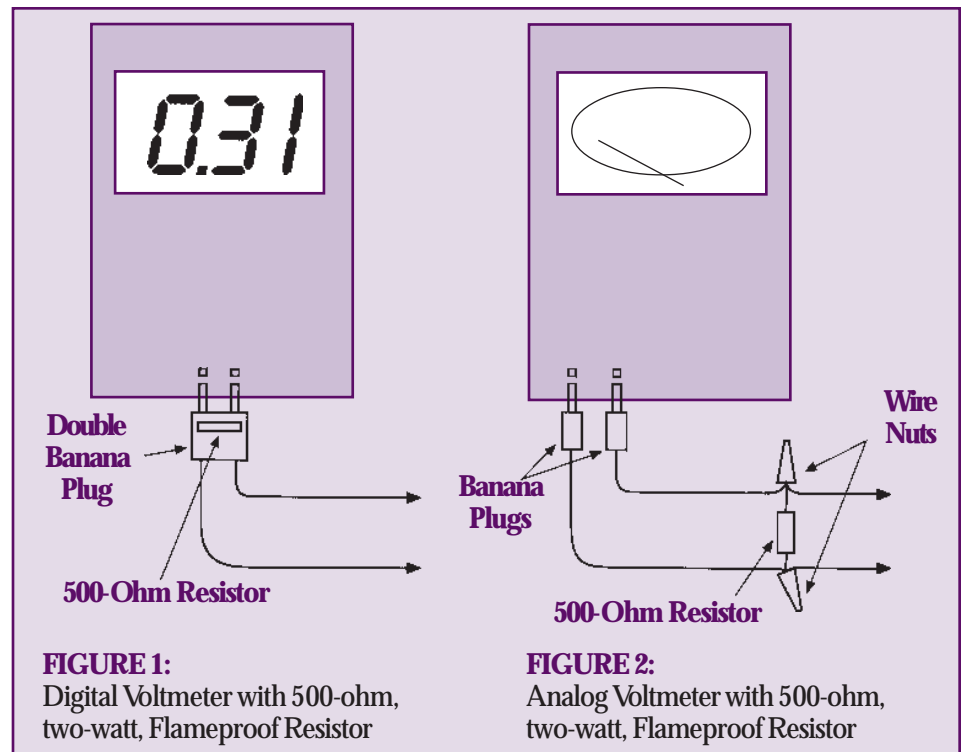


FIGURE 1: Digital Voltmeter with 500-ohm, two-watt, Flameproof Resistor

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.

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.

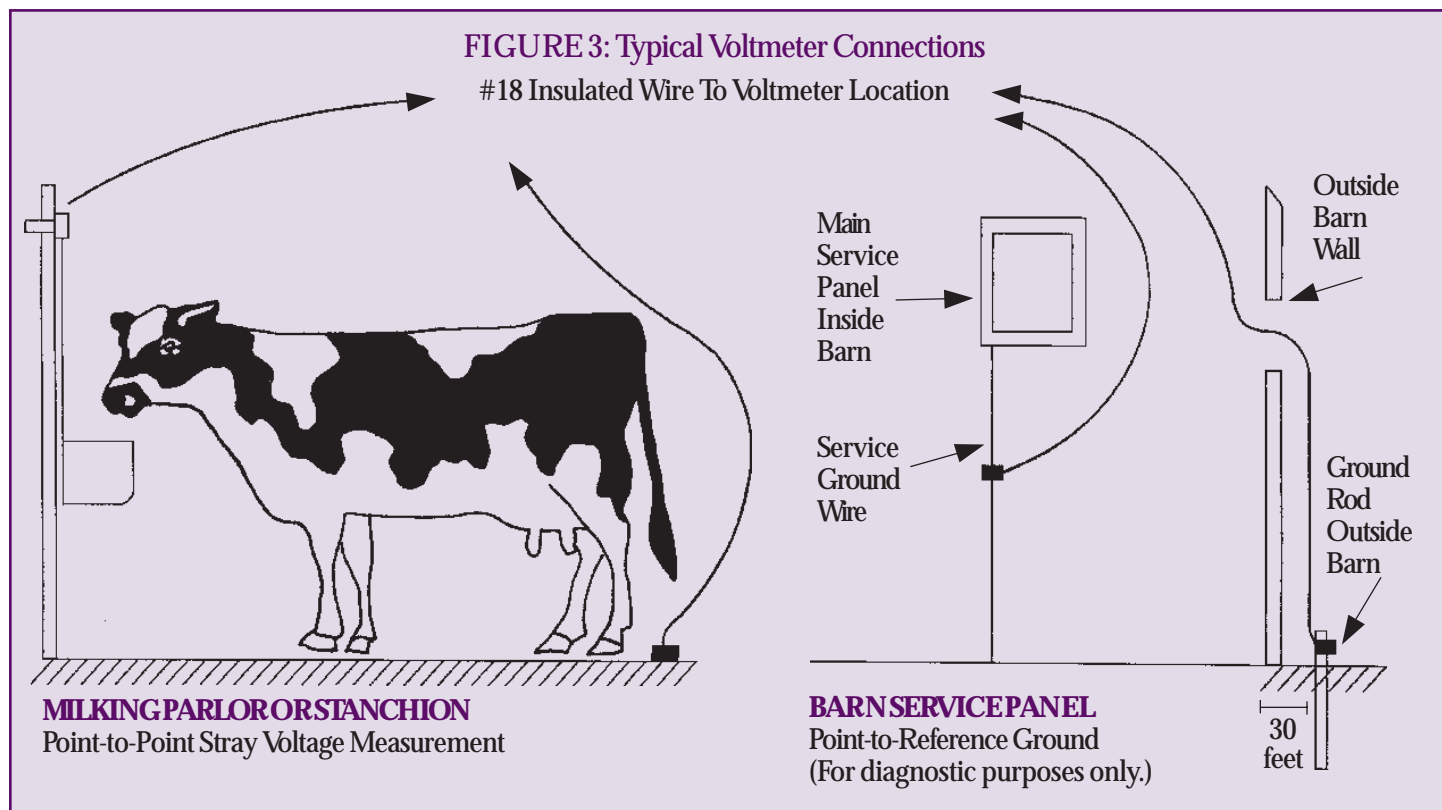
The voltmeter should be installed in a dry location where it can be conveniently read during milking time.

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.

FORMOREINFORMATION

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.



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 milklime	___	___
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		
<i>Energized</i> 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 <i>broken, missing, dirty</i> 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			VOLTS (AC)	VOLTS (AC)
FROM	TO			
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.

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

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*