



Stray Voltage Testing Protocol

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Wisconsin PSC

- ◆ In 1989, the Wisconsin PSC proposed a battery of tests for SV investigators to determine the source of SV.



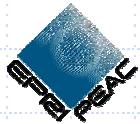
Testing Protocol

- ◆ Cow Contact Point and Source Resistance Test
- ◆ Load Box Test
- ◆ Secondary Neutral Voltage Drop Test
- ◆ Signature Test
- ◆ Primary Profile Test
- ◆ 24-Hour Test



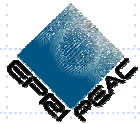
Five Tests

- ◆ The five tests are used to determine if the SV is above the "Level of Concern"
- ◆ The "level of concern" is not a damage level.
- ◆ Rather, it is a very conservative, pre-injury level, below the point where moderate avoidance behavior is likely to occur and well below where a cow's behavior or milk production would be harmed.
- ◆ The "level of concern" refers only to the exposure of farm animals in a confinement area to electricity from off-farm or on-farm electrical supply systems and not to any farm personnel in the same area.



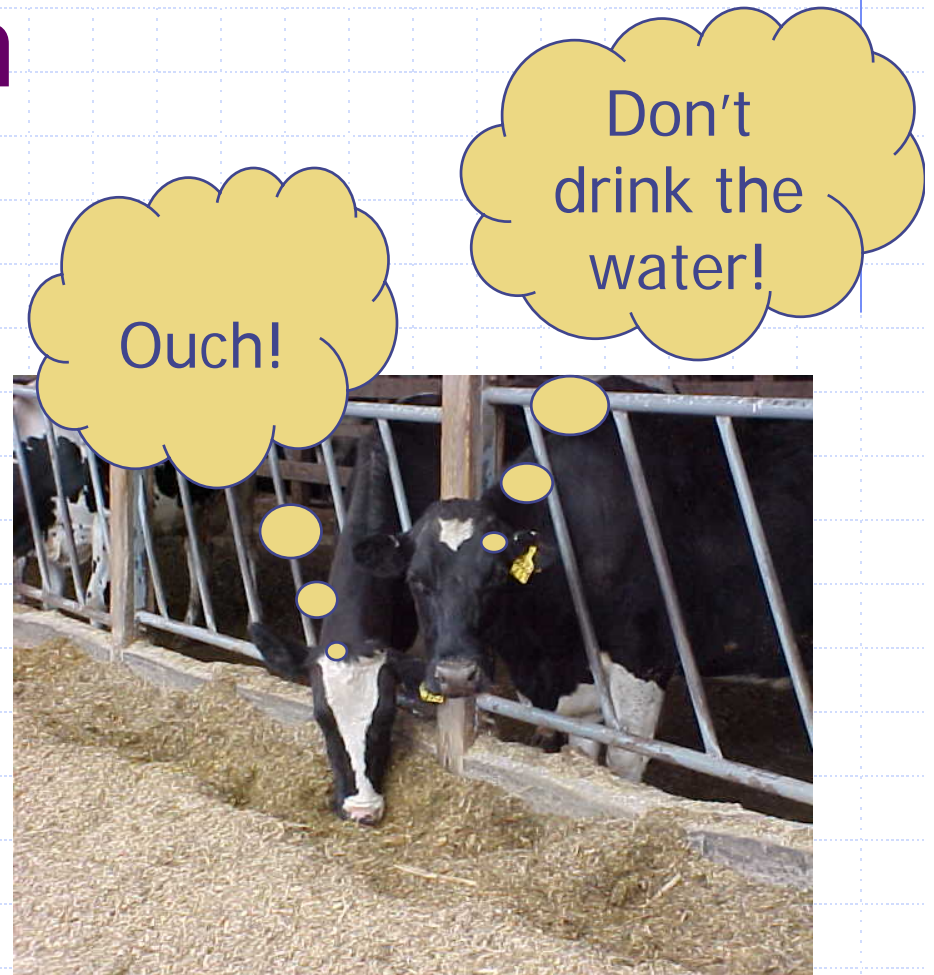
Level of Concern

- ◆ “The Level of Concern” is defined as:
 - 2.0 milliamps AC, 60 Hertz Steady-state RMS Current
 - 1.0 Volt AC, 60 Hertz, Steady-state RMS Voltage
- ◆ This is based on a 500 Ohm resistor in the cow contact area



Level of Concern

- ◆ This level of voltage/current is an amount of electricity where some form of mitigative action should be taken for Bessie's sake.



Testing Protocol

- ◆ Establish Cow Contact Point
- ◆ Perform source resistance test
 - Value should be less than 500 Ohms
 - Average of 3,500 farms shows 192 Ohms
- ◆ Second resistance check is made prior to tear down to verify original value has not changed



Load Box Test

- ◆ The Load Box test is used to determine how much the primary system might be contributing to the cow contact voltages
- ◆ Specifications are given for the load box
- ◆ If farm is isolated, two sets of tests are performed
 - As found
 - Bonded



Data Collected

- ◆ Primary line current (I_p)
- ◆ Primary neutral current (I_{pn})
- ◆ Secondary neutral current (I_{sn})
- ◆ Net secondary neutral current (I_{sn-net})
- ◆ 3 voltages from primary neutral to reference (V_p)
- ◆ Secondary neutral to reference (V_s)
- ◆ The voltage values at cow contact (V_{cc})
- ◆ The difference in voltage from the primary neutral to the secondary neutral is also recorded (V_{ps})

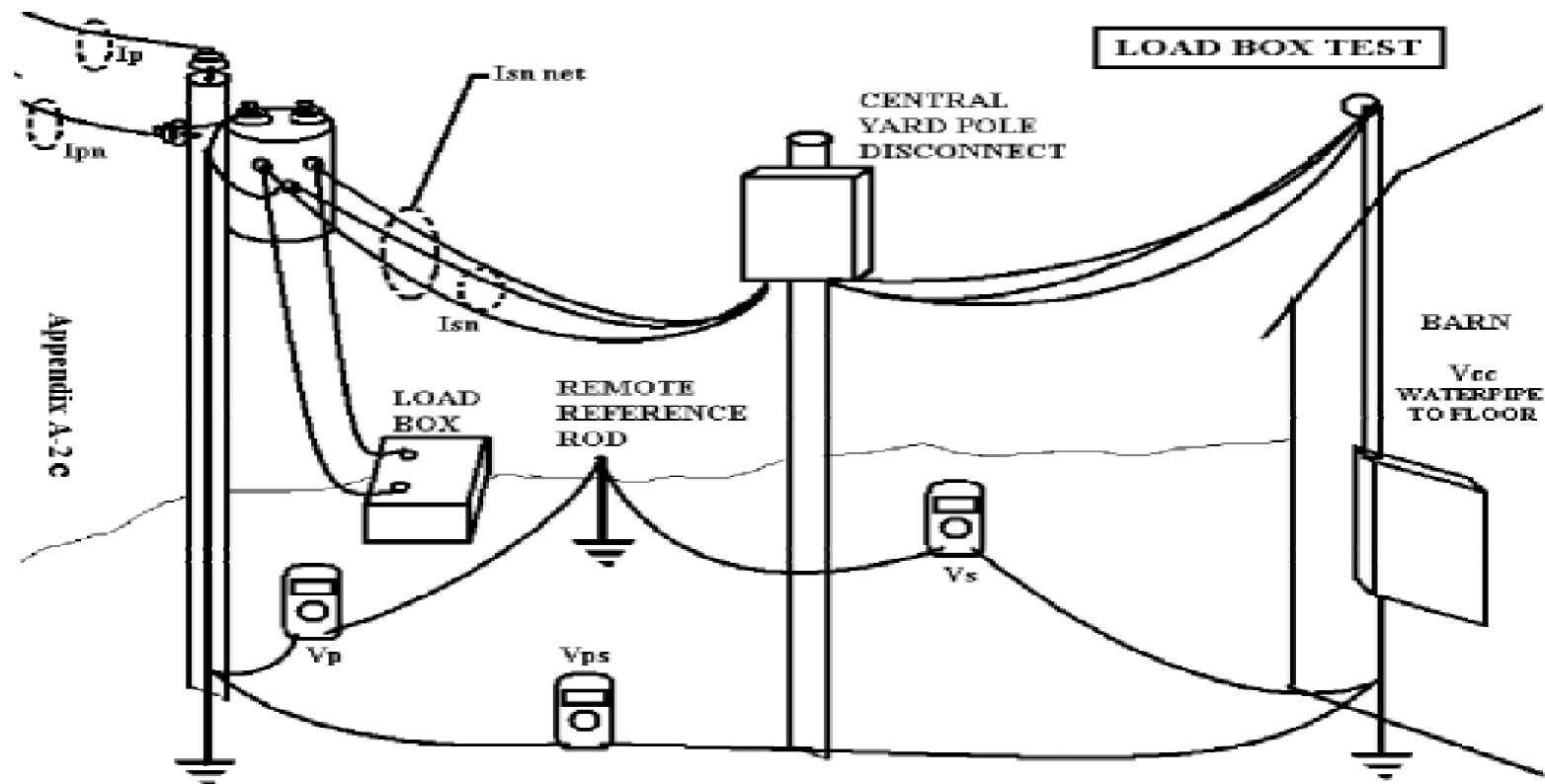


Data Collected

- ◆ V_p is measured at the bottom of the transformer pole where the primary neutral is connected to its ground rod.
- ◆ V_s is measured at the main electrical service panel of the animal confinement area where the connection is made to the grounding electrode system.

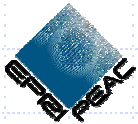


Load Box Test



Secondary Neutral Voltage Drop

- ◆ Secondary neutral voltage drop has been found to be the main on-farm source of stray voltage in Wisconsin.
- ◆ This test is used to determine the source and impact of each secondary service on the farm.
- ◆ Use a proxy load of known characteristics, such as a 120-volt rated hair dryer or paint peeler drawing about 10 - 15 amps AC

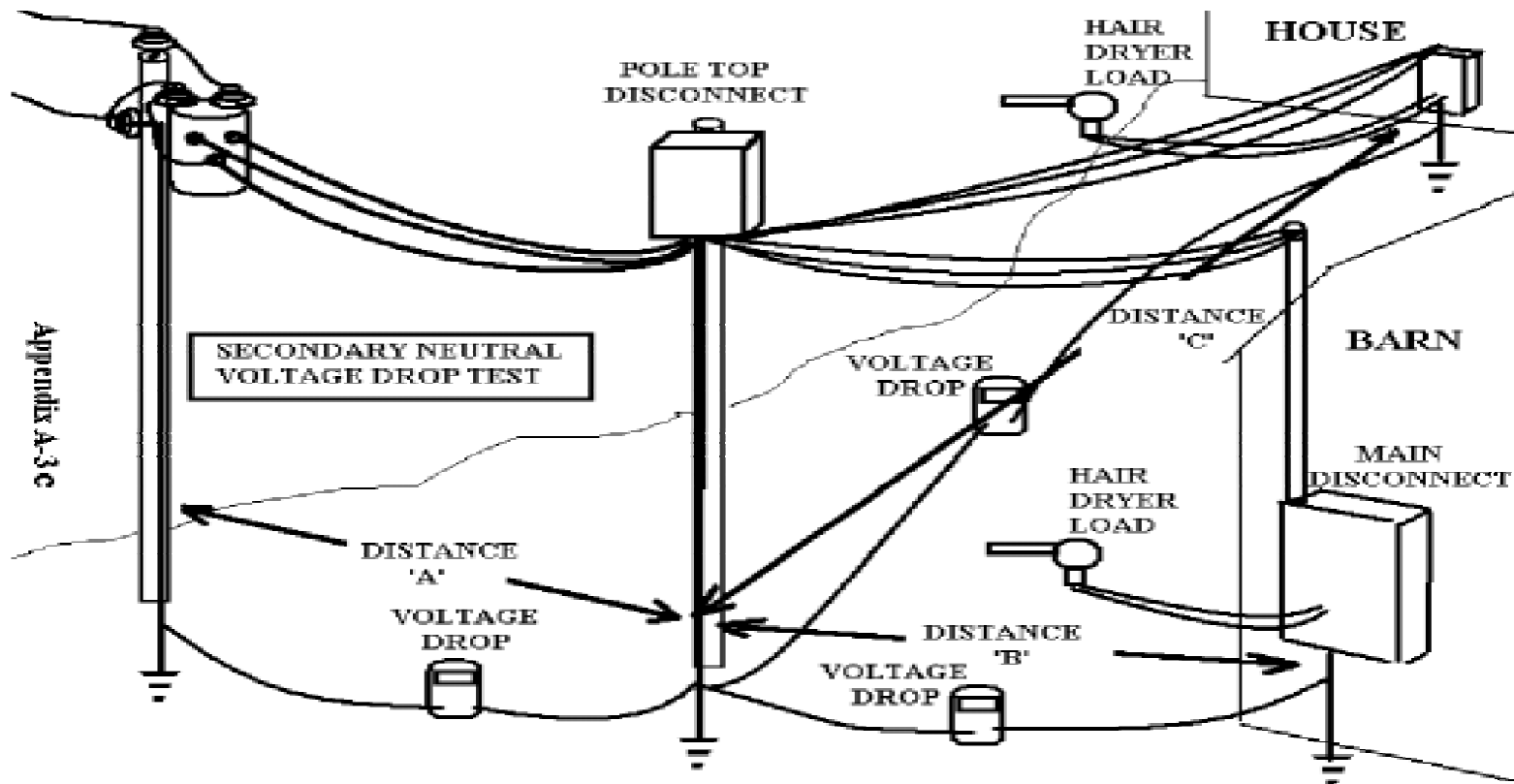


Secondary Neutral Voltage Drop

- ◆ This test creates a known and stable neutral current and subsequent voltage drop for each neutral serving a
 - main panel
 - sub panel
 - service area
- ◆ It is important that all other service entrance main disconnects be turned off at this time so the impact of just one service at a time can be determined.
- ◆ The data collected for each such service are
 - neutral wire gauge and exact length of neutral wire
 - neutral current measured and Voltage drop measured
 - Vcc
 - the primary neutral to reference voltage (V_p)
 - secondary neutral to reference voltage (V_s) at both ends



Secondary Neutral Voltage Drop



Appendix A-3c



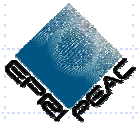
Signature Test

- ◆ In the signature test, individual pieces of major current-drawing electrical equipment are started and stopped at specific times and for specific intervals to determine their impact on the farm's electrical system.



Signature Test

- ◆ The signature test is best accomplished shortly after the load-box test when minimal farm electrical activity exists and only one service at a time is energized.
- ◆ A digitizing data recorder is usually used during this test with the sample interval set to 1 second. The data recorder should be set to monitor a minimum of four data points:
 - voltages from primary neutral to remote reference (V_p)
 - secondary neutral to remote reference (V_s)
 - primary neutral to secondary neutral (V_{ps})
 - the cow contact voltage (V_{cc}).
- ◆ The physical locations monitored are the same as for the load box test.

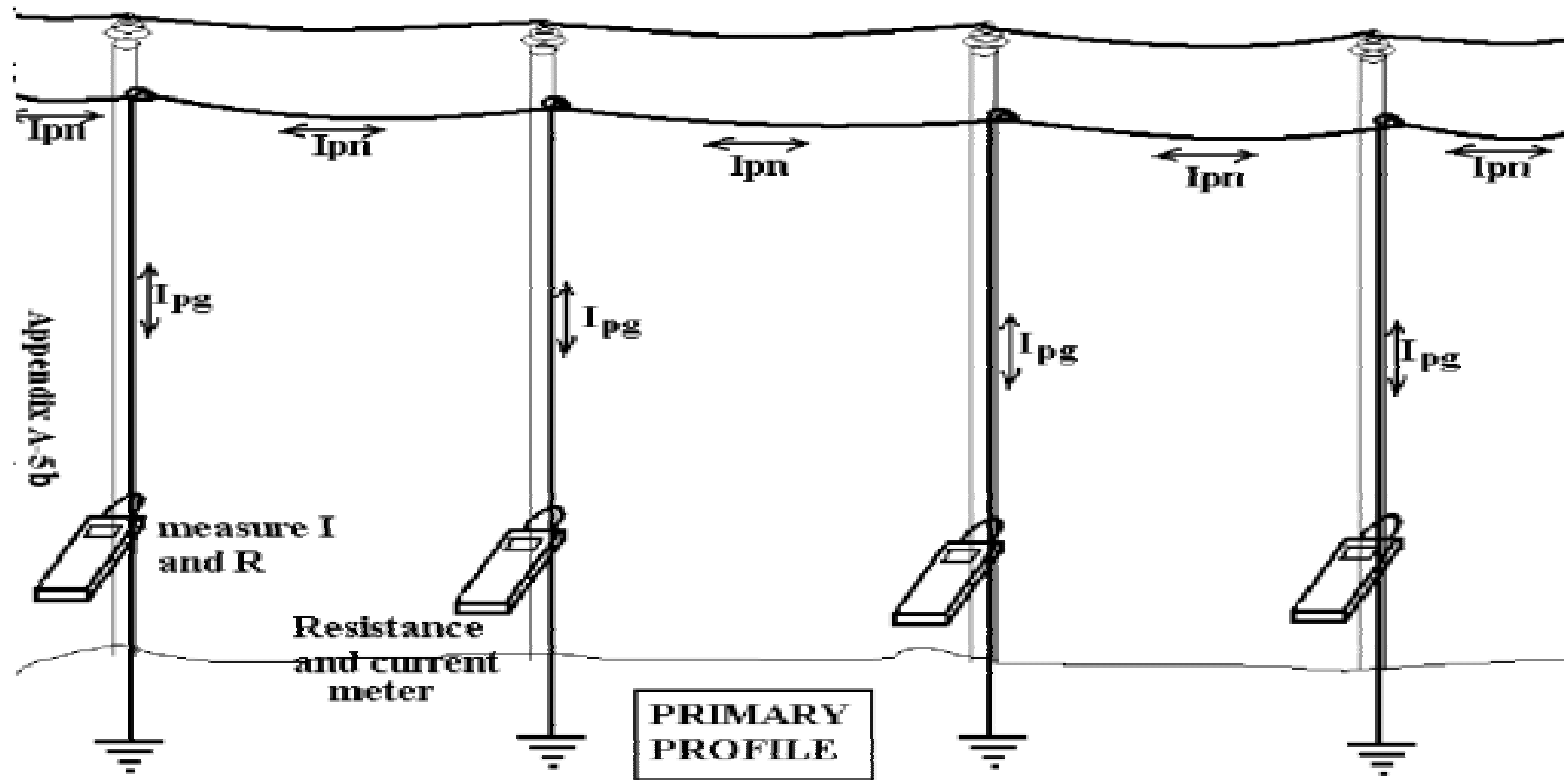


Primary Profile Test

- ◆ These tests are performed either during a morning milking or an evening milking or when the electrical activity on the primary distribution system is likely to be at a maximum.
- ◆ This test uses a meter or meters that measure both ground rod resistance and ground rod current at one time. The primary system ground rods for three-fourths of a mile on each side of the farm (if possible) are measured.
- ◆ It is important to note the condition of each pole, if out of the ordinary, as well as other devices present such as transformers, capacitor banks, telephone pedestals, or broken ground connections as well as the farm tap pole or transformer pole.
- ◆ This test should ideally record the ground rods of a minimum of about 13 or 14 poles over 1.5 miles.

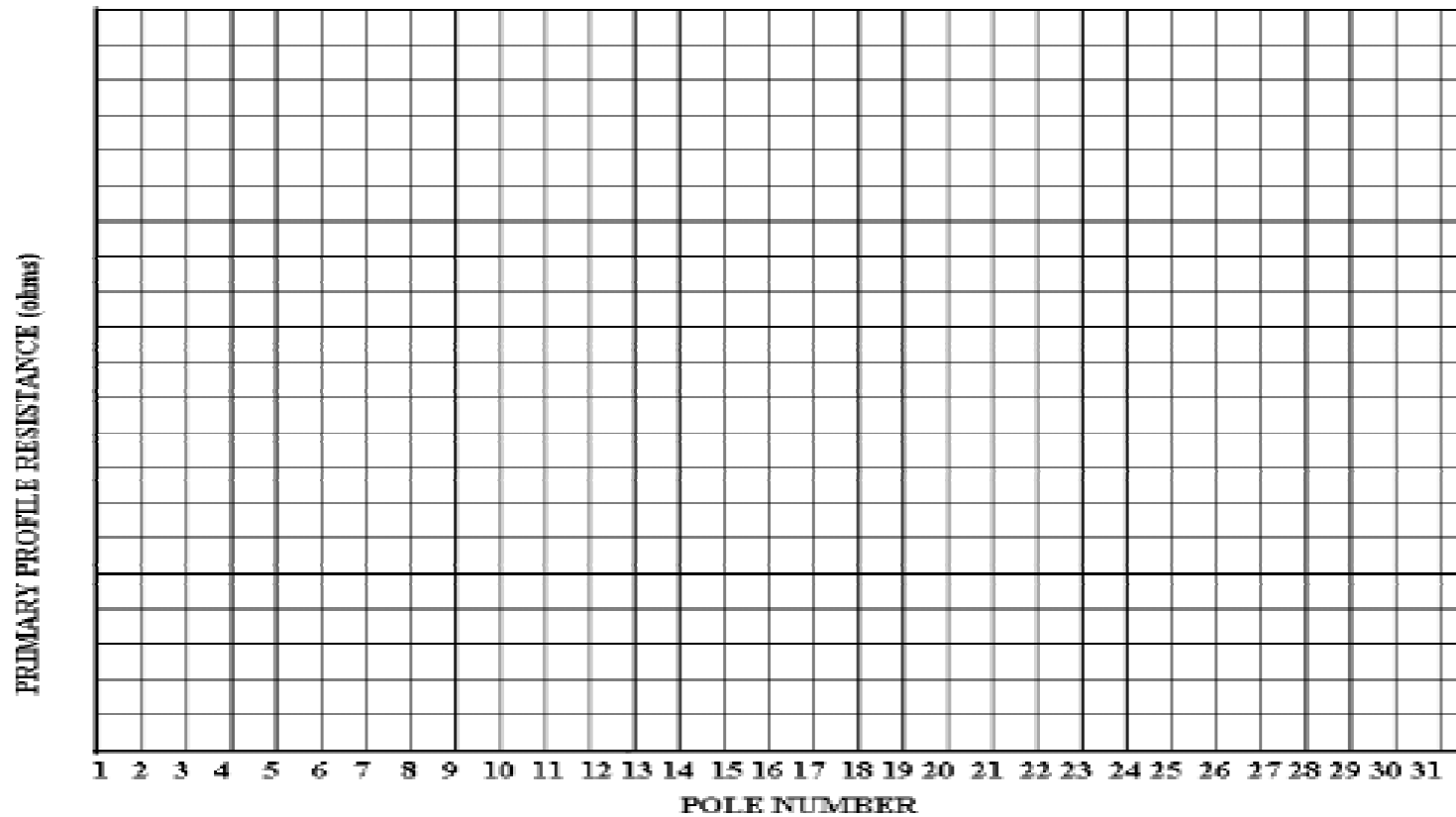


Primary Profile Test



Primary Profile Test

Resistance

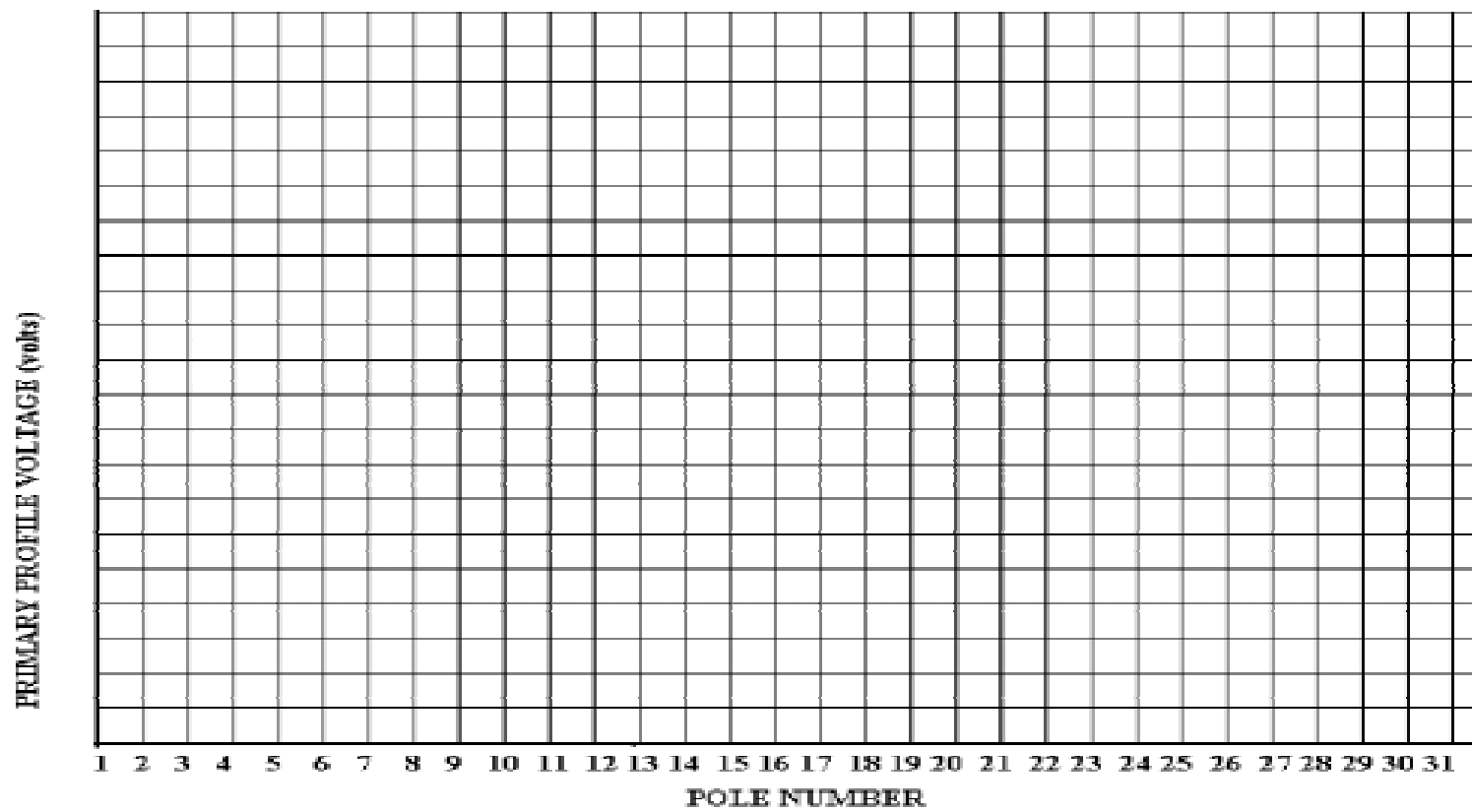


Appendix A-5d



Primary Profile Test

Voltage

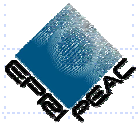


Appendix A-5e



24-Hour Test

- ◆ The 24-hour test is a test where the investigator places a recording voltmeter for about 24 hours to cover at least two milking periods.
- ◆ The four channel assignments are the same as in the signature test described previously.
- ◆ The “average rms” report graph from the recording voltmeter is the most useful in determining if the steady state level of concern has been exceeded at any time during the recording interval.



24-hour Test Report

"24-HOUR" TEST REPORT FORM

Customer name: _____ Date: _____

Start time: _____ Stop time: _____

Measure the following points with a long term digitizing data recorder: Vp from the primary pole ground rod to remote reference, Vs from the barn's main disconnect panel neutral/ground electrode, Vps between the previous two points, and Vcc, the cow contact voltage.

Data Recorder Settings and Assignments:

Waveform capture: OFF, Impulse capture: ON, Record min RMS: NO, Record RMS: YES, Record max RMS: YES, Record time: Maximum, RMS Storage interval: 10 Sec.

Channel	Variable	Inputs	Lower RMS	Upper RMS	Impulse
Red	Vp	ON	OFF	OFF	15 V.
Black	Vs	ON	OFF	OFF	15 V.
Blue	Vps	ON	OFF	OFF	15 V.
White	Vcc	ON	OFF	ON, 3V.	10 V.

After recording the data, analyze the reports section and record the following for the number of occurrences of each type of event. The first is from the exceedence report and the second two are from the out-of-limits report.

1. VOLTAGE LEVEL: exceeding 1.0 v. RMS max. Occurrences:
2. VOLTAGE LEVEL: exceeding 3.0 v. RMS max. Occurrences:
3. IMPULSE VOLTAGE LEVEL: exceeding 10.0 v. PEAK max. (For a time duration of 130 microseconds to 16.67 milliseconds.) Occurrences:

Additional comments:



Conclusions

- ◆ The testing protocol can be a very useful format for collecting and documenting data relative to stray voltage investigations on single and multiple electrical source dairy farms.
- ◆ The data acquired can be used to record the amount of AC, 60 Hz, rms, steady state stray voltage found during the investigation and the specific conditions under which it is present.
- ◆ An experienced SV investigator may use the testing information to suggest the source of such stray voltage and offer mitigation methods based on scientifically collected data that will properly address the situation.

