



Stray Voltage: The Research Perspective

Douglas J. Reinemann, Ph.D.
University of Wisconsin - Madison
Milking Research and Instruction Lab



What do we know about Stray Voltage?

- ☛ The causes and cures for stray voltage are well understood.
- ☛ The effects of electrical exposure on farm animals are also well understood and have been studied in great detail for over 50 years.

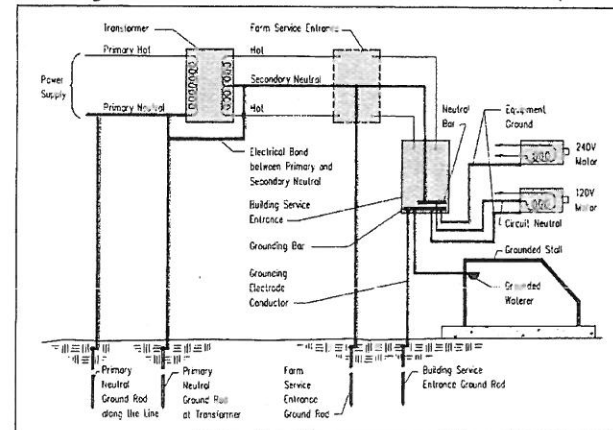


Can we find it and fix it?

- ☛ Voltages are developed on both off and on the farm.
 - ☛ both must be assessed
- ☛ Investigative techniques are well developed
 - ☛ vast majority of problems solved by applying accepted codes

YES!! 

The source of Stray Voltage is voltage developed by current flowing on the resistance of the Grounded-neutral system



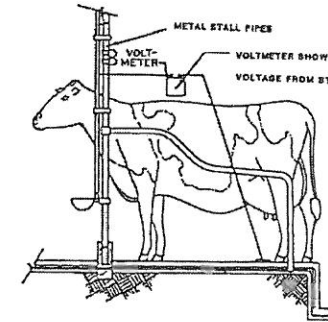
Neutral-to-earth or stray voltage can be reduced in several fundamental ways:

- ☛ Reduce animal contact voltage by bonding (Equipotential Planes)
- ☛ Reduce Neutral-to-Earth Voltage by
 - ☛ Reduce Neutral current
 - ☛ Reduce Neutral resistance
 - ☛ Improve the Grounding of Neutrals

These are already part of code requirements and good engineering practice



Cow - Contact is where its at!
For measurement



Voltage = Current x Resistance

- ☛ Current passing through an animal is the cause of responses.
 - ☛ 500 Ohm Cow + Contact in low resistance environments
 - ☛ 1000 Ohm Cow + Contact in other areas



Do we know what levels are problematic?

- ☛ Compilation of all known experiments in which responses to voltage or current exposure were documented
- ☛ Spanning 1962 to 2012 (50 Years)
- ☛ From Research Groups Around the World
- ☛ Over 100 Scientists Represented



New Zealand: Phillips, 1962

- ☛ First published Cow study
- ☛ Voltages on milking plants in New Zealand 0 to 20 V - most between 3 and 10 V.
- ☛ Sources of voltage: unbalanced loads and High resistance neutrals
- ☛ Voltage applied teat-to-rear hooves
- ☛ After these experiments 3 volts was chosen as a likely minimum level for response.



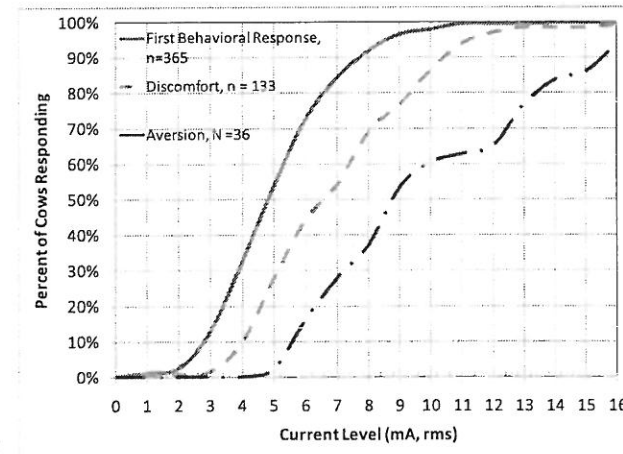
Reasonable Level

- ☛ Zero tolerance is
 - ☛ Impossible
 - ☛ Expensive
 - ☛ May be Dangerous
 - ☛ Not warranted base on research results
- ☛ Sensitivity to 50/60 Hz
- ☛ Sensitivity to High Frequencies



Ways That Stray Voltage Can Impact Farm Operations

- ☛ Direct effects
 - ☛ Mild behavioral reactions = sensation
 - ☛ Involuntary muscle contraction = twitching
 - ☛ Intense behavioral responses = pain
- ☛ Severity depends on
 - ☛ amount of electrical current (milliAmps) flowing through the animal's body
 - ☛ Body pathway
 - ☛ Individual animal Sensitivity



- ☛ Over 300 cows with constant voltage exposure
 - ☛ Most responses 2 to 8 Volts
- ☛ Over 450 cows with constant current exposure
 - ☛ Most responses 2 to 8 Milliamps
- ☛ Over 750 Cows Tested
 - ☛ 1000 Ohms reasonable estimate of cow + contact resistance in real-world situations
 - ☛ May be some unusual cases as low as 500 Ohms



Do We Know What Levels Are Problematic?

- ☛ No adverse response for cow contact voltage levels
 - ☛ Below 2 volts in low resistance environments
 - ☛ Below 4 volts in typical farm environments
- ☛ 4 milliamps of current passing through a cow.

Doug Phillips: 3 volts, 1962

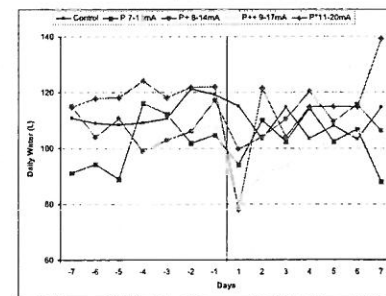


Animal Response to Stray Voltage

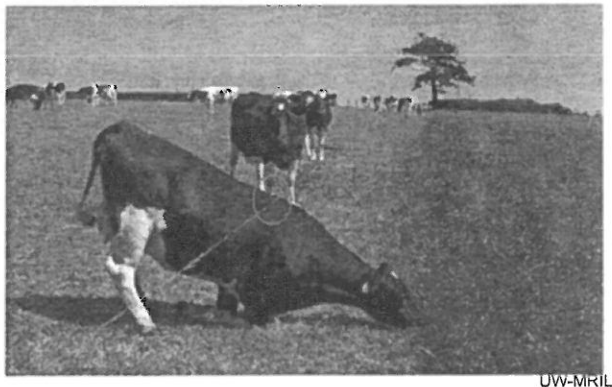
- | | |
|--------------------|--|
| ☛ Behaviors | ☛ Documented > 2- 4V |
| ☛ Milk production | ☛ Some effect >8V for extreme exposure |
| ☛ Somatic cells | ☛ No effect up to 8V |
| ☛ Reproduction | ☛ No effect up to 8 V |
| ☛ Milkout problems | ☛ Some effects >12 V |
| ☛ Stress Hormones | ☛ Some effects >16V |



Results of Aversion study. 60 Hz Current (measured zero to peak) applied to water bowl on day 1. measured as

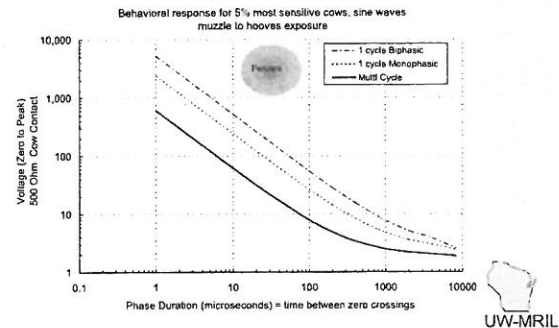


Learned Behavior - Avoid Contact

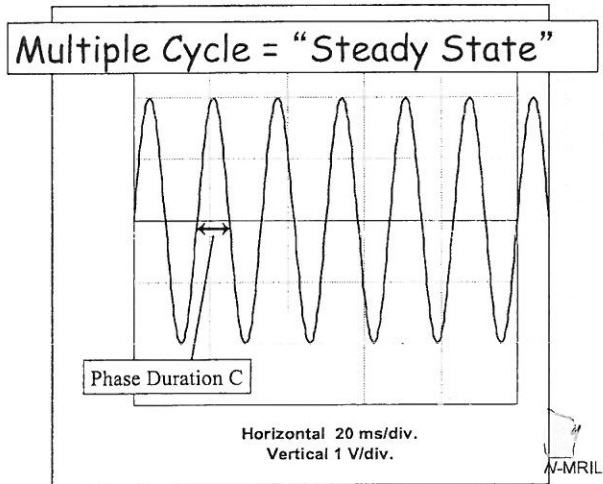
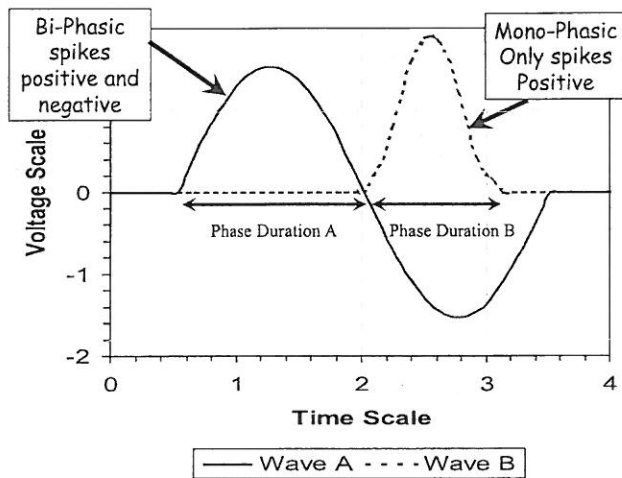


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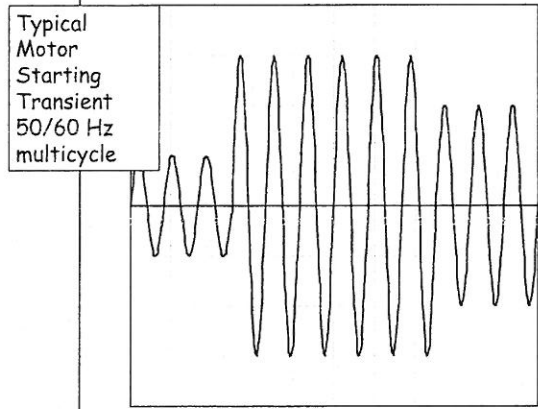
What do we know about high frequency events? A lot!!



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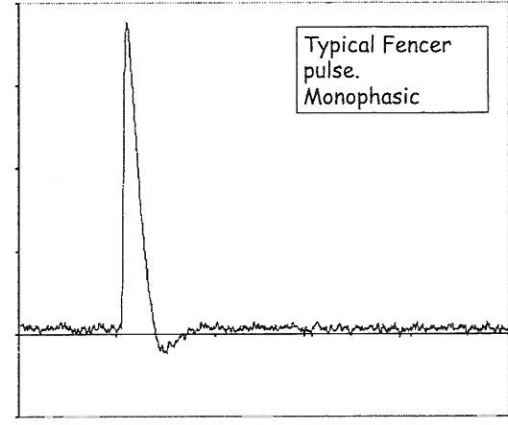


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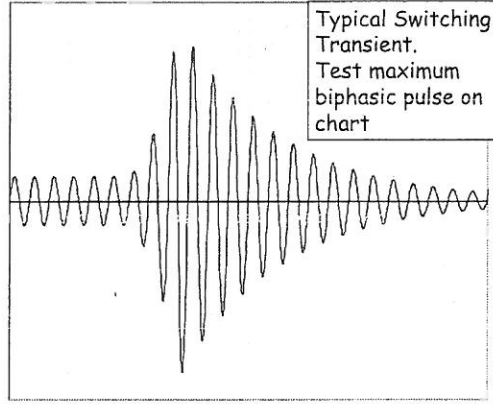
Typical Motor Starting Transient 50/60 Hz multicycle

Horizontal 20 ms / div.
Vertical 0.5 V / div



Typical Fence pulse. Monophasic

Horizontal 50 μ s / div.
Vertical 10 V / div.



Typical Switching Transient. Test maximum biphasic pulse on chart

Horizontal 100 ns / div
Vertical 1V / div



Exposure Conditions Required to Produce an Effect

- ☛ Adverse effect requires BOTH annoying current AND forced exposure
- ☛ Location
 - ☛ Areas vital to normal daily activities
- ☛ Times / day
 - ☛ Annoying stimulus must occur frequently



Exposure during milking

- ☛ Highly unlikely location for problems
 - ☛ Milk hose has very high resistance
 - ☛ Milking parlors usually well bonded (equipotential)
 - ☛ Body resistances high for hide/stall contact



Diagnosis

- ☛ Animal behavior or other symptoms **CANNOT** be used to diagnose stray voltage problems
 - ☛ All known responses to stray voltage exposure can be produced by other causes
- ☛ The **ONLY WAY** to determine if stray voltage is a potential cause is to perform electrical testing



Ground Currents, Electric, And Magnetic Fields

- ☛ Science Advisors Research conducted to examine this possibility - main finding
 - ☛ No credible scientific evidence to verify the specific claim that currents in the earth or associated electrical parameters such as voltages, magnetic fields and electric fields, are causes of poor health and milk production in dairy herds



Steady Stream Of Unorthodox Approaches

- ☛ Not based on sound scientific principles
- ☛ Produced a great deal of mistrust in the agricultural community
- ☛ Have not stood the test of time as effective means to address stray voltage concerns.



Does it work?

- The soundness and repeatability of scientific research and the success of its practical application has been validated over the past 25 years on over 9000 stray voltage investigations on farms in Wisconsin.

