The Smart Position on Stray Voltage

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

UW-MRIL

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.

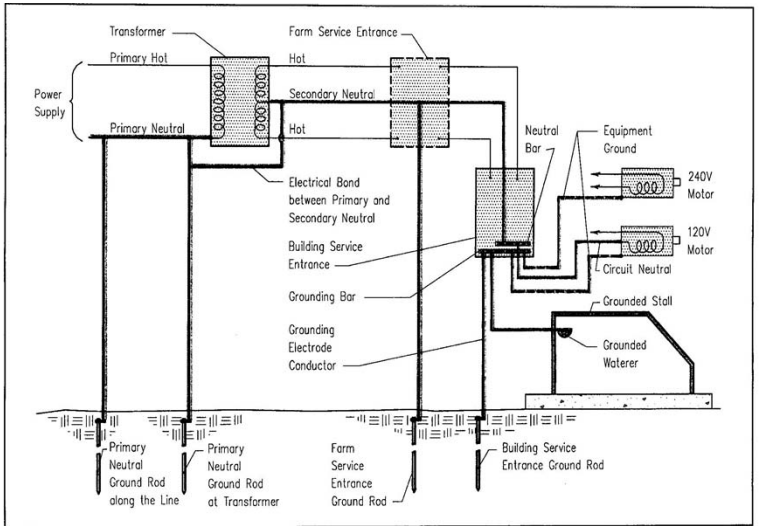
A LOT!!!

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 Multi-earthed-neutral system

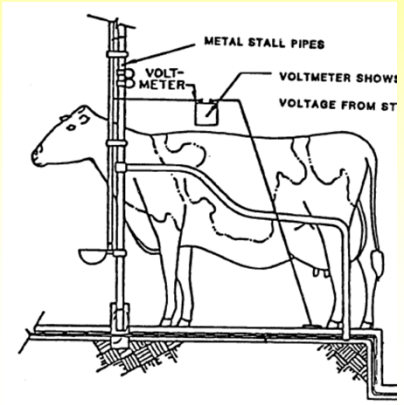


Neutral-to-earth or stray voltage can be reduced in three fundamental ways:

- Reduce the current flow on the MEN system,
- Reduce the resistance of the MEN system, or
- Improve the earthing of the MEN system

UW-MRIL

Cow – Contact is where its at! For measurement



UW-MRIL

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

UW-MRIL

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

UW-MRIL

Reasonable Level

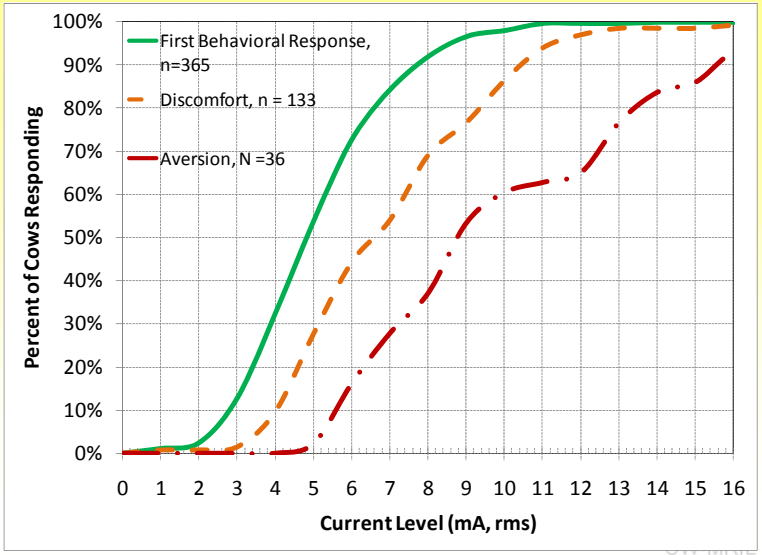
- Zero tolerance is
  - Impossible
  - Expensive
  - May be Dangerous
  - Not warranted base on research results
- Sensitivity to 50/60 Hz
- Sensitivity to High Frequencies

UW-MRIL

Ways That Stray, or Tingle, 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

UW-MRIL



- 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

UW-MRIL

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.

UW-MRIL

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!!!

UW-MRIL

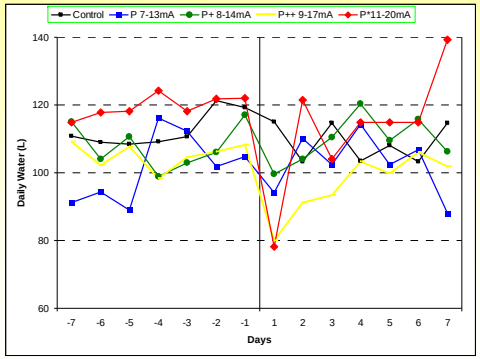
Animal Response to Stray Voltage

- Behaviors
- Milk production
- Somatic cells
- Reproduction
- Milkout problems
- Stress Hormones

- Documented > 2- 4V
- Some effect >8V for extreme exposure
- No effect up to 8V
- No effect up to 8 V
- Some effects >12 V
- Some effects >16V

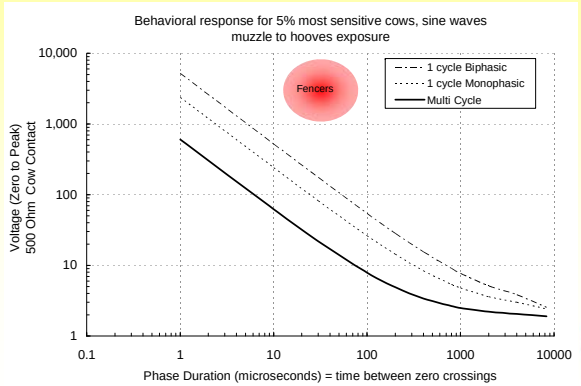
UW-MRIL

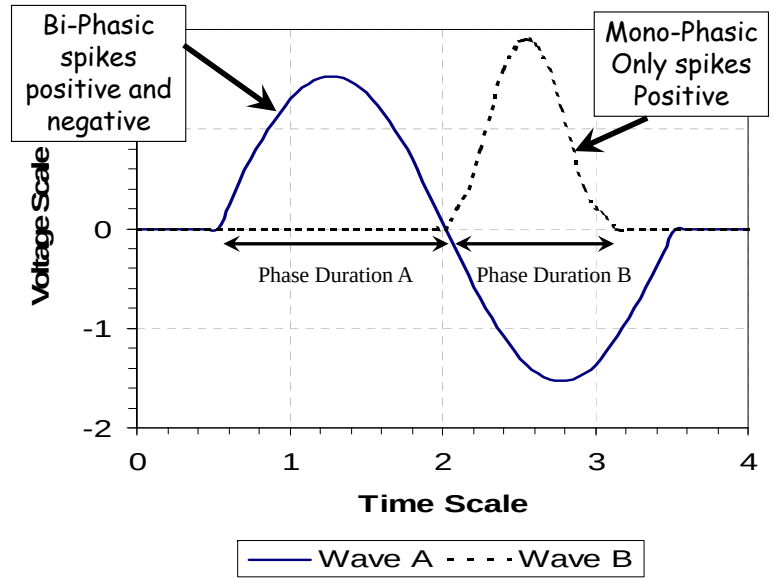
Results of Aversion study. 60 Hz Current (measrued zero to peak) applied to water bolw on day 1. measured as



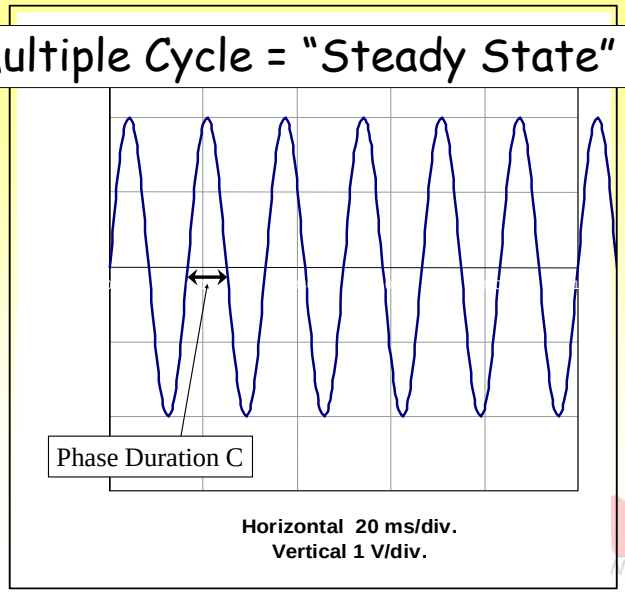
UW-MRIL

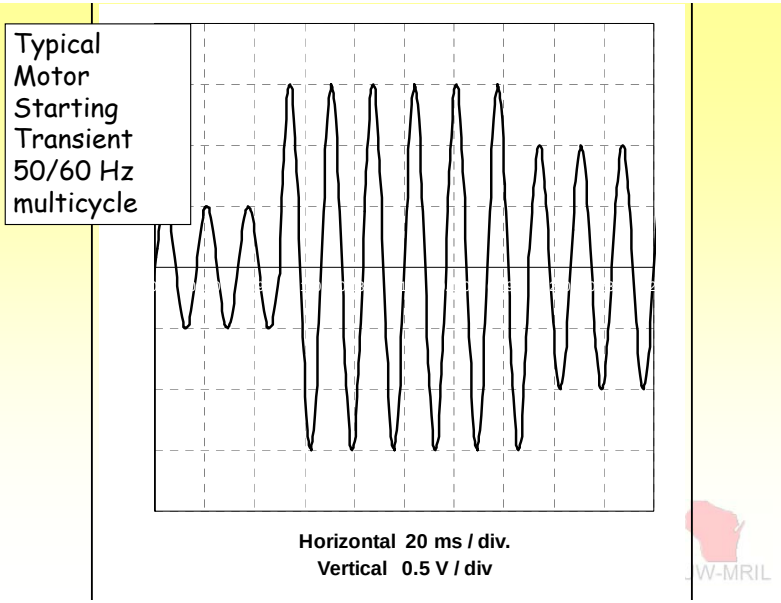
What do we know about high frequency events? A lot!!

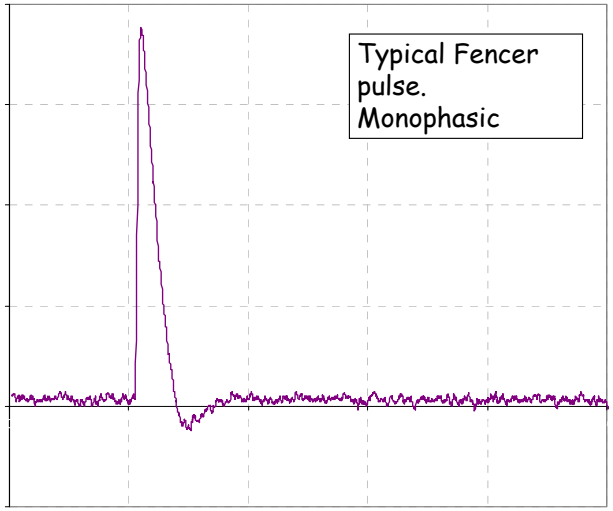




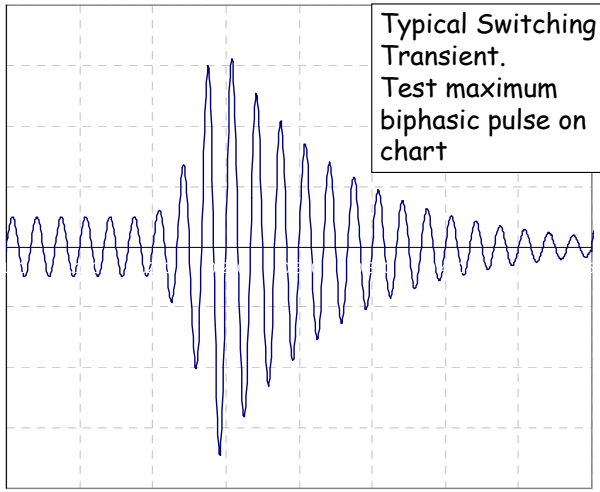
Multiple Cycle = "Steady State"







Horizontal 50 µs / div.
Vertical 10 V / div.



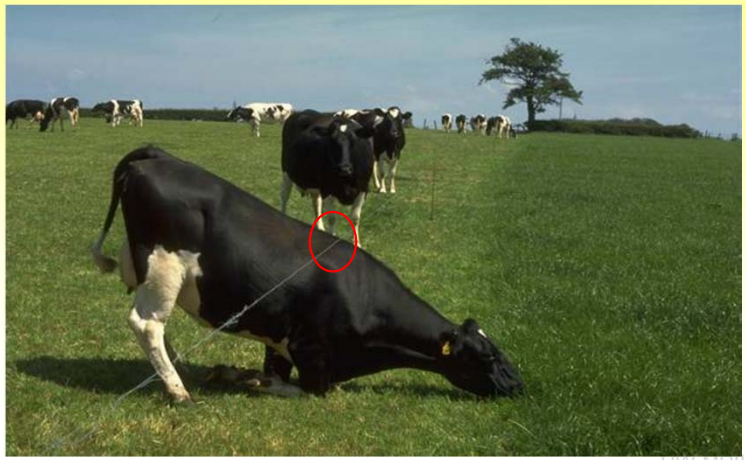
Horizontal 100 ns / div
Vertical 1V / div

Variable frequency motor controllers

- Reduced electrical power use =
  - Reducted neutral current =
  - Reduced stray voltage
  - Reduced 'starting transients'
- Can cause interference with RFID if not properly shielded
- Will cause waveform distortion of neutral current/voltage
  - not enough to change 50/60 Hz sensitivity
- Can cause induced voltages on metalic objects
  - The solution is proper shielding and earthing

UW-MRIL

Learned Behavior – Avoid Contact



UW-MRIL

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

UW-MRIL

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

UW-MRIL

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

UW-MRIL

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

UW-MRIL

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.