"Stray Voltage"
Ground Current Problems

Prepared for: Ontario Energy Board

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November 22, 2007

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"Stray Voltage": Order in Council for OEB

Order in Council
Décret

Ontario
Executive Council
Conseil des ministres

On the recommendation of the undersigned, the Lieutenant Governor, by and with the advice and concurrence of the Executive Council, orders that:

Sur la recommandation du soussigné, le lieutenant-gouverneur, sur l'avis et avec le con- sentement du Conseil des ministres, décrète ce qui suit:

WHEREAS it is desirable to improve the quality of electricity service in order to address certain issues related to stray voltage which are currently being experienced by the agricultural sector and, in particular, by farm customers.

AND WHEREAS the Minister may, with the approval of the Lieutenant Governor in Council, issue directives under section 27 of the *Ontario Energy Board Act, 1998* (the "Act") in order to direct the Ontario Energy Board (the "Board") concerning general policy and the objectives to be pursued by the Board.

AND WHEREAS, in recognition of the fact that one of the primary objectives of the Board, as contained in paragraph 1(1) 1 of the Act, is to protect the interests of consumers with respect to quality of electricity service, it is desirable that the Board develop its own processes, procedures and regulatory instruments to implement measures in order to address the issue of stray voltage as it is currently being experienced by farm customers.

NOW THEREFORE the Directive attached hereto, is approved.

Recommended: _____ Minister of Energy

Concurred: _____ Chair of Cabinet

Approved and Ordered: MAY 16 2007 Date

_____ Administrator of the Government

O.C./Décret 1081/2007

This Order in Council signed by the Minister of Energy, Dwight Duncan, originated as a Private Member's Bill initiated by Maria Van Bommel, MPP for Lambton-Kent-Middlesex, in response to decades of complaints from farmers in Ontario.

Authority Verified
Compétence vérifiée James Rehob

Please print name
Nom en lettres moulées s.v.p. James Rehob

Telephone
Téléphone (416) 325-6676

Recommended by the Management Board of Cabinet on
Recommandé par le Conseil de gestion du gouvernement le _____

Secretary
Secrétaire _____

O.C./Décret

MINISTER'S DIRECTIVE

TO: THE ONTARIO ENERGY BOARD

I, Dwight Duncan, Minister of Energy, hereby direct the Ontario Energy Board (the "Board") under section 27 of the *Ontario Energy Board Act, 1998* (the "Act") as follows:

1. The Board shall implement such measures which, in its own discretion, having regard to the objective related to quality of electricity service provided for under paragraph 1(1) 1 of the Act, are necessary to ensure electricity service to farm customers, in relation to "tingle" or "stray" voltage, is of a quality that does not unduly impact the operation of the farm.

_____ Minister of Energy

MAY 16 2007 Date

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Private Member's Bill:
First Reading: Oct 3, 2006; **Second** Reading: Oct 19, 2006,
NOTE: 2nd Reading passed unanimously by Members in the House

Ground Current Pollution Act, 2006

EXPLANATORY NOTE

The Bill has the following purposes:

1. To define objectionable current flow on ground rods, commonly known as stray voltage, and to prohibit electricity providers from causing occurrences of objectionable current flow.
2. To establish a time frame for electricity providers to respond to complaints about objectionable current flow, to require an investigation of complaints and, if an investigation shows that an electricity provider is responsible for an occurrence of objectionable current flow, to require the provider to remedy the problem in a timely manner.
3. To create an offence and penalty for failing to remedy the problem that gave rise to a complaint in a timely manner.
4. To provide that the Ministry of Government Services develop and implement a plan to eliminate objectionable current flow in Ontario.

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Why do we have a stray voltage (ground current) problem?

1. Power quality is deteriorating.
2. Load is increasing.
3. Antiquated utility infrastructure needs upgrade.
4. Utility neutrals now connected to ground contributing to problem.

Result: Objectionable ground current (stray voltage)

Solution: Put the ground current back onto the neutral wires where it belongs.

4

Power quality is deteriorating

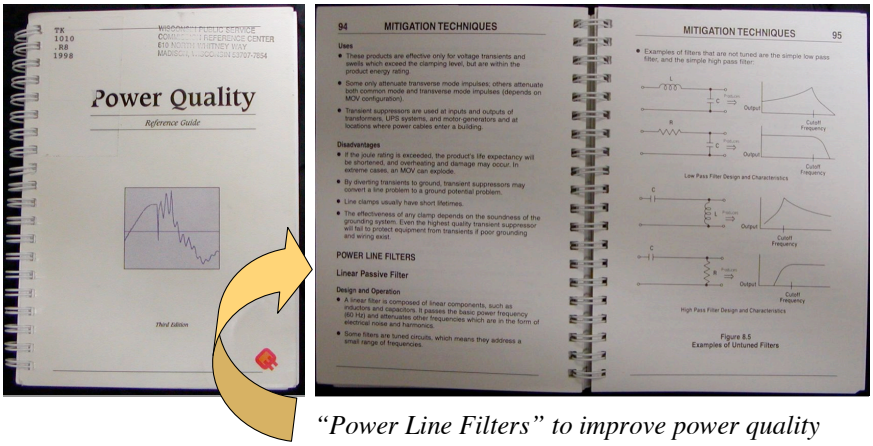
*"Dirty power costs U.S. industry anywhere from **$4 billion to $6 billion a year**, according to Karl Stahlkopf, a **vice president** at the utility-financed Electric Power Research Institute (**EPRI**) in Palo Alto."*

This does **NOT** include HEALTH COSTS
nor does it include the cost to FARMERS!

5

Power quality is deteriorating

Dirty Electricity = Poor Power Quality



"Power Line Filters" to improve power quality

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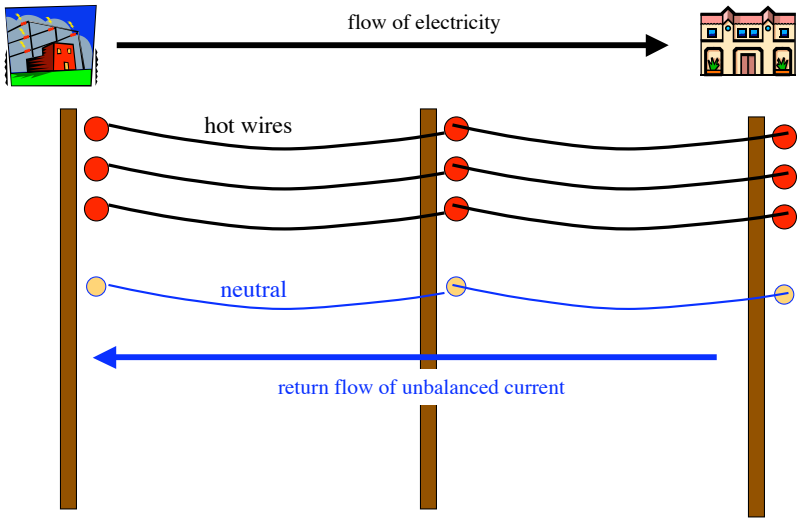
Antiquated utility infrastructure needs upgrade



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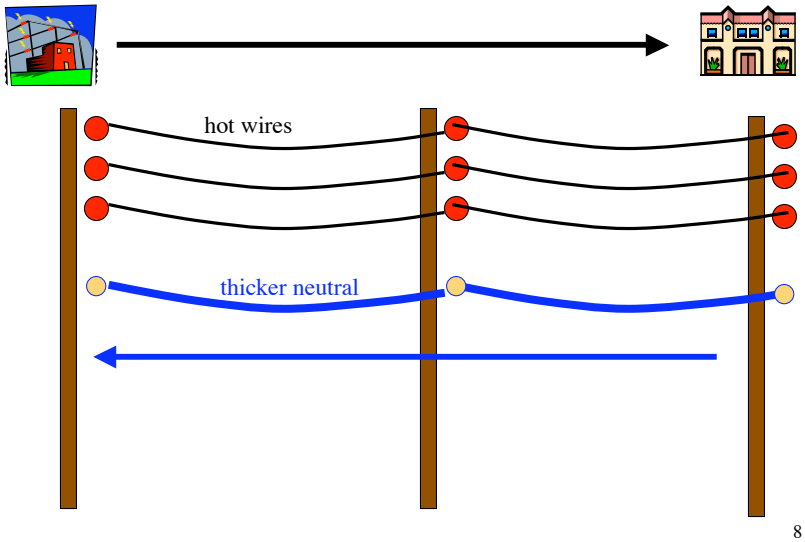
Antiquated utility infrastructure needs upgrade (thicker neutral)



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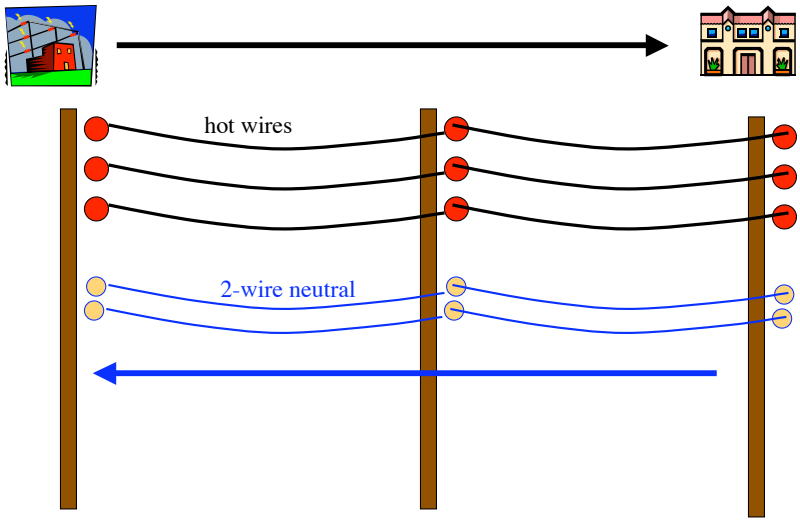
Antiquated utility infrastructure needs upgrade (5 wire system)



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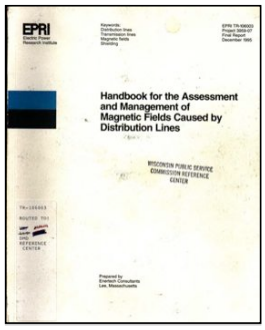
Antiquated utility infrastructure needs upgrade

*"Fortunately, there are **proven** and relatively **inexpensive** techniques for addressing any type of **ground current** transients, including those that are intermittent."*

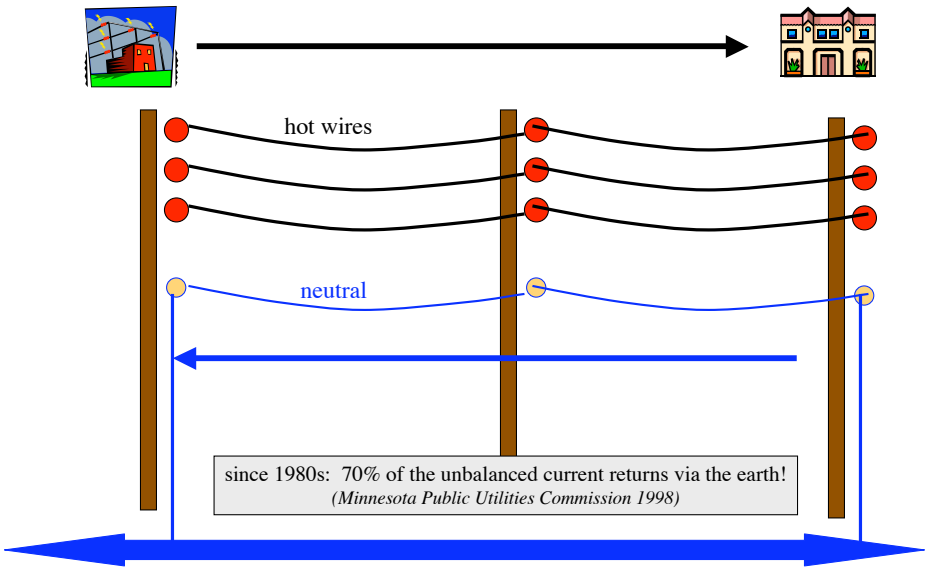


EPRI 1995: Five-Wire Primary Lines

*"A method that practically eliminates ground currents associated with primary distribution lines and still maintains the advantages of a four-wire multi-grounded system, is the **five-wire system**"*

10

Utility neutrals now connected to ground



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Where Ground Current Flows

Current will travel along the path of least resistance (Ohm's Law)

Current will take any and all paths (Kirchoff's Law)

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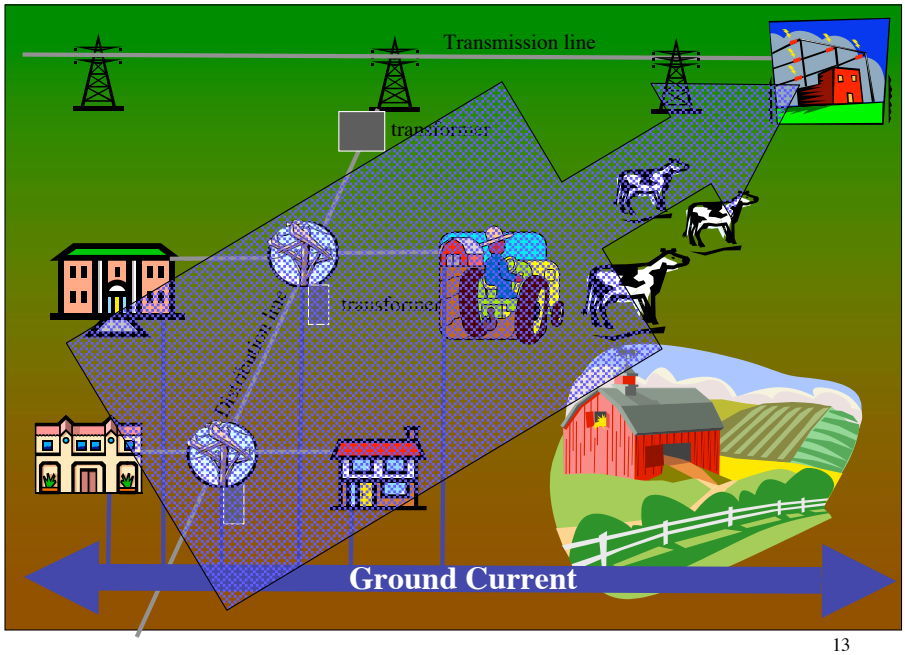

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How to determine if stray voltage is coming from farm or from utility?

- Turn power to farm off and if stray voltage is detected then it is probably coming from the utility.
- Important to measure the **60 Hz** and **higher frequency** voltages since both are a problem.
- If this is done properly it is possible to determine the direction and source of flow.

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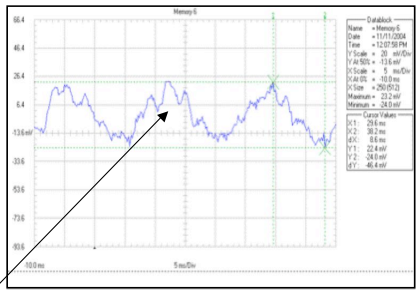
Stray voltage: flows along the ground



NOTE: Power to farm was OFF.

60 Hertz and higher frequencies detected. Cows on farm are not producing at their optimum. Power to farm is off during measurements. Stray voltage at this farm is caused by the utility!

The above waveform was collected between two remote ground rods less than 20 feet apart on the Kerstendale farm near Port Perry Ontario (Stetzer 2004).

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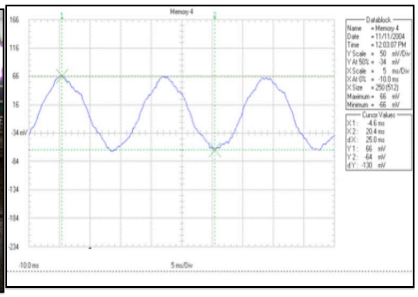
Stray voltage: flows along water pipes



NOTE: Power to farm was off.

Cows have difficulty drinking and hence milk production is down. Power to farm is off. Where is the stray voltage coming from? Utility?

The above waveform was collected between a plate placed in the water and another plate on the concrete floor in the free stall area of the Kerstendale Farm near Port Perry Ont. It represents the voltage potential applied to the cow from nose to rear hoof while attempting to drink (Stetzer 2004).

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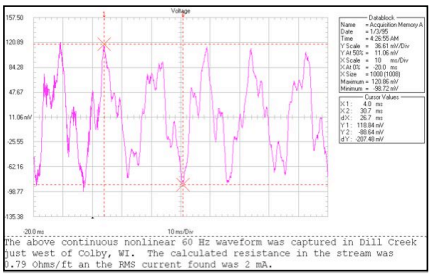
Stray voltage: flows in water



NOTE: No fish in this creek.

Stray voltage can affect wildlife!

The above waveform was collected in Dill Creek. Voltages in the creek are higher than those used for electro-fishing (Stetzer 2004).

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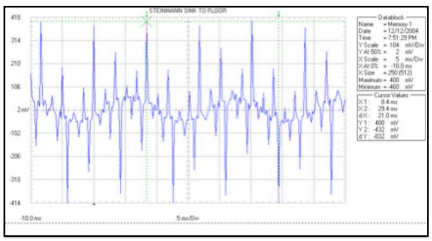
Stray voltage: flows from sink to floor

[92 times too high]



The waveform above was recorded between the sink and floor in the Hans Steinmann home in Manitoba Canada (Stetzer 2004).

The Steinmann home has **92 times** more current than what **EPRI** and the **NIEHS** report to have a biological effect "**relevant to cancer**".

Note: voltage flows through body when touching water, washing dishes, bathing, etc.

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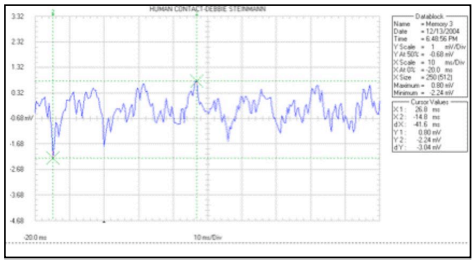
Stray voltage: flows from leg to leg



The waveform above was recorded using two EKG patches placed on Debbie Steinmann's ankles while she was standing in the kitchen of her parents' home in **Manitoba Canada** (Stetzer 2004).

Note: voltage is flowing through this girl's body.

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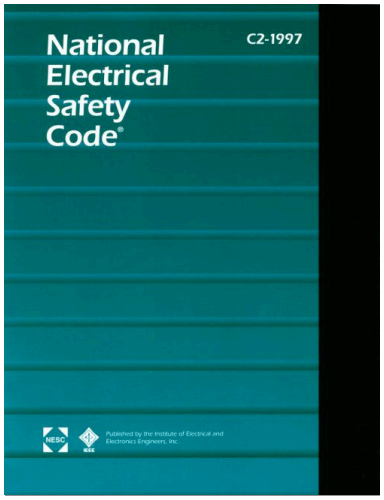
National Electrical Safety Code (1997)



Rule 92D:
Current in Grounding Conductor

"Ground connection points shall be so arranged that under normal circumstances there will be no **objectionable** flow of current over the grounding conductor."

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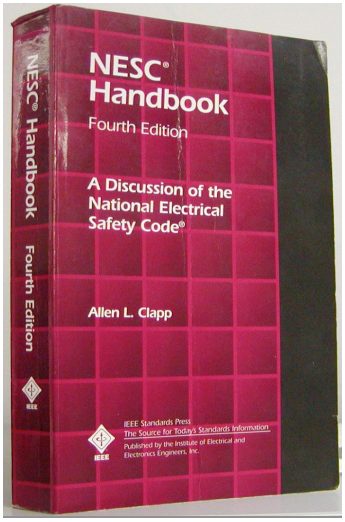
National Electrical Safety Code Handbook



- "Rule 92D refers to actions required in the case of 'objectionable' flows of current over the grounding conductor. The word 'objectionable' is undefined in the NESC; it is left to the designer's discretion, utilizing good design and operating practice, to identify and remedy the situation."

- **NOTE: Ground Current Pollution Act defines "objectionable current flow" of current as**

  *any steady state of electrical ground current for **five seconds or more** on a grounding conductor or any other conductor that normally does not carry electric current, except for any temporary flow of electrical fault current that is caused by a phase-to-ground fault condition and that results from the performance of a grounding conductor's protective functions regarding faults or lightning; ("courant indésirable")*

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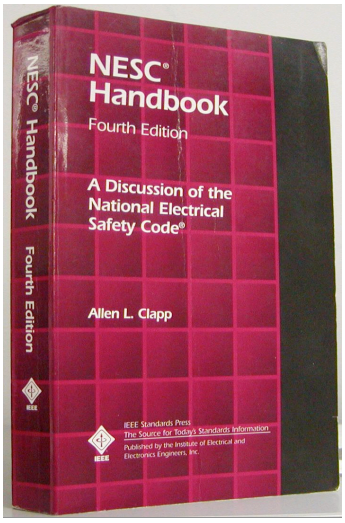
National Electrical Safety Code Handbook



Objectionable Ground Current:

- "...areas that are often known to present specific problems (such as milking **barns** without adequate voltage gradient control, **pipelines**, electric **railways**, **conduits**, etc.) may need special attention to limit damage to equipment or uncomfortable conditions for **personnel** or **animals**."

- From Rule 215B: "Objections to use of the earth as part of a supply circuit are made from both safety and service standpoints."

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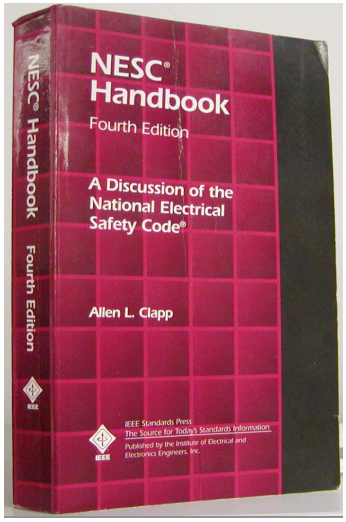
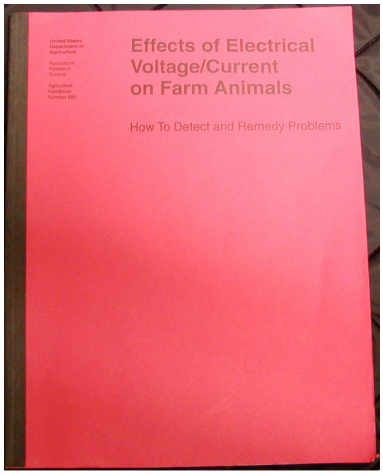
National Electrical Safety Code Handbook



- "When the earth returns were used in some rural areas prior to the 1960's, they became notorious offenders in dairy areas because circulating currents often cause both step and touch potentials**.** In some cases, they have adversely affected milking operations by shocking the cattle when they were connected to the milking machines, and have affected feeding. (See Rule 92D - Current in a grounding conductor.)

In 1960s when earth was used to return currents it affected cows. Today the neutral wire is connect to ground and the earth is used once again to return currents! This needs to be stopped . . . immediately!

Effects of Electrical Voltage/Current on Farm Animals



Power Quality:

" Power utilities generally have not addressed the need to maintain good power quality for certain equipment; so thus far, the consumers have had to identify, select, purchase, and install the proper equipment to modify, as needed, the basic power delivered by the utility."

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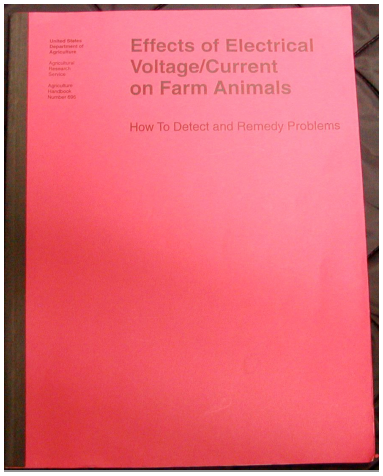
Effects of Electrical Voltage/Current on Farm Animals



Load Growth:
"The increase in neutral currents and leakage or uncleared fault currents to earth due to electrical load growth on a farm or along a distribution line can lead to an increase in the neutral-to-earth voltage.

Transients are voltage or current impulses of short duration that occur either regularly or irregularly."

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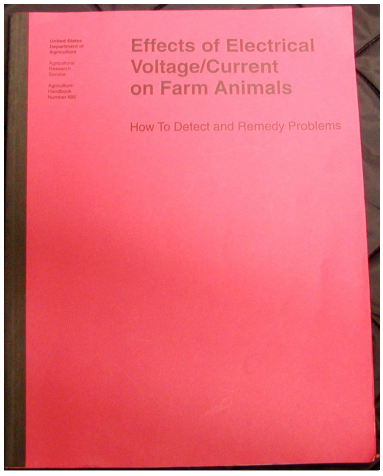
Effects of Electrical Voltage/Current on Farm Animals



Power Systems:
"The U.S. electrical power system is a huge network and is based on a specific transmission, distribution, and utilization philosophy. When consumer equipment consisted primarily of lights, motors, and tube-type electronic equipment, and electrical loads were relatively small, neutral-to-earth voltages and transients were not great problems, due to the lower neutral currents and the tolerance of the equipment. With increasing use of low-signal-level solid-state computers and microprocessors, increasing electrification and automation of farms, and increased loads on distribution lines, the issue of power quality and tolerable neutral-to-earth voltage is becoming increasingly important."

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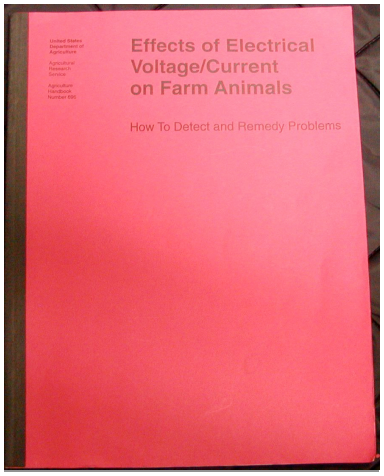
Effects of Electrical Voltage/Current on Farm Animals



"It will become necessary in the future to more clearly specify the power characteristics that the utility is to provide at the delivery point, the limits to which a consumer's type of usage can be allowed to affect other customers and the utility, and who is to monitor and require conformance to the specifications. The ramifications of meeting these needs are that difficult economic, technical, and legal problems will arise and will have to be solved**."**

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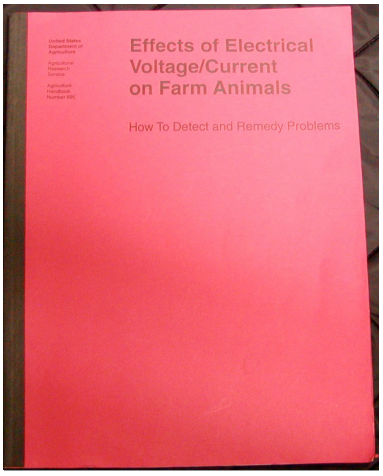
Effects of Electrical Voltage/Current on Farm Animals



"**Transient-effects research is necessary to fully evaluate power system effects on animals**. Surveys to establish the existence and characteristics of transients and the effects of transients on animals are needed to determine whether a full research program is required. Both short term and long term tests would be needed to provide data on transient current effects on animals. **…Continuing exposure to consistent or intermittent transients may have harmful effects if they exceed levels yet to be determined."**

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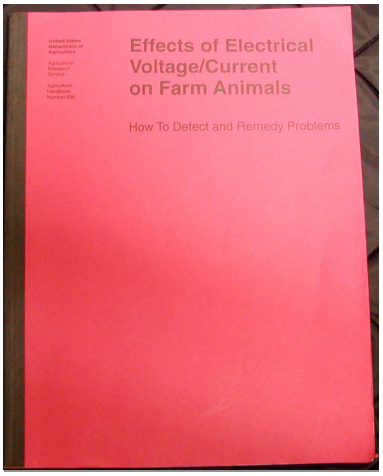
Effects of Electrical Voltage/Current on Farm Animals



Recommendation:
"Power quality problems and the effects on farm operations and animals need to be better understood through continuing research."

"The effect of a transient voltage superimposed on the regular power voltage (dc or ac) is to cause a momentary change in the waveform. When the transient causes the momentary voltage to be greater than normal, it may cause a transient current to flow in an animal. …If the transient waveform has sufficient energy (magnitude and duration), there may be an animal response."

NOTE: values of 10 mV (peak-peak) of high frequency transients (kHz range) can affect dairy cows, causing them to lift their feet to break the circuit. *Video available upon request.*

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What levels of stray voltage are "safe"?

1. Two types of stray voltage need to be considered:
   - Good power quality: the fundamental 60 Hertz frequency
   - Poor power quality: transients, harmonics, etc in the kHz range and higher
2. For 60 Hertz frequency:
   - 0.5 volts may be "safe"
3. For higher frequencies (kHz and higher):
   - 10 milli volts (mV) is KNOWN to have adverse effects on cows

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Stray voltage (ground current) is not limited to farms nor are the harmful effects limited to livestock.

1. On farms stray voltage can affect the **health** of **farmers** and their **families** as well as their **livestock**.

2. Stray voltage is present in **urban** centres and has been linked to **childhood leukemia**.

3. Stray voltage can also affect **wildlife**.

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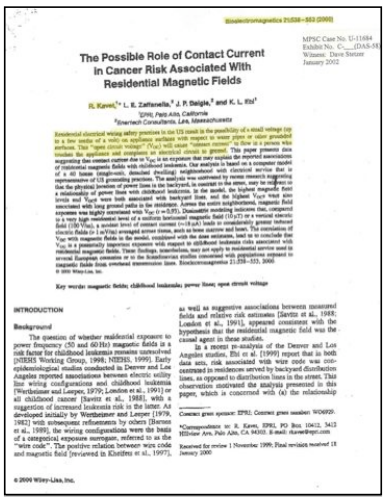
People can be adversely affected by Ground Current/Contact Current

Kavet et al. 2000. *The Possible Role of Contact Current in Cancer Risk Associations with Residential Magnetic Fields*. Bioelectromagnetics 21:538-553.


The Possible Role of Contact Current in Cancer Risk Associated With Residential Magnetic Fields

1. Residential electrical wiring safety practices in the US result in the possibility of a small voltage (up to a few tenths of a volt) on appliance surfaces with respect to **water pipes** or other **grounded surfaces**.

2. This "open circuit voltage" (Voc) will cause "contact current" to flow in a person who touches the appliance and completes an electrical circuit to ground.

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Childhood cancer in relation to indicators of magnetic fields from ground current sources.

Wertheimer N, Savitz DA, Leeper E
Bioelectromagnetics 1995; 16:86-96.

Abstract

This study examines childhood cancer risk in relation to certain factors likely to indicate magnetic field exposure from ground currents in the home. **Substantial ground currents are most often found in homes having conductive plumbing,** in which an uninterrupted metallic path in the water pipes and water main connects the grounding systems of neighboring houses. Information on plumbing conductivity was obtained from water suppliers for the homes of 347 cases and 277 controls identified in an earlier study of magnetic field exposure and childhood cancer in the Denver area. **An increased cancer risk was observed for children in homes with conductive plumbing:** The matched odds ratio was **1.72** (1.03-2.88) and increased to **3.00** (1.33-6.76) when analysis was limited to cases and controls who were residentially stable from the reference date to the study date. A measurement metric likely to indicate active ground currents (measurements having above-median intensity and a nonvertical orientation of < 55 degrees from the horizontal) was identified. In contrast to measured field intensity alone, for which only modest associations with cancer have been reported, this metric shows a high and significant cancer risk **[matched O.R. = 4.0 (1.6-10.0)]** consistent over a range of intensity and angle cutpoints. Such elevated nonvertical fields were also associated with cancer in an independent data set, which was gathered to study adult nonlymphocytic leukemia in the Seattle area. **The associations of cancer with conductive plumbing and with this exposure metric both suggest that cancer risk is increased among persons with elevated magnetic field exposure from residential ground currents.**

Author Address
Department of Epidemiology, University of North Carolina School of Public Health, Chapel Hill, USA.

Ground current in urban homes linked to childhood leukemia.

Ground currents (stray voltage) not limited to rural areas).

4-fold increase in cancer rate!

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Electromagnetic Hypersensitivity (EHS)

A growing population is becoming electrically sensitive.

- 3% population has full blown EHS
- 35% population has symptoms of EHS

In Ontario, with a population of **11.4 million**, this accounts for between **342,000** (3%) and **4 million** (35%) people.

EHS is recognized as a disability in Sweden.

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WHO International Seminar and Working Group meeting on EMF Hypersensitivity

(Prague, October 25-27, 2004)

". . . a phenomenon where individuals experience **adverse health effects** while using or being in the vicinity of devices emanating electric, magnetic, or electromagnetic fields (EMFs)."

"Whatever its cause, EHS is a **real** and sometimes a **debilitating** problem for the affected persons, while the level of EMF in their neighborhood is no greater than is encountered in normal living environments. Their exposures are generally several orders of magnitude **under** the limits in internationally accepted standards."

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Stray Voltage: Utility Responsibility

Utilities need to:

1. update their outdated distribution systems to meet today's technological loads.
2. get the current out of the ground and put it back on the wires where it belongs.
3. provide good power quality to their customers.

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Final Thoughts

- If the OEB determines that stray voltage above **0.5 volts at 60 Hertz** is safe (allowable) on farms; and
- If the OEB fails to recognize that **higher frequencies** are more harmful and need lower guidelines (less than **10 mV**); and
- If the OEB fails to recognize that stray voltage affects more than **livestock** and that the **health of farm families**, as well as **urban dwellers**, and **wildlife** are also affected;

then the OEB is doing a disservice to its customers and to the people of Ontario and is not adhering to paragraph 1(1) 1 of the ACT, *is to protect the interests of consumers with respect to quality of electricity service*.

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Inspirational quotes:

"Our lives begin to end the day we become silent about things that matter."
--Martin Luther King, Jr.

“Facts don’t cease to exist because they are ignored.”
--Aldous Huxley

"Never doubt that a small group of thoughtful, committed people can change the world. Indeed, it is the only thing that ever has." -- Margaret Mead

Acknowledgement:

I wish to thank Dave Stetzer for providing some of the slides.

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