



A FARMER'S GUIDE TO

Basic Troubleshooting of On Farm Stray Voltage

This document provides technical information that can guide basic electrical troubleshooting on farm electrical systems and help identify and mitigate the customer contribution of stray voltage.



WHAT IS STRAY VOLTAGE?

Stray voltage is caused by the normal delivery and use of electricity, voltage may typically exist between two conductive surfaces. Examples of conductive surfaces include concrete floors, metal stabling, milk pipelines, water bowls, etc. This voltage, known as animal contact voltage, stray voltage or tingle voltage, usually presents no harm, however, if the voltage level is high enough, it may affect livestock behaviour and health. The Ontario Energy Board requires Local Distribution Companies (LDC) to investigate where a livestock farm customer provides the distributor with information that reasonably

indicates that farm stray voltage may be adversely affecting the operation of the customer's farm. The LDC is required to mitigate their stray voltage contribution if the animal contact current (ACC) exceeds 2.0 mA or animal contact voltage (ACV) exceeds 1.0 V. These investigations have also determined that the customer's electrical system could be the cause of the problem with deteriorated wiring/equipment or non code compliant installations found on the farm. The LDC will not mitigate customer caused stray voltage and unless addressed, the farm will continue to have issues.

1 Grounding and Bonding

When trying to troubleshoot stray voltage, care should be taken to ensure bonding and grounding conductors are electrically continuous (i.e. avoid cutting or removing bonding or grounding conductors). These conductors serve an important safety function and their removal can result in dangerous conditions such as fire or shock hazards.

If grounding or bonding conductors have been removed or cut, as shown in Picture 1, they should be repaired immediately by a qualified person. If the equipment is part of the LDC's (Utility) transformer, pole or lines (Picture 2), the LDC should be contacted immediately.



Picture 1: Example of a disconnected bond wire



Picture 2: Example of an LDC grounding conductor on the pole that has been damaged

2 Equipotential Bonding

Livestock typically feel stray voltage when they contact two conductive surfaces which are at different electric potentials (voltage). In order to mitigate this, all conductive surfaces should be bonded together, to create equipotential (i.e. same voltage) surfaces. Conductive surfaces may include metal water pipes, stanchions, water bowls, vacuum lines and concrete floors. Bonding these surfaces together is an effective mitigation technique that is easiest and most economical to achieve during initial construction. More information can be found in ESA bulletin 10-23-*



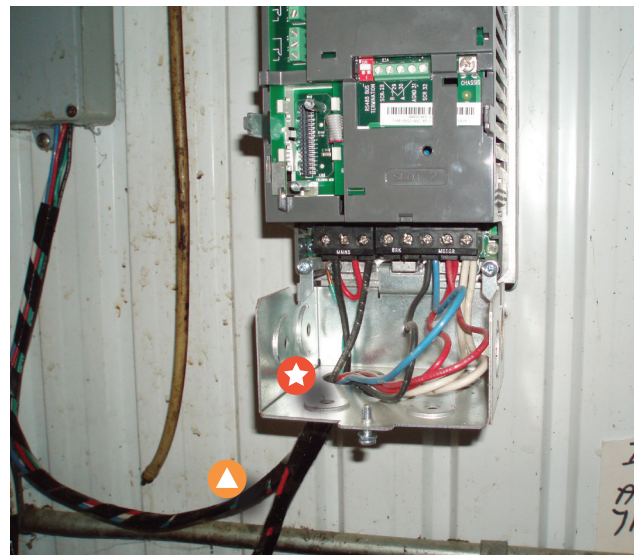
Picture 3: Example of metallic mesh installation used to create equipotential.

3 Conductors

Wiring on farms, particularly in buildings housing livestock, is subject to harsh conditions such as mechanical damage, pooling water, high humidity, corrosion and rodents. Damaged insulation covering on conductors (Pictures 4 and 5) may inadvertently energize objects that may be a contributing factor to stray voltage. **Conductors with signs of damage should be replaced or repaired immediately by a qualified person.**



Picture 4: Example of conductor insulation damage.



Picture 5: Example of conductors in contact with sharp edges

- ★ Conductors exposed to sharp edges
- ▲ Not an approved cable assembly or in an approved raceway

4 Poor Neutral Connections

The neutral (or white wire) in your farm building's electrical system is vital in maintaining electrical safety. A loose neutral wire may result in stray current flowing through unintended paths. A disconnected or poor neutral connection can cause unstable voltages that often result in an electrical fire. Loose connections can be the result of many factors such as improper torquing during the original installation, heavy loading, aging, vibration or corrosion. Confirm electrical equipment is deenergized prior to checking for loose or corroded connections.



Picture 6: Example of conductors missing connector  Missing connector and open connection



Picture 7: Example of a corroded neutral connection  Corroded Termination

5 Electrical Equipment

If shutting off a particular circuit or disconnecting electrical equipment results in an improvement of the stray voltage issue, that circuit or electrical equipment may be defective and require repair. All electrical equipment should be checked regularly for damage. Electrical equipment, such as panelboards (Picture 8) and receptacles (Picture 9), within these buildings are often subjected to high levels of corrosion or humidity that can result in failure of the equipment. When it is not possible to relocate equipment, it should be approved for the level of corrosion or moisture with ratings such as NEMA 4X. Deteriorated electrical equipment, such as water heaters, heated water bowls or well pumps can not only be a contributing factor to stray voltage, but can also result in electrical fire or shock hazards.



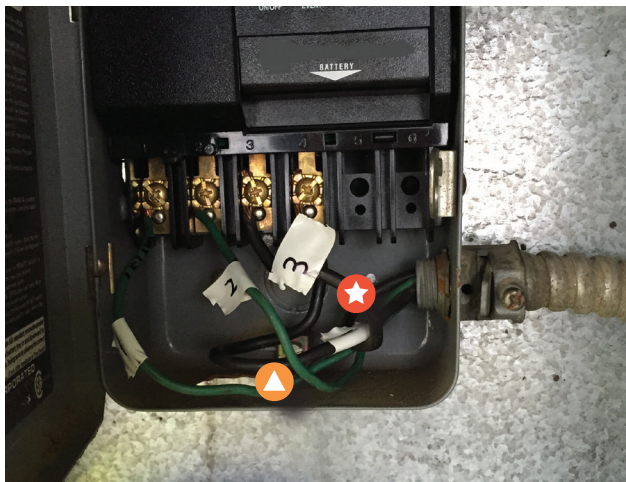
Picture 8: Example of a deteriorated electrical panel





Picture 9: Example of a damaged receptacle

6 Improper Wiring or Disconnection of Electrical Equipment

Connection of devices to the wrong voltage or the use of electrical equipment in a manner for which it is not approved can have unintended consequences, including stray voltage. It is recommended to purchase a non-contact proximity tester (Picture 11) and walk through your farm operation to test all metallic surfaces of electrical equipment and check if there is any voltage detected.



Picture 10: Example of a hazardous installation of an electrical timer

-  Missing bond connector
-  Green conductors used as current carrying conductor

A fault in the timer may result in the enclosure becoming energized resulting in hazardous conditions.



Picture 11: Example of a non-contact proximity tester

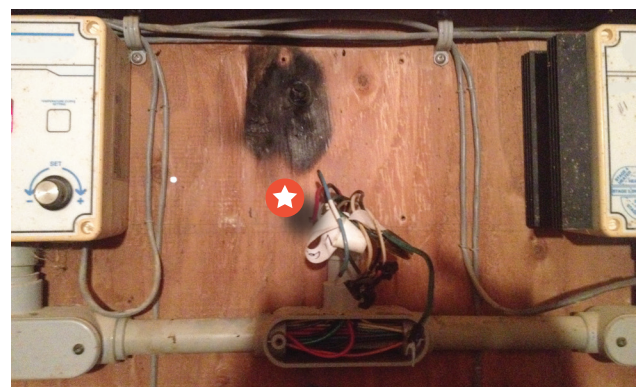


Picture 12: Example of an unapproved electrical installation of a light switch


A lamp cord has been used to feed a switch that is not located in an approved electrical enclosure. Touching exposed energized parts, such as the switch connections could be lethal. In addition to the improper wiring method that may be susceptible to damage, the switch is not supplied with a bonding conductor, so any fault or failure may cause current flow through unintended paths, serious shock or burn hazards to personnel and in some cases, electrical fires.

In addition to electric shock, improperly disconnected electrical equipment may leave exposed energized conductors that can result in stray voltage. It is important that disconnected conductors be capped off and enclosed in an approved electrical enclosure. See Picture 13.

It is recommended to remove all unused electrical wiring.



Picture 13: Example of exposed electrical conductors

-  Missing cover and exposed connectors

7 Flickering or Dimming Lights

There are a variety of causes for flickering or dimming lights. Flickering or dimming lights can often be a sign of the health of your farm's electrical system.

Flickering or dimming lights may be a result of:

- **Overloaded circuit or overloaded neutral conductor**

When too much equipment is used at the same time, the circuit or neutral may become overloaded, causing the circuit voltage levels to drop.

- **Undersized conductors**

When conductors are undersized due to a long run or the size of the load, the voltage levels of the circuit drop. This is often more obvious when heavier loads such as motors are located far from the supply of electricity. Motors typically draw increased current at start-up resulting in lowering the voltage for the farm's electrical system.

- **Damaged electrical equipment**

Damaged electrical equipment can result in a loose or open connection. A loose connection can cause lighting to flicker. (See Sections 3 & 4: Conductors & Poor Neutral Connections)



Picture 14: Example of receptacle damaged from corrosion and arcing

8 Variable Frequency Drives (VFDs)

VFDs have become an effective cost saving measure in farming operations; however, an improperly installed VFD may contribute to stray voltage symptoms. Where possible, the VFD should be located as close as practical to the motors being controlled. Incorrect wiring methods for VFDs may result in stray voltage symptoms. If shutting off the motors with VFDs reduces stray voltage symptoms there may be a problem with the installation. Often a shielded cable is specified by the VFD manufacturer to be installed to mitigate stray voltage.



Picture 15: Example of a VFD

9 Electric Fences, Cow Trainers or Crowd Gates (Energizers)

Improper installation or use of energizers for electric fences, cow trainers or crowd gates can cause stray voltage. If shutting off your energizer seems to reduce the animal behavioural response there may be an issue with the installation. The output of an energizer should be completely isolated from a building housing livestock by maximizing the separation of the energizers grounding from the buildings electrical wiring grounding. For an energizer, it is critical that there is adequate separation and isolation between the farm electrical service neutral/ground and the earth-return part of the energizer. Please see the Midwest Rural Energy Council guide “Installation and Operation of Electric Fences, Cow Trainers and Crowd Gates” for more information.



Picture 16: Example of an electrical fence energizer

The fencer is connected to an electrical panel contained in the wooden box rather than separated from the electrical system

10 Extension Cords

Extension cords should only be used on a temporary basis as they are not a substitute for permanent wiring. Extension cords are not permitted to be:

- Secured to any structural member;
- Run through holes in walls, ceilings, floors; or
- Run through doorways, windows, or similar openings.

Extension cords should be inspected and checked for damage before and after each use.

Buildings housing livestock contain extremely harsh environments and extension cords should be rated for such conditions. Extension cords should not be used as permanent wiring because even extra heavy duty extension cords are susceptible to mechanical or rodent damage and may deteriorate over time, resulting in exposed conductors that could create stray voltage and fire/shock hazards.

Improperly repaired cords could also become a source of stray voltage due to loose, open or reversed connections.

NOTE

An application for inspection from The Electrical Safety Authority (ESA) is required for repairs or modifications of electrical systems on farms. External contractors (Not employees of the farm) performing electrical work are required to be a Licensed Electrical Contractor (LEC) as per Ontario Regulation 570/05. ESA recommends using an LEC for all electrical installations.

On Farm Stray Voltage Contribution

Level 1 Checklist

The level 1 checklist is intended to provide the farmer with basic electrical items that can be visually inspected. A check mark placed in the YES column indicates a potential customer problem or contribution to stray voltage. ESA highly recommends the use of a Licensed Electrical Contractor for all work on electrical installations.

| | YES | NO | SECTION |
|--|-----|----|----------|
| ELECTRICAL PANELS – check all electrical panels for: | | | |
| Damaged ground and bond wires | | | 1 |
| Loose, cut or corroded ground/bond wires | | | 4 |
| Loose, cut or corroded neutral connections | | | 1 |
| Corrosion or water damage | | | 5 |
| Missing connectors /conductors exposed to sharp edges | | | 3 |
| WIRING | | | |
| Damaged insulated jacket, pinched wiring | | | 3 |
| Signs of overheating | | | 3 |
| Wires sitting in water | | | 3 |
| Wires not terminated in a junction box | | | 6 |
| Missing wire connectors | | | 3/4 |
| Wires wrapped around metal pipes | | | 3 |
| Bonding/grounding wires damaged or disconnected | | | 1/2 |
| DEVICES | | | |
| Receptacles/switches that are damaged/corroded | | | 5 |
| Signs of overheating, arcing | | | 5/7 |
| Light fixtures damaged, corroded | | | 5/7 |
| Lights that are flickering | | | 7 |
| EXTENSION CORDS | | | |
| Damaged, frayed | | | 3/10 |
| Improperly rated for the environment | | | 10 |
| Missing/broken ground pin | | | 1/10 |
| Signs of overheating | | | 3/10 |
| Sitting in water | | | 3/10 |
| Wrapped around metal pipes | | | 3/10 |
| Used as permanent wiring | | | 10 |
| ELECTRIC FENCE/COW TRAINER/CROWD GATES | | | 9 |
| Damaged, broken, missing insulators | | | |
| Electric fence or ground wire connected to water, milk lines or stanchions | | | |
| Ground connected to the farm's electric service ground wiring | | | |
| Inadequate spacing of the return of fence return electrode from the farm grounding | | | |
| Deteriorated fence wiring insulation | | | |
| TYPICAL PROBLEMS THAT MAY RESULT/INDICATE STRAY VOLTAGE | | | |
| Equipotential bonding not installed | | | 2 |
| Variable frequency drives (VFD) installed | | | 8 |
| Receiving electrical shocks from any equipment/wiring | | | 3/5 |
| Fuses/breakers frequently blowing/tripping | | | 7 |
| Shutting the power off resolves the issue | | | 5 |
| Electric portable heaters on bulk milk storage tank | | | 5 |