

DEPARTMENT OF LABOR AND ECONOMIC GROWTH

PUBLIC SERVICE COMMISSION

RULES AND REGULATIONS GOVERNING ANIMAL CONTACT CURRENT MITIGATION

(By authority conferred on the Public Service Commission by sections 1 and 7 of 1909 PA 106, sections 5 and 8 of 1919 PA 419, and sections 4 and 6 of 1939 PA 3, MCL 460.551, 460.557, 460.55, 460.58, 460.4, and 460.6)

R 460.2701 Definitions.

Rule 1. (1) As used in these rules:

(a) "Alternating current" (AC) means a current that flows in and through a conductive material, first in one direction and then in the opposite direction on a regular time interval.

(b) "Ampere" means a measure of the rate of flow of electric current through a conductive material. A milliamp (the unit of measure commonly used for stray voltage measurements) is 1/1,000 (0.001) of an ampere.

(c) "Animal" means vertebrates including, but not limited to, dairy and beef cattle, sheep, swine, poultry and horses.

(d) "Animal contact current" (AcC) means an AC electrical current that is measured, calculated, and may potentially flow through an animal due to an electrical contact voltage between 2 points simultaneously in contact with the animal at locations normally accessible by the animal.

(e) "Animal contact voltage" (AcV), commonly referred to as stray voltage, means the measured difference in an AC electrical potential when measured with a shunt resistor between 2 points that an animal can simultaneously contact in locations normally accessible by the animal.

(f) "Commission" means the Michigan public service commission.

(g) "Communication service provider" means a supplier of telecommunication or other electronic media services.

(h) "Cycle" means 1 complete positive and 1 complete negative alternation of current or voltage.

(i) "Direct current" (DC) means a current that flows in only 1 direction, in and through a conductive material.

(j) "Harmonics" means a repeating sine wave that fits within the main sine wave. The main sine wave is 60 cycles per second (60 Hz) and is called the fundamental frequency. Harmonic currents, which are multiples of the fundamental current, result in sine wave distortion. This distortion may be caused by electronic components in equipment, such as variable speed motor drives and computers.

(k) "Neutral-to-earth voltage" (NEV) means an AC electrical potential difference between a utility grounded neutral or complainant grounded neutral and the earth.

(l) "Ohm" means a measure of electrical resistance of a conductive material that limits the flow of electric current.

(m) "Ohm's Law" means the mathematical relationship between volts, amperes, and ohms. If any 2 of these quantities are known, then the third can be calculated. A formula for this relationship is:

Volts (pressure)

----- = Amperes (current flow)

Ohms (resistance)

(n) "Preventive action level" means a steady state animal contact current that meets or exceeds 2 milliamperes RMS using a nominal 500 ohms resistor at 60 Hz from all sources, including off-premises and on-premises sources.

(o) "Root mean square" (RMS) means a measure of the effective energy value of a wave or cycle. For regularly-shaped sine waves, the RMS value is 0.707 multiplied by the peak value of the sine wave.

(p) "Shunt resistor" means an electrical component resistor with a nominal resistance value of 500 ohms (which simulates the electrical resistance of an animal) placed in a circuit to measure animal contact voltage (AcV) and placed across the input terminals of the voltage

measurement device. Animal contact current (AcC) is calculated by dividing the measured shunted voltage at an animal contact location by the value of the shunt resistor.

(q) "Sine wave" means a smooth curve starting at zero and building up to a maximum before decreasing back to zero. The curve continues below the zero line, building to a negative maximum, returning to zero to complete 1 cycle. The smooth curve repeats. The voltage and current in an AC electrical circuit trace out the shape of a sine wave repeating 60 times each second, or 60 Hz.

(r) "60 hertz" or "60 Hz" means alternating current (AC) electricity that completes 60 cycles per second. The frequency is the number of cycles per second expressed as hertz (Hz). The utility industry in North America generates and distributes power at 60 Hz, or 60 cycles per second.

(s) "Steady state" means a 1 minute average of RMS voltage or amperage values.

(t) "Stray voltage," also referred to as AcV, means the measured difference in an AC electrical potential when measured with a shunt resistor between 2 points that an animal can simultaneously contact in locations normally accessible by the animal through step or touch both inside and outside of farm buildings.

(u) "Transient" means a rapid change in current that produces a deviation from a normal sine wave. It normally lasts for only a fraction of a cycle. If repeating, it usually does so for only a few cycles. It is generally caused by on- or off-site electrical circuit failures, switches opening and closing, and motors starting and stopping.

(v) "Utility" means an electric company, whether private, corporate, cooperative or municipal, that provides electricity to a consumer.

(w) "Volt" means a measure of electric pressure or energy level (voltage) between 2 points that can push electrons through a conductive material.

"Electrical Tech Note - 231"; Agriculture Engineering Department, Michigan State University; Figure 7, Page 6

Typical Harmonic Waveform

"The Handbook for Electric Metering -- ninth edition", Edison Electric Institute, EEI Publication No. - 06-92-01, Figure 4-10 Page 62

(2) These definitions are an application of the Institute of Electrical and Electronics Engineers (IEEE) 100, "The Authoritative Dictionary of IEEE Standards and Terms," 7th Edition. Printed copies of the dictionary are available from the Institute of Electrical and Electronics Engineers 445 Hoes Lane, Piscataway, New Jersey, 08854, at a cost of \$160 at the time of adoption of this rule. A printed copy of the dictionary is also available at the Michigan Public Service Commission, 6545 Mercantile Way, Lansing, Michigan, 48911.

History: 2007 AACS.

R 460.2702 Measuring animal contact voltage.

Rule 2. (1) A utility shall respond to a request for investigation and work with the complainant to conduct an initial investigation to determine stray voltage levels. If resolution is not met, the complainant may request further investigation as provided for in this rule.

(2) Upon conclusion of (1) and upon request of the complainant, a utility shall conduct an investigation of each complainant inquiry or complaint concerning animal contact current or voltage, commonly referred to as stray voltage. The following shall apply:

(a) The level of animal contact current shall be determined from measurements of animal contact voltage using Ohm's Law. The voltage measurement shall be made between 2 points, which an animal can simultaneously contact and under which animal contact voltage is most likely to occur. When measuring from the floor or earth, a single metallic plate with an area of 12 to 16 square inches shall be used to simulate the foot of the animal. One lead of the measuring instrument shall be connected to the plate, which shall be placed on the floor or earth where an animal may stand. The other lead of the measuring instrument shall be connected to a conductive object that an animal could reasonably contact while 1 of its feet is at the location of the plate. For all measurements of animal contact voltage a shunt

resistor shall be used to simulate the resistance of the animal. A suitable material, such as a medical grade electrode contact gel, shall be used to simulate real conditions and maintain conductivity to the floor or earth for the duration of the testing period.

(b) An approved method for determining the utility contribution to the animal contact current is contained in R 460.2707, Protocol to Evaluate Utility Contribution to Animal Contact Current.

History: 2007 AACS.

R 460.2703 Action required to mitigate animal contact current.

Rule 3. (1) If the steady state animal contact current from all sources as measured by the utility in accordance with this rule meets or exceeds the preventive action level, and if the utility contribution exceeds 1 milliampere RMS, then the utility shall commence action within 2 business days, or at a mutually agreed upon timeframe between the complainant and the utility, to reduce the utility contribution to 1 milliampere or less.

(2) If a utility is required to take action, then the utility shall make modifications or corrections to its facilities in accordance with the standards and codes approved by the commission.

(3) If the utility determines that some or all of the utility contribution is carried through a communication service provider's facilities, then the communication service provider shall eliminate the communication service system as a pathway for animal contact current from the utility's system within the time limit described in subrule (1) of this rule. For any disagreement between the utility and the communication service provider under this subrule, either party may seek a resolution from the commission.

History: 2007 AACS.

R 460.2704 Request for investigation.

Rule 4. (1) After completion of the procedures in R 460.2702 and R 460.2703, a complainant or the utility may request, with notification to the other party, that the commission appoint at least 3 and up to 5 experts to investigate in the manner in R 460.2705. If the commission appoints at least 3 and up to 5 experts, those experts shall have the rights and responsibilities as described in that rule and shall issue their investigation report and conclusions to the commission, the complainant, and the utility.

(2) The funding mechanisms in R 460.2705 shall be used to defray the costs of the experts as determined by the commission.

History: 2007 AACS.

R 460.2705 Appointment of experts.

Rule 5. (1) If a complainant or the utility requests an investigation through the commission under R 460.2704 of these rules, then the commission may appoint at least 3 and up to 5 experts to investigate the complaint and report findings to the commission within the scope of these rules. The commission shall consider expert individuals based on, but not limited to, all of the following criteria:

(a) Expertise specific to the specie affected.

(b) Objectivity - individuals not directly impacted by the resolution.

(c) Neutral third-party.

(d) Training and expertise in primary distribution systems and certification in secondary wiring systems.

(2) The experts shall limit their conclusions and reports to the subject of the dispute and the facts and circumstances of the specific case for which they were appointed.

(3) Either party may request specific disciplines be represented on the expert team.

(4) The experts shall submit a report to the commission with the results and conclusions of their inquiry, which may suggest corrective measures for resolving the complaint. The reports of the experts shall be received in evidence and the experts shall be made available for cross-examination by the

parties at any hearing. The experts shall report to the commission within 30 days of their employ. The commission may grant up to a 30-day extension.

(5) The reasonable expenses of experts, including a reasonable hourly fee or fee determined by the commission, shall be submitted to the commission for approval and, if approved, shall be funded under subrule (6) of this rule.

(6) The utility shall reimburse the experts appointed by the commission for the reasonable expenses incurred in the course of investigating the complaint.

History: 2007 AACs.

R 460.2706 Request for a contested case hearing.

Rule 6. (1) After completing the procedures described in R 460.2702 to R 460.2705, if a complainant of a utility claims to have animals that have experienced behavior or production problems due to animal contact current caused by a utility's distribution system, then the complainant may file a formal complaint and request a contested case hearing before the commission to resolve the dispute. In accordance with the rules and procedures for contested cases, the commission shall consider facts and evidence to determine the following:

(a) Whether the utility's supply of electricity or electrical service is causing animal contact voltage or current of sufficient magnitude and duration to result in behavior or production problems.

(b) Whether the utility has taken reasonable steps to avoid or mitigate any animal contact current.

(c) Whether the claims or defenses are supported by valid scientific research and prevailing scientific opinion.

(d) Other findings the Commission deems necessary and relevant.

(2) If a decision is favorable to the complainant, then the utility shall determine the manner and nature of any necessary modifications or corrections to its facilities, as approved by the commission.

(3) If a decision is favorable to the utility, then further action by the utility is not required.

History: 2007 AACs.

R 460.2707 Protocol to evaluate utility contribution to animal contact current

Rule 7. (1) The following shall be the protocol for testing animal contact current when the utility utilizes a grounded distribution system with a primary neutral conductor, except that a utility may submit an alternative protocol to the commission for approval to determine the utility contribution to animal contact current:

(a) Identify animal contact location to be tested.

(b) Measure and record the steady state animal contact voltage (AcV) at the animal contact location concurrently with the neutral-to-earth voltage at utility primary distribution system (NpEV) and at the animal building panel (NbEV) for a period of 72 hours during a mutually agreed upon time frame to determine the maximum probable level of animal contact current under normal operating conditions.

(c) Determine the highest level of animal contact voltage that occurred during the 72-hour monitoring, and the primary neutral-to-earth voltage at the utility transformer location that occurred at that same time.

(d) Turn off farm electrical load and apply a temporary electrical load at the utility transformer to produce the same level of neutral-to-earth voltage at the utility transformer as found in subdivision (c) of this subrule. Measure the animal contact voltage again.

(e) Using the animal contact voltage measured in subdivision (d) of this subrule, compare it to the animal contact voltage measured in subdivision (b) of this subrule to determine the utility contribution to animal contact current using Ohm's law.

(2) The following measurement and monitoring procedures shall be used:

(a) Conduct an evaluation of animal contact voltage (AcV) to determine the location that may result in the maximum probable current flow through the animal. This location shall be called the chosen animal contact location and shall be monitored for a period of 72 hours during a mutually agreed upon time frame. The following shall apply:

(i) Identify all probable animal contact locations where an animal is likely to simultaneously make contact with 2 points between which a voltage may be present. This includes locations of concern identified by the complainant.

(ii) Measure animal contact voltage (AcV) with a nominal 500-ohms shunt resistor (R shunt) placed across the input leads of the voltage measuring instrument.

(iii) Measurements to the floor or earth shall be made with a metal plate with an area of 12 to 16 square inches, and with a conductive material between the metal plate and the floor or earth.

(iv) Measuring instruments shall be capable of digitally recording necessary measurements to determine the steady state voltage. Measuring instruments shall be calibrated to factory specifications by a recognized and certified laboratory. The commission shall determine the acceptability of each measuring device. The data recorded shall become part of the report.

(b) Establish the locations from which to monitor neutral-to-earth voltage (NpEV and NbEV) measurements. The following procedures shall be followed:

(i) Establish an earth reference ground by installing a metal rod or pipe, with a diameter not less than ½ inch, in the earth to a depth of not less than 1 foot and located not less than 50 feet from any underground water pipes, utility lines, metal equipment making contact with the earth, or grounding electrodes of any electrical system.

(ii) Determine which farm electrical panel serves the equipment or general location of the animal contact location. This electrical panel shall be called the animal building panel. The neutral-to-earth voltage at the animal building panel (NbEV) shall be measured from the panel grounding terminal to the reference ground established in subdivision (b)(i) of this subrule. This measurement can be used to validate that the animal contact voltage (AcV) was not inadvertently disconnected or disturbed during the 72-hour monitoring period.

(iii) The neutral-to-earth voltage at the utility's primary distribution neutral conductor (NpEV) shall be measured from the utility's primary neutral grounding electrode conductor at the utility transformer serving the farm to the reference ground established in subdivision (b)(i) of this subrule.

(c) Simultaneously measure and record the 3 steady state voltages, AcV, NpEV and NbEV, for a period of 72 hours during a mutually agreed upon time frame. If more than 1 instrument is used, then the instrument clocks shall be synchronized. The following shall be used:

(i) The animal contact voltage (AcV) with a nominal 500-ohm shunt resistor (R shunt) placed across the input leads of the voltage measuring instrument.

(ii) The neutral-to-earth voltage at the animal building panel (NbEV).

(iii) The neutral-to-earth voltage of the utility primary distribution system neutral (NpEV) at the utility transformer serving the farm.

(3) Determine the utility contribution to animal contact current. This procedure may be conducted using non-recording digital voltage measuring instruments. All of the following apply:

(a) Examine the voltage recordings and locate the highest steady state value of animal contact voltage (AcV) which will be called the animal contact test voltage (AcVt).

(b) Determine the steady state value of utility primary distribution system neutral voltage (NpEV) that was present at the time the animal contact test voltage occurred. This will be called the primary neutral-to-earth test voltage (NpEVt).

(c) Install 1 voltage instrument to measure the voltage of the utility primary distribution system neutral to the reference ground (NpEV) and another voltage instrument to measure the animal contact voltage (AcV) with a nominal 500-ohm shunt resistor (R shunt) placed across the input leads of the voltage measuring instrument.

(d) Turn off all farm electrical loads while leaving the transformer energized and leaving the secondary neutral conductor connected to the farm electrical system. This can be accomplished by opening the main farm electrical disconnect and removing the electric meter, or by some other effective means.

(e) Add a temporary load to the transformer (that does not utilize the secondary neutral) until the primary neutral to reference ground test voltage (NpEVt) is achieved, and record the animal contact voltage that occurs. This measurement will be called the utility contribution to animal contact voltage (AcVu).

(f) If the primary neutral to reference test voltage (NpEVt) cannot be achieved as described in subrule 3(e) of this rule, then the utility contribution to the animal contact voltage (AcVu) will be determined by using the linear relationship between the primary neutral to reference voltage

(NpEV) and the animal contact voltage (AcV) with and without the temporary load applied to the transformer where the following apply:

(i) AcVo means the animal contact voltage measured with all farm electrical loads turned off as determined in (d) of this subrule.

(ii) AcVtemp means the animal contact test voltage as determined in subdivision (e) of this subrule at the level of temporary load applied.

(iii) NpEVo means the primary neutral-to-earth voltage with all farm electrical loads off as determined in (d) of this subrule.

(iv) NpEVt means the primary neutral-to-earth voltage as determined in subdivision (b) of this subrule.

(v) NpEVtemp means the primary neutral-to-earth voltage as determined in subdivision (e) at the level of temporary load applied.

(g) If paragraphs (i) to (v) of subdivision (f) of this rule apply, then the utility contribution to animal contact voltage (AcVu) shall be scaled by multiplying the change in animal contact voltage (AcV) resulting from the temporary load at the utility's transformer (AcVtemp - AcVo) by the ratio of (NpEVt - NpEVo) divided by (NpEVtemp - NpEVo). The resulting scaling in animal contact voltage shall be added to the animal contact voltage (AcVo) to determine the utility contribution to animal contact voltage (AcVu) as follows:

(i) $AcVu = \{[(NpEVt - NpEVo) / (NpEVtemp - NpEVo)] \times (AcVtemp - AcVo)\} + AcVo$.

(h) Animal contact current contributed by the utility system (AcCu) is determined by using Ohm's law. To determine the current contributed by the utility, divide the utility contribution to animal contact voltage (AcVu) by the value of shunt resistance or R shunt. The formula for determining AcCu is $AcCu \text{ amps} = AcVu \text{ volts} / R \text{ shunt ohms}$.

History: 2007 AACS.