

ARTICLE 20:10

PUBLIC UTILITIES COMMISSION

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CHAPTER 20:10:39

STRAY ELECTRICAL CURRENT AND VOLTAGE REMEDIATION RULES

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20:10:39:01. Definitions. Terms used in this chapter mean:

- (1) "Ampere," a unit of measure of electrical current;
- (2) "Cow contact current" or "Icc," the alternating current, 60 Hertz, root mean square, steady-state current measured through the shunt resistor;
- (3) "Cow contact voltage" or "Vcc," the alternating current, 60 Hertz, root mean square, steady-state voltage measured across the shunt resistor;
- (4) "Current," the flow or amount of electricity past any single point in a conductor or conductive element per unit of time;
- (5) "Ground," the point of lowest potential for an electrical system;
- (6) "Ishunt," the measurement of current across the shunt resistor;
- (7) "Milliampere" or "mA," one one-thousandth of an ampere;
- (8) "Ohm," the standard unit of electrical resistance;
- (9) "Open circuit voltage" or "Voc," the difference of electrical potential between two terminals when disconnected from any circuit;
- (10) "Primary neutral to reference voltage" or "Vp," the voltage that exists between the primary grounding conductor point of an electrical system's utility transformer and a remote reference electrode;
- (11) "Primary system," the high voltage utility electrical system, including the generation, transmission, and distribution systems. The term also refers to the high voltage side of a

distribution transformer;

(12) "Remote reference electrode," a temporary point of measurement established by correct installation of a ground rod;

(13) "Resistance," an electrical quantity that quantifies the ability of a physical material to conduct or not conduct electricity;

(14) "Root mean square," a mathematical conversion used to equate alternating and direct currents and voltages on similar terms;

(15) "Secondary neutral to reference voltage" or " V_s ," the voltage that exists between the secondary grounding electrode or grounding conductor point of an electrical system's service entrance panel and a remote reference electrode;

(16) "Secondary system," the part of the electrical system on the customer's side of both the meter and transformer;

(17) "Service provider," any person, company, or other legal entity providing stray current or voltage testing, consulting, measurements, analysis services, construction, or hardware;

(18) "Shunt resistor" or "Rshunt," a physical resistor or combination of resistors used to simulate a dairy cow during the measurement of cow contact voltage or cow contact current. A shunt resistor must be 500 Ohms, plus or minus two percent;

(19) "Source resistance" or " R_{source} ," the portion of resistance in the circuit, other than the resistance of the shunt resistor;

(20) "Transient deviation," a non-steady-state increase or spike in voltage or current. For the purpose of identifying and reporting transient deviations in cow contact voltage or cow contact current, a transient deviation occurs when the recorded maximum V_{cc} or I_{cc} in a recording interval exceeds 200 percent of the steady-state V_{cc} or I_{cc} recorded during the same recording interval;

(21) "Voltage," the electrical quantity that describes the push or potential that electrical energy needs to flow in a circuit;

(22) "Voltage drop," the difference in voltages when a current passes through a resistance or impedance in a closed loop circuit and a voltage drop is produced across that resistance or impedance; and

(23) "Vshunt," the measurement of voltage across the shunt resistor.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:02. Purpose of rules – Conformance to electrical codes. This chapter standardizes the measurement and testing procedures used to measure stray current or voltage in dairies. This chapter does not replace existing safety standards embodied in electrical codes. Under this chapter, testing is intended to determine:

- (1) The presence and amount of any stray current or stray voltage within the dairy;
- (2) The sources of any stray current or voltage detected; and
- (3) The percent of contribution from the utility side and the dairy side of the dairy service entrance to the total stray voltage or stray current measured on the dairy.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:03. Measurement and testing by utility. A utility measuring or testing for stray current or stray voltage at the request of a dairy producer, as directed by the commission, or on its own initiative, shall conduct the measurements in accordance with this chapter.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:04. Notice to utility. A dairy producer, who believes the producer's cattle are being affected by

stray electricity, shall provide notice to the utility regardless of whether the dairy producer conducted tests or measurements of stray current or stray voltage.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:05. Cooperation between the dairy and utility. When a written notice is filed with the utility, the dairy producer shall make any contact points, service panels, ground rods, or other electrical equipment at the dairy available to the utility for measuring and testing. The utility shall provide reasonable notice and cooperate with the dairy producer to establish an appropriate time to conduct the tests and measurements. The dairy shall cooperate with the utility so that all tests and measurements necessary to identify the existence and magnitude of stray current or voltage, if any, are completed within 14 business days of the utility's receipt of the notice.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:06. Service provider. A service provider shall follow the rules in this chapter.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:07. Qualified testing professional. Measuring and testing for stray current or stray voltage shall be performed by a qualified testing professional. The following persons are presumed to be qualified testing professionals:

- (1) A professional engineer, licensed in any state, who has completed no fewer than 48 hours of commission-approved stray voltage training and who has been involved in no fewer than 5 prior investigations involving the measurement or testing of stray current or

stray voltage;

(2) An electrician holding an electrical contractor's license, master electrician's license, or equivalent, in any state, who has completed no fewer than 48 hours of commission-approved stray current or stray voltage training and who has been involved in no fewer than 5 prior investigations involving the measurement or testing of stray current or stray voltage; or

(3) A technician who, under the supervision of a person presumed qualified under subdivision 20:10:39:07 (1) or (2), who has completed no fewer than 8 hours of commission-approved stray current or stray voltage training and has been involved in no fewer than 5 prior investigations involving the measurement or testing of stray current or stray voltage.

The commission shall establish and update a list of commission-approved stray current and stray voltage training programs.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:08. Qualified testing analyst. Analysis of data under this chapter shall be performed by a qualified testing analyst. A qualified testing analyst is a professional engineer, licensed in any state, who has completed no fewer than 48 hours of stray current or stray voltage training, and who has been involved in no fewer than 5 prior investigations involving measurement or testing of stray current or stray voltage.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:09. Additional qualified testing professional or analyst. A person who does not satisfy the qualifications in § 20:10:39:07 or 20:10:39:08 may be determined by the commission to be a qualified

testing professional or a qualified testing analyst if, on a motion of any party, the commission finds the person possesses the knowledge, skill, experience, training, or education that qualifies that person to offer expert testimony before the commission.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:10. General requirements for stray voltage measuring and recording. Equipment used for the measurement or testing of stray voltage, stray current, and resistance shall meet the following criteria:

- (1) The accuracy and resolution of any instrument used to measure or record cow contact voltage or cow contact current shall limit the error to five percent or less at one volt or two milliamperes;
- (2) Instruments used to measure cow contact voltage must be capable of separating and independently measuring alternating current and direct current voltages. These instruments must have a minimum internal impedance of 10,000 ohms and must be capable of measuring the true-root mean square voltage;
- (3) A clamp-on ammeter, a digital multi-meter with clamp-on device, or an in-line ammeter must be capable of separating and independently measuring alternating current and direct current and capable of measuring the true-root mean square current. A clamp-on ammeter must have the resolution and accuracy required in subdivision (1);
- (4) Resistance is measured using either a volt ohmmeter or a digital multi-meter. Resolution must be to the level of 1 ohm or less when measuring a resistance of less than 1,000 ohms. Accuracy must be within plus or minus 5 ohms for a 500 ohm resistance; and
- (5) Grounding electrode resistance-to-earth measurements are made with a three-point fall-of-potential instrument or a clamp-on resistance-to-earth tester.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:11. Calibration of measuring equipment. All measuring equipment shall be calibrated according to the manufacturer's recommended calibration schedule, but no less than annually. Measuring equipment may not be used after its next calibration due date has passed. Calibration shall be performed by:

- (1) The manufacturer of the equipment, who shall certify that the equipment meets the manufacturer's specifications for accuracy and resolution; or
- (2) A calibration laboratory currently certified as meeting the standards of the Institute of Electrical and Electronic Engineers and the International Organization for Standards.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:12. Calibration certificates. The service provider performing the tests and measurements shall maintain certificates from the manufacturer or the calibration laboratory that demonstrate compliance with the calibration requirements.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:13. Field check of measuring equipment. Before voltage or current measurement or testing is performed, the instrument shall be field-checked by the service provider. A field-check is done by comparing the measurements of the instrument to the measurements of another instrument or against a known source.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:14. Requirements for monitoring systems and recording devices. A digital recording device is used to record current and voltage for extended periods of time. A digital recording device must have the same level of resolution and accuracy as specified in § 20:10:39:10. Digital recording devices with deviation settings must permit the deviation setting to be set low enough to meet the resolution and accuracy requirements in subdivision 20:10:39:10(1).

Monitoring systems combine measuring and recording functions in a single instrument. Monitoring systems shall have the same level of resolution and accuracy as specified in § 20:10:39:10.

Recording devices and monitoring systems shall be capable of recording transient deviations of one-tenth of a second or less in duration from the steady-state. Any recording device must be able to log the time and date of all data recorded and have its internal clocks synchronized.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:15. Requirements for load boxes. A load box is a primarily non-inductive nominal 240 volt, resistance heating type load with a minimum nominal full load of 18 kilowatts. A load box must be capable of operating at 2 or more load settings, including approximately 50 percent and 100 percent of the load box's rated total load.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:16. Stray current or voltage test. Six tests are used to detect and measure stray current or stray voltage:

(1) the cow contact test;

(2) the 48 hour test;

- (3) the primary profile test;
- (4) the secondary neutral voltage drop test;
- (5) the load box test; and
- (6) the signature test.

Efforts shall be made by the service provider to perform the tests under conditions substantially similar to the conditions existing at the times the dairy producer believes stray current or stray voltage affected the cattle.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:17. Testing sequence. The cow contact test and the 48 hour test shall be performed in all investigations, subject to the provisions of § 20:10:39:21. The cow contact test shall be performed first. The primary profile test, the secondary neutral voltage drop test, the load box test, and the signature test may be performed in any order and may be performed without first determining if the tests are required under § 20:10:39:19. The primary profile test, the secondary neutral voltage drop test, the load box test, and the signature test may be performed before the start of recording for the 48 hour test or while the 48 hour test is in progress. The 48 hour test may be interrupted to conduct the secondary neutral voltage drop test, the load box test, and the signature test, or to review and analyze the data recorded.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:18. Preventive action level not exceeded. If the results of the cow contact test and the 48 hour test indicate that stray current or stray voltage does not exceed the preventive action level as defined in SDCL 49-47-1(5), the utility has no further obligations under these rules during the test cycle.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:19. Preventive action level exceeded. If stray current or stray voltage exceeds the preventive action level after completion of the 48 hour test, the utility shall perform the four remaining tests, unless testing is suspended or limited pursuant to § 20:10:39:21. The utility shall also perform an analysis to determine if a portion of the stray current or stray voltage attributable to an off-farm source exceeds 50 percent of the preventive action level.

If the preventive action level is exceeded and the portion of the stray current or stray voltage attributable to an off-farm source does not exceed 50 percent of the preventive action level, the utility has no further obligations under these rules during the test cycle.

If the preventive action level is exceeded, and the portion of the stray current or stray voltage attributable to an off-farm source exceeds 50 percent of the preventive action level, the utility shall conduct remediation pursuant to SDCL 49-47-3.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:20. Report prepared by qualified analyst. The utility shall have a qualified testing analyst prepare a report, pursuant to § 20:10:39:59, for all testing conducted under this chapter.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:21. Suspended or limited testing. With a written agreement between the utility and the dairy producer, a stray current or stray voltage investigation may be suspended at any point in the investigation. With a written agreement between the utility and the dairy producer, the utility may employ a limited set of tests or measurements on a dairy as part of an intentionally limited evaluation. If

the utility proposes to suspend a stray current or stray voltage investigation or to conduct a limited evaluation, the reasons for doing so must be set forth in the written agreement between the utility and the dairy producer.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:22. Use of remote reference electrodes. In preparation for testing, a remote reference electrode must be installed and penetrate the soil to a depth of approximately 30 inches. When practicable, the remote reference electrode shall be installed at least 25 feet away from the nearest underground conductive electrical equipment, of any type, or at a distance equal to three to four times the buried depth of any metallic structure connected to the service entrance neutral. When practicable, the remote reference electrode must be located no closer than 25 feet from the centerline of a primary electrical conductor right-of-way and no closer than 100 feet from the edge of a transmission line right-of-way.

The remote reference electrode shall be checked for remoteness before being used for tests or measurements, and, if found to be insufficiently remote, a new location for the remote reference electrode shall be found and retested for remoteness. Remoteness of the remote reference electrode is determined by measuring the voltage from the transformer grounding electrode to the remote reference electrode. The ground electrode resistance and current at the transformer are also measured.

Remoteness is adequate if the measured voltage between the transformer grounding electrode and the remote reference electrode is within 20 percent of the voltage calculated by multiplying the transformer grounding electrode current by the transformer grounding electrode resistance.

If the transformer grounding electrode is within 25 feet of other primary or secondary grounding electrodes, the remoteness test shall be conducted at the first primary system grounding electrode upstream of the transformer that is greater than 25 feet from other primary or secondary system grounding

electrodes.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:23. Inspection, repair, and measurement requirements. Before testing, the utility shall inspect the utility transformer, measure grounding electrode resistance, and make and record any repairs necessary for safety. In the case of a customer-owned transformer, qualified personnel shall inspect the installation, measure grounding electrode resistance, and make and record any repairs necessary for safety. Measurements that require contact with utility or customer-owned primary wires or equipment shall be made by the utility or other qualified personnel.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:24. Use of ammeters. In-line or series ammeters shall be installed under safe conditions in accordance with the National Electrical Safety Code and the National Electrical Code with the entire dairy system or the specific circuit to be tested de-energized.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:25. Pre-test documentation. All pre-test calibration requirements required by §§ 20:10:39:11, 20:10:39:12, and 20:10:39:13 shall be completed and documented. A drawing of the dairy shall be prepared by the qualified testing professional indicating:

- (1) The location of the buildings;
- (2) Secondary electrical service panels and secondary feeder systems serving cow contact areas;

- (3) Transformers and central distribution point;
- (4) Existing grounding electrodes, if known;
- (5) The location of all cow contact points to be tested;
- (6) All remote reference electrodes; and
- (7) All primary and secondary neutral test points used in conjunction with the remote reference electrodes.

A list of planned test points shall be prepared by the qualified testing professional using the applicable form before beginning each test. Each test point shall be listed separately and a specific reference number is given to each planned test point.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:26. Suspension of testing due to presence of a safety hazard. If the service provider reasonably concludes that a dairy's noncompliance with the National Electrical Code or the National Electrical Safety Code poses a significant and immediate safety hazard that prevents completion of any test or measurement required by this chapter, the utility's obligation to proceed under this chapter is suspended until the hazard is eliminated.

At the discretion of the service provider conducting the test, livestock shall be removed from any area where electrical equipment or wiring is examined or electrical measurements are taken. Testing may be suspended if the presence of cows or other animals creates a potential hazard to the qualified testing professional. The locations of electric fences and other electrified cow control devices shall be noted in the drawing of the dairy and the report and de-energized, where practical.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:27. The cow contact test. The cow contact test determines the locations, if any, where stray current or stray voltage exceeds the preventive action level and identifies the locations where the cow contact voltage will be recorded in the 48 hour test.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:28. Conducting the cow contact test. The selection of cow contact points to be tested shall include a number of locations reasonably likely to demonstrate the presence of stray current or stray voltage, if any. The voltage across the shunt resistor or current through the shunt resistor is measured between cow contact points. The source resistance is calculated during analysis for all cow contact points.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:29. Use of a voltmeter to conduct the cow contact test. When using a voltmeter to measure voltage between contact points where one of those points is the floor surface or earth, a metal plate must make a high-quality conductive contact with the floor surface or earth, using the procedures described in § 20:10:39:31.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:30. Use of a milliammeter to conduct the cow contact test. When using an in-line milliammeter or a clamp-around milliammeter to measure current between contact points and one of those points is the floor surface or earth, a metal plate must make a high-quality conductive contact with the floor surface or earth, using the procedures described in § 20:10:39:31.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:31. Metal plate requirements. A metal plate used to make an electrical contact with the floor surface or earth must be square, rectangular, or round, and have a surface area equal to or greater than 16 square inches. A weight of not less than 20 pounds shall be placed on the metal plate and applied evenly across the metal plate and not to the adjacent floor surface or earth. The metal plate shall be placed a distance of not less than 12 inches from any metal equipment making contact with the floor surface or earth. The surface of the metal plate must be clean and free of corrosion before use.

When the metal plate is placed on a floor surface, the surface must be flat. The floor surface shall be cleaned with a wire brush to remove debris and then cleaned with water. A paper towel, or similar material, soaked in saltwater shall be placed between the metal plate and the floor surface.

When the metal plate is placed on the earth, the surface must be flat. Any debris shall be removed and water added to the area, if necessary, to dampen the soil.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:32. Recording the cow contact test data. The qualified testing professional conducting the cow contact test shall record the location of each test point and the values measured at each test point. At each cow contact location, an open circuit voltage reading and a voltage reading with the shunt resistor placed across the input to the meter are taken. The readings are taken with not more than ten seconds between each reading. A current measurement may be taken in place of the voltage measurement. Data for these test points are recorded on the cow contact test form on file with the commission.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:33. Source resistance calculation. The source resistance is calculated for each cow contact location measured and the value recorded on the cow contact test form on file with the commission. The following formulas are used to calculate source resistance:

(1) $R_{\text{source}} = R_{\text{shunt}} \times ((V_{\text{oc}} - V_{\text{shunt}}) / V_{\text{shunt}})$; and

(2) $R_{\text{source}} = V_{\text{oc}} / I_{\text{shunt}} - R_{\text{shunt}}$.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:34. The 48 hour test. The 48 hour test determines if stray current or stray voltage exceeds the preventive action level at selected locations over a 48 hour period. The 48 hour test demonstrates whether the primary or secondary sides of the system have a specific impact on the recorded current or voltage at a specific time of day. The results of the 48 hour test may be highly indicative of the presence of stray current or stray voltage.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:35. Data collection for the 48 hour test. A digitizing data recorder, with averaging capability and capable of detecting and recording transient deviations of one-tenth of a second or less in duration, is used to record the following:

- (1) Voltage from primary neutral at the transformer to the remote reference electrode;
- (2) Voltage from secondary neutral in the service panel serving the area of the cow contact point to the remote reference electrode;
- (3) Voltage from primary neutral at the transformer to secondary neutral at the service panel serving the area of cow contact; and

- (4) Cow contact current through or voltage across a shunt resistor at each high voltage point found in the cow contact test.

A recording interval of not more than ten seconds may be used if the transient deviations of voltage or current are one-tenth of a second or less in duration and are recorded to the maximum ability of the instrument.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:36. Measurement requirements for the 48 hour test. When conducting the 48 hour test, measurements to the earth or concrete surface must be to a metal plate, using the procedures described in § 20:10:32:31. When making measurements to metal objects, corrosion shall be removed to obtain a low resistance connection.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:37. Recording the 48 hour test data. All of the data gathered by the recording equipment during the 48 hour test, including transient deviations, shall be downloaded and retained with the records of the investigation. The steady-state data shall be summarized in the investigation report. The recorded data shall be made available to the dairy producer or utility upon request. The qualified testing professional conducting the test shall record the location of each test point and the values measured at each test point. The identification of the cow contact point and transient deviations shall be recorded on the 48 hour test forms on file with the commission. A plot of the voltage versus time may be substituted for the recording of measured values.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:38. Reduced recording period for the 48 hour test. If a qualified analyst concludes that remediation by the utility is required because the preventive action level is exceeded and the portion of the stray current or stray voltage attributable to an off-farm source exceeds 50 percent of the preventive action level, the recording period may be reduced but to no fewer than 24 hours.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:39. The primary profile test. The primary profile test measures or calculates neutral-to-earth voltage for a multi-grounded distribution system.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:40. Data collection for the primary profile test. The primary profile test requires concurrent measurement of the ground electrode resistance and current at all primary system ground points within three quarters of a mile on either side of all primary service points serving the dairy, or to the end of the line if less than three quarters of a mile. Alternatively, the voltage between a remote reference electrode and the primary ground point being tested may be measured.

The primary profile test is conducted starting at one end of the distribution system and working toward the other along the main primary distribution system.

If the dairy is served by a dedicated tap of less than one-half mile in length from a distribution line, the neutral-to-earth voltage is measured at each primary ground along the tap and along the distribution line to a distance of three quarters of a mile in each direction from the point of the tap. If the dairy is served by a dedicated tap that extends more than one-half mile from the distribution line, the neutral-to-earth voltage is measured at each primary grounding electrode along the tap and

along the distribution line to a distance of one-half mile in each direction from the point of the tap.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:41. Recording the primary profile test data. The qualified testing professional conducting the primary profile test shall record the location of each test point and the values measured at each test point. Data and calculation results for each test point shall be recorded on the primary profile test form on file with the commission.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:42. The secondary neutral voltage drop test. The secondary neutral voltage drop test determines the impact of each secondary service on the neutral-to-earth and cow contact voltages on the dairy under controlled conditions.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:43. Conducting the secondary neutral voltage drop test. The secondary neutral voltage drop test is performed for all service entrances. A proxy load of known characteristics is required for the secondary neutral voltage drop test. The proxy load must create a known and stable current and subsequent voltage drop for each neutral serving a main panel, sub-panel, or end-of-service area. Service entrances not being tested shall be turned off.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:44. Data collection for the secondary neutral voltage drop test. The following data shall be collected for each secondary neutral tested:

- (1) Gauge and type of neutral wire;
- (2) Length of neutral wire;
- (3) Neutral current;
- (4) Voltage drop between both ends of the secondary neutral being tested;
- (5) Cow contact voltage or cow contact current at the same points used in the 48 hour test;
- (6) Voltage from the primary neutral at the transformer to remote reference electrode; and
- (7) Voltage from secondary neutral in the service panel serving the area of the cow contact point to the remote reference electrode.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:45. Measurements used for the secondary neutral voltage drop test. For the secondary neutral voltage drop test, the three voltages, the cow contact voltage, the primary neutral to reference voltage, and the secondary neutral to reference voltage, are measured with the proxy load off and then on. Calculated expected voltage drops are compared with measured voltage drops. If the measured and calculated voltage drops differ significantly, further investigation shall be undertaken to determine the source of additional voltage drop within the circuit. Neutral current shall be measured and recorded with the proxy load on.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:46. Recording the secondary neutral voltage drop test data. The qualified testing

professional conducting the secondary neutral voltage drop test shall record the location of each test point and the values measured at each test point. Data and calculation results for each test point shall be recorded on the secondary neutral voltage drop test form on file with the commission.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:47. The load box test. The load box test determines the extent to which the primary system contributes to stray current or stray voltage at cow contact points.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:48. Timing of the load box test. The load box test shall be performed at the same time of day as the time of the highest cow contact voltage found in the 48 hour test.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:49. Conducting the load box test. Except for dairies with three-phase balanced primary service, each of the following five steps for the load box test is conducted for at least two minutes:

- (1) The load box is de-energized, the dairy remains on, and the data is recorded;
- (2) The load box is de-energized, the dairy is shut off, and the data is recorded;
- (3) The load box is set to half load, the dairy is shut off, and the data is recorded;
- (4) The load box is set to full load, the dairy is shut off, and the data is recorded; and
- (5) The load box is set to full load, the dairy is turned on, and the data is recorded.

For dairies with three-phase balanced primary service, the qualified testing professional only performs steps one and two.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:50. Data collection for the load box test. The load box test requires the recording of eight data points during each of the five test steps. The eight data points that are measured or calculated and recorded for each step are:

- (1) Primary line to neutral voltage;
- (2) Load box current;
- (3) Voltage at load box connection to secondary system;
- (4) Transformer current as calculated by multiplying load box current by voltage at load box and dividing by primary line to neutral voltage;
- (5) Voltage from primary neutral at the transformer to remote reference electrode;
- (6) Voltage from secondary neutral in the service panel serving the area of the cow contact to remote reference electrode;
- (7) Voltage from primary neutral at the transformer to secondary neutral at the service panel serving the area of cow contact; and
- (8) Cow contact voltage or cow contact current at the same points used in the 48 hour test.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:51. Calculating the K factor for the load box test. The K factor is a calculated ratio of cow contact voltage divided by secondary neutral to reference voltage. The K factor should be less than one. If the K factor is greater than one then there is contribution to cow contact voltage from a source other than secondary neutral to reference voltage.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:52. Recording the load box test data. The qualified testing professional conducting the load box test shall record the location of each test point and the values measured at each test point. Data and calculation results for each test point shall be recorded on the load box test form on file with the commission.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:53. The signature test. The signature test determines the contribution to stray current or stray voltage of individual pieces of equipment operating on the dairy. The test is best performed when there is minimal farm electrical activity.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:54. Data collection for the signature test. During the signature test, individual pieces of major current drawing equipment shall be started and stopped. The effects of starting, operating, and stopping each piece of equipment are measured and recorded for a period of operation of not less than 15 seconds. The qualified testing professional conducting the test shall identify and record the equipment being tested and record the specific times the equipment was started and stopped. A digitizing data recorder with averaging capability shall be used to measure and record the required electrical data. The measurements shall be taken at the same locations at the dairy where the measurements were taken for the load box test and the 48 hour test. The following measurements shall be taken:

- (1) Voltage from primary neutral at the transformer to remote reference electrode;
- (2) Voltage from secondary neutral in the service panel serving the area of the cow contact

point to remote reference electrode;

(3) Voltage from primary neutral at the transformer to secondary neutral at the service panel serving the area of cow contact; and

(4) Cow contact voltage or cow contact current at the preselected point.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:55. Recording the signature test data. All of the data gathered by the recording equipment during the signature test, including transient deviations, shall be downloaded and retained with the records of the investigation. The steady-state data is summarized in the investigation report. The recorded data shall be made available to the dairy producer or utility upon request. The location of each test point shall be recorded on the signature test form on file with the commission. A plot of the voltage versus time may be substituted for the recording of measured values.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:56. Analysis of the data collected during the tests. The qualified testing analyst examines the data recorded for the 48 hour test and shall determine the highest steady-state value of cow contact voltage or cow contact current. The qualified testing analyst shall determine the value of primary neutral to reference voltage that was present for the highest cow contact value. These values are identified as cow contact voltage or cow contact current and primary neutral to reference voltage at the time of maximum cow contact voltage or cow contact current. These values are recorded as $V_{cc48\text{ hr}}$, $I_{cc48\text{ hr}}$, or $V_{p48\text{ hr}}$. The three data sets created from the values are:

(1) The primary to reference ground voltage and the cow contact voltage or cow contact current measured during the load box test with the farm power off and the load box off

shall be recorded as Vp OFF and either Vcc OFF or Icc OFF;

- (2) The primary to reference ground voltage and the cow contact voltage or cow contact current measured with the load box set at one-half load shall be recorded as Vp HALFLoad and either VccHALF LOAD or IccHALFLoad; and
- (3) The primary to reference ground voltage and the cow contact voltage or cow contact current measured with the load box at maximum shall be recorded as Vp FULLLOAD and either VccFULLLOAD or IccFULLLOAD.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:57. Determination of any contributions to stray current or voltage for single phase dairies.

The utility contribution to cow contact voltage or cow contact current is determined by the following formulas:

- (1) Utility contribution to cow contact voltage = $((V_{p48} - V_{p\ Half}) / (V_{p\ Full} - V_{p\ Half})) \times (V_{cc\ Full} - V_{cc\ Half}) + V_{cc\ HALF}$; or
- (2) Utility contribution to cow contact current = $((V_{p48} - V_{p\ HALF}) / (V_{p\ FULL} - V_{p\ HALF})) \times (I_{cc\ FULL} - I_{cc\ Half}) + I_{cc\ HALF}$.

The values determined are compared to the preventive action level.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:58. Determination of any contributions to stray current or voltage for three-phase dairies.

The utility contribution to cow contact voltage or cow contact current for dairies with three-phase balanced load service is determined by directly using the results of the load box test results for steps one and two, as specified in § 20:10:39:49.

The cow contact voltage measured during step one of the load box test shall be the total cow contact voltage. The cow contact voltage measured during step two of the load box test is the contribution to cow contact voltage from the utility, or $V_{ccutility}$. The contribution to cow contact voltage by the dairy is the difference between cow contact voltage and cow contact voltage from the utility. The formula is: $V_{ccdairy} = V_{cc} - V_{ccutility}$.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:59. Written report required – Copy to the dairy producer. Within 30 days after completion of any tests required to be performed by the utility under this chapter, a qualified testing analyst shall prepare a written report and provide a copy to the dairy producer. The report shall include a summary of the tests performed, a copy of the drawing of the dairy prepared pursuant to § 20:10:39:25, all of the data or results obtained from the tests, and an analysis of the data or results obtained from the tests. If remediation is required by SDCL 49-47-3, the report shall specify the actions taken or to be taken.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.

20:10:39:60. Remediation. If the utility is required to conduct remediation, the utility shall commence remediation in accordance with SDCL 49-47-3. Remediation efforts may include addressing other off-dairy sources. If a utility's contribution to stray voltage exceeds 50 percent of the preventive action level and the utility determines that another customer is a significant contributing source of stray voltage, the utility shall notify both the dairy producer and the other customer in writing.

Source:

General Authority: SDCL 49-47-2.

Law Implemented: SDCL 49-47-2, 49-47-3.