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Electrical Systems for Agricultural Buildings (Recommended Practices)

This NebGuide describes some of the specialized wiring practices and equipment required in agricultural buildings.

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During June 1982, electrical system failures resulted in animal losses in excess of \$100,000 on three Nebraska swine farms. In 1983, more than \$45,000 worth of feeder pigs were electrocuted on another Nebraska farm. Dairy and beef animals also have been electrocuted--as have producers. A survey of more than 400 Nebraska farms revealed that over 50 percent have problems due to poor on-farm wiring. A more recent survey of 14 farms revealed none with 100 percent properly wired buildings. Many had conditions which were serious threats to safety.

Nebraska insurance companies report that about 70 percent of all on-farm fires involve the electrical system. Losses have been so extreme that some insurance companies will not write insurance on a building not wired to the *National Electrical Code* (NEC) minimum standards.

The NEC is part of Nebraska State law. All wiring legally must meet NEC minimum requirements--even if it's not inspected.

Agricultural buildings--especially those used to house livestock--require special care in selecting wiring materials, wiring methods and electrical equipment because of corrosive dust, gases and moisture. These special requirements apply to adjoining areas such as feed and utility spaces as well.

As part of your planning, confer with your power supplier's agricultural or customer service representative. They can help assure proper planning of all components of the electrical system. Advance knowledge of your plans also allows your power supplier to schedule other necessary changes, such as installing a larger transformer, to meet your expanded needs.

A companion NebGuide, *Electrical Systems for Agricultural Buildings (Checklist)*, G87-846, is an aid in evaluating your electrical system. Item numbers are keyed between the two NebGuides for easy

reference.

1. **National Electrical Code** — The NEC establishes *minimum* standards required to assure safety and reduce risk of electrical system failure. Wiring materials and devices should bear the label of a recognized testing agency such as the Underwriters Laboratories (UL), Electrical Testing Laboratories (ETL) or Factory Mutual (FM). (NOTE: These are the only testing agencies currently recognized by the Nebraska State Electrical Board.) Installation in accordance with the NEC means all 115 Vac (volts, alternating current) electrical appliances require both a ground (safety) and grounded (neutral) conductor. Grounds and neutrals must be kept electrically separate everywhere except in the main service panel. All equipment must be double insulated or wired with a grounding (safety) conductor regardless of operating voltage. Conduit may not be used as the only grounding conductor in agricultural buildings.



Figure 1. Use of UL listed equipment and installation in accordance with the National Electrical Code helps assure safety and a long service life.

2. **Electrician** — Use of a licensed electrician is recommended. Licensed electricians are more likely to be familiar with requirements of the NEC and accepted good practices.
3. **Inspection** — No matter who installs an electrical system, the possibility of an error or oversight always exists. In Nebraska, representatives of the State Electrical Division (State Electrical Board, 800 South 13th Street, Suite 109, P.O. Box 95066, Lincoln, NE 68509-5066, Phone 402/471-3550) are located around the state and are available to conduct on-farm inspections for a nominal fee. Inspection of agricultural installations is not mandatory under Nebraska law. However, inspection is required by some power suppliers. Under present law, the inspectors can only serve as advisors but their training and experience are valuable in identifying possible problem areas. Use of the services of an electrical inspector is strongly recommended.
4. **Electrical Service** — Each building should have only one electrical service. The service entrance panel must have a main service disconnect and should be surface mounted on a fire-resistant surface in a clean, dry room. If the panel must be located in an adverse environment, use a dusttight, watertight, corrosion-resistant enclosure. If the panel is mounted on the outside of the building, all openings between the enclosure and building (including conduit) must be sealed with electrician's putty. Do not use silicone caulk or foam-in-place insulation products.

Panels mounted in a building must have at least a 1/4 inch air space between the mounting surface and enclosure. Never recess panels into exterior walls as condensation causes accelerated corrosion. Locate all panels with at least 3 feet of clear open space in front and so the door can be opened a full 90°. The space in front of an electrical panel should not be used for storage. Easy access is required for servicing and in case of an emergency.

5. **Grounding** — All service entrances must be provided with a grounding electrode (ground rod, minimum 8 feet) and a properly sized (based on service capacity, NEC Table 250-94) grounding

electrode conductor properly clamped to the electrode. This conductor and grounding electrode must be installed and protected to minimize the risk of physical damage. The resistance from the grounding electrode to the surrounding soil must be 25 ohms or less. Where multiple ground rods are used to reduce resistance to ground, separate the rods at least twice the length of the ground rods and interconnect with a No. 6 copper conductor and clamps approved for burial.

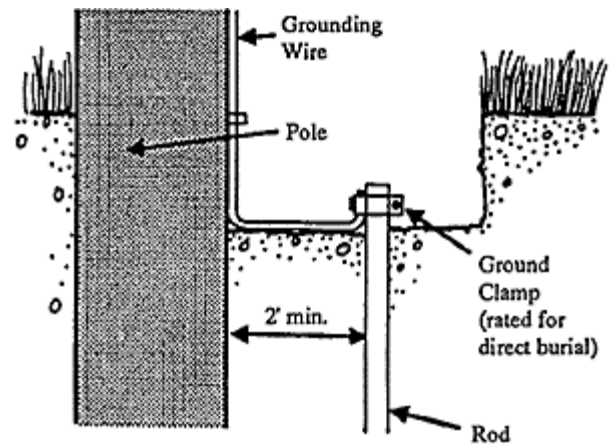


Figure 2. Install ground rods and grounding electrode conductors to minimize the risk of damage. (Note: Backfill hole and cover ground rod after inspection and approval.)

6. **Enclosures** — Equipment located outdoors must be designed and installed so water will not enter. The National Electrical Manufacturers Association (NEMA) has designations for enclosures based on installation location requirements. As a minimum, outdoor enclosures must be rainproof and sleet-resistant (NEMA 3R or equivalent). In areas subjected to even occasional washdown (all swine facilities, milking centers, treatment rooms, etc.), use watertight, dusttight, corrosion-resistant enclosures (NEMA 4X or equivalent). General purpose indoor residential style enclosures (NEMA 1) may not be used in agricultural buildings. In feed/grain processing areas, use dusttight and watertight enclosures (NEMA 4, 4X or 12 with drip kit).
7. **Wiring Location** — Surface mount all wiring (cables and conduit) to facilitate maintenance and inspection, minimize rodent damage and reduce moisture migration. Under no circumstances should wiring be concealed within the walls or extended into the attic or ceiling spaces. Holes through the inside finish material and vapor barrier destroy the effectiveness of the vapor barrier. Attach surface wiring in machinery storage facilities, free-stall barns, and similar structures under or to the sides of trusses and to the sides of poles and columns. Provide protection (conduit, wood overlay, etc.) for all wiring within 8 feet of the ground or floor surface. In horse and goat barns, provide protection to a height of at least 10 feet. A general rule of thumb is to provide protection for all equipment within two times animal height above the floor.
8. **Cable** — Type UF — underground feeder — cable is required in all damp, corrosive areas of agricultural buildings. Weatherproof connectors and fittings are a required part of the system. Attach cable with nonmetallic cable straps and corrosion-resistant nails. Type NM — nonmetallic — and NM-B cable may not be used in agricultural buildings. (Note: Romex® is a common trade name for NM cable.)
9. **Conduit** — Use nonmetallic conduit where multiple circuit conductors are needed or where wiring is subject to physical damage. Schedule 40 conduit is appropriate for general wiring. Where mechanical protection is needed, use Schedule 80 conduit. Surface mount all conduit. Where conduit passes between areas with different temperatures, the conduit must be sealed with electricians' putty, or equivalent. Do not use silicone caulk. Metallic conduit is not appropriate in most agricultural buildings. Gases and moisture in agricultural buildings lead to rapid deterioration of all types of metallic conduit. Electrical Nonmetallic Tubing (ENT) is not permitted in agricultural buildings.

To prevent breakage of conduit or equipment due to thermal expansion-contraction of nonmetallic conduit, use one 6-inch expansion joint per 50 feet of conduit. Additional expansion joints are

required on installations subject to extreme temperature variations. An expansion joint is required between all rigidly mounted equipment, such as light fixtures.

Conductors used in conduit should have a Type W designation. The W indicates the insulation is approved for use in wet areas. Type THHN/THWN conductor is most common. Type SFF conductor is required in some incandescent light fixtures.

10. **Branch Circuits** — Use No. 12 AWG or larger copper wire for all 115 volt general purpose circuits. No. 14 AWG copper wire should only be used for circuits with known, controlled loads. Conductors servicing continuous loads (such as heat lamps and fans) must be larger. The allowable current for continuous loads is only 80 percent of the conductor rating. Provide individual branch circuits or individual fuses for all permanently installed equipment such as fans, heaters, augers, etc. A disconnecting means is required within sight of and within 50 feet of all equipment. Locating the disconnect and fuse within 10 feet of the controlled equipment is recommended. Match branch circuit conductors and overcurrent protection devices to the equipment being controlled. Overload protection is needed in all motor installations.
11. **Equipment Grounding** — All equipment and all metallic components of the electrical system and building within 8 feet of the floor or soil surface must be bonded to the grounding electrode system (NEC 250-42). A grounding electrode (rod) at the site of a piece of metallic equipment is not permissible, except as a complement to a grounding conductor (bare copper or green insulation) from the service distribution panel. The soil is not permitted to be used as the only path for grounding circuits [NEC 250-51 and 250-91(c)]. All high pressure power washers must also be equipped with ground fault circuit interrupters (GFCIs) for added protection [NEC 422-8(d)(3)].

Equipment grounding conductors (bare copper or green insulation) must be kept electrically separate from other grounded conductors (neutrals, white or gray insulation) in the electrical system except at the service entrance [NEC 250-23(a)]. The equipment grounding conductor is intended to carry current only in the event of an electrical fault.
12. **Boxes and Fixtures** — Corrosion of metallic conduit, boxes and fixtures frequently leads to electrical system failure. Boxes and fixtures made of a nonmetallic material or corrosion-resistant stainless steel, i.e., non-magnetic, are recommended for all agricultural buildings and are required in any building housing livestock or containing corrosive dust. Select equipment designed for use with dusttight and watertight conduit and cable fittings. Plastic boxes designed for use in residential or other clean, dry environments are not permitted in agricultural buildings.
13. **Switches and Receptacles** — Equip all devices with dusttight and watertight corrosion-resistant, gasketed covers. When mounted on a vertical surface, hinge the cover at the top. Single pole switches installed with spring-loaded covers must be installed so they are "off" when in the down position. A preferred alternative is to use switches with external levers or weatherproof pushbutton covers. Surface-mounted fixtures made of thermosetting plastic (e.g., Bakelite®) are not permitted in agricultural buildings. Install combination fuse and switch devices in nonmetallic boxes with covers.

Circuit breakers may not be used as general on/off switches except to control fluorescent lights. Circuit breakers used in this way must be approved for switching duty and must be marked "SWD".

Thermostats must be made of corrosion-resistant material and must be in watertight and dusttight

enclosures. Some thermostats in nonmetallic enclosures are not UL listed. Use of such equipment could affect insurability.

14. **Lighting Fixtures** — Use dust and moisture tight nonmetallic fixtures with shatterproof, vapor tight globes for incandescent light bulbs. Observe wattage limitations of fixtures when planning the lighting system. Special high temperature wire is required in some incandescent fixtures. Except where frequent on/off cycles occur (for example, in enclosed walkways between buildings) use of fluorescent lights is recommended. Fluorescent lights are more energy efficient and produce about three times more light per unit of electricity than incandescent lights. Select fluorescent light fixtures made of corrosion-resistant materials with gasketed covers. Fixtures with fiberglass or aluminum enclosures and Lexan® covers are recommended. Do not use fixtures made of ABS plastic and with acrylic diffusers in buildings where chemicals and high pressure hot water cleaning and sanitizing systems are used. Special cold-start ballasts are needed for fluorescent lights used in buildings such as machine sheds, free-stall dairy barns and swine growing/finishing buildings.
15. **Entry of Cable and Conduit into Boxes** — Whenever possible, cable or conduit should enter boxes and panels from the side or bottom. This will minimize the dripping of condensation onto electrical contact surfaces and reduce corrosion. Boxes for single outlets and switches may have to be wired from top and bottom. Alternatively, such boxes can be mounted sideways and wired from each side.
16. **Mounting of Electrical Devices** — Surface mount all electrical devices in agricultural buildings. A minimum clearance of 1/4 inch is required between all boxes and the mounting surface to reduce entrapment of moisture, dust, and other corrosive materials. Never recess boxes or other electrical equipment enclosures into exterior walls. The inability to adequately insulate between the backside of electrical panels and boxes and outside walls allows condensation to form in the devices and accelerates corrosion of electrical equipment.
17. **Fixture Mounting Height** — Locate switches, receptacles, and other devices 4-6 feet above floor level to minimize potential damage from animals and equipment. Additional protective devices and methods are required where electrical equipment is accessible by animals such as cows, horses and goats. Avoid excessively high mounting heights which limit access for servicing or access and operation during an emergency.
18. **Suspended Appliances** — Support suspended lighting fixtures, heating appliances and other electrical devices by chain or other mechanical method. Do not support any equipment by the power cord, conduit or electrical cable. The support should extend from a solid mounting at the ceiling and be attached to the appliance.
19. **Heat Lamp Sockets** — Use porcelain sockets for all lamps designed to produce heat. Fixtures made of rubber and plastic are not acceptable.
20. **Motors** — Totally enclosed motors designed for farm service are essential for long life in the severe environment of agricultural buildings, especially feed processing areas and facilities used to house animals. Permanent wiring of all fixed motors is recommended. Do not connect permanently installed equipment with plug and cord. The continually open receptacles destroy the integrity of the electrical system. Wire movable equipment and equipment which vibrates during operation with flexible cord (Type SE or SJE) or liquidtight flexible nonmetallic conduit. Use conductors with stranded wires. Wire outdoor equipment such as floating pumps or aerators with

Type STJEW, SEW or STEW flexible cord. Do not use submersible pump cable because sunlight (ultraviolet radiation) quickly destroys the insulation of such cables.

21. **Electrically Heated Stock Waterers** — All electrically heated stock waterers must have a grounding conductor from the service entrance to the waterer to assure a low impedance (resistance) path and sufficient current flow to trip a circuit breaker or blow a fuse in the event of an electrical fault. A grounding electrode may be installed at the waterer for added protection. However, a grounding electrode is not, by itself, sufficient. A switch with a properly sized fuse adjacent to the waterer offers convenience and additional safety. Install a ground-fault circuit-interrupter (GFCI) device near the waterer for added safety and protection.

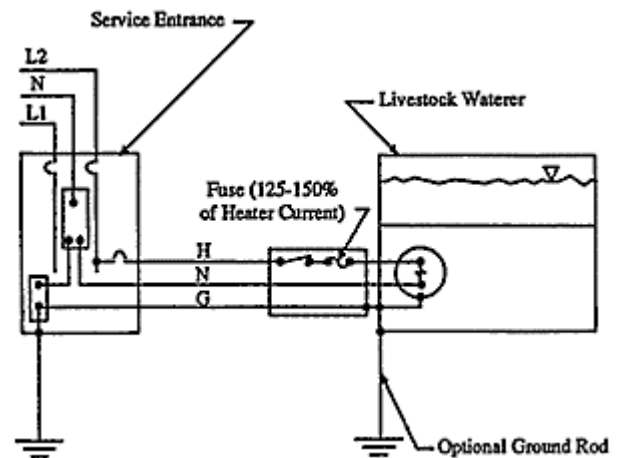


Figure 3. Installation of electrically heated stock waterer.

Electric heat tape is commonly used to prevent freezing of exposed water lines. To reduce the risk of electrocution, use only three-wire (third wire grounding) heat tapes.

22. **Grounding of Building Components** — All metallic building components within 8 feet of the floor or soil surface must be grounded (NEC 250-42). This includes all materials such as siding, structural frames, rain gutters, feeders, grates, gates, farrowing crates, free-stall dividers, milking parlor equipment, etc. Although these components may have individual ground rods, they must also be bonded to the electrical grounding electrode system servicing the building. Metallic parts *not* likely to become energized need not be grounded.
23. **Conductor Attachment to Building** — Where building openings are used for the transfer of materials between the inside and outside of the building, the point of attachment of conductors must be out of reach. The point of attachment of overhead wires should not be closer than 10 feet to either side of the opening and 3 feet above it. Under no circumstances should electrical conductors be attached below such openings. Attach overhead wires in a way that ensures portable elevating equipment can be maneuvered into openings without making contact with overhead wires.
24. **Standby Power** — Most livestock operations require standby electrical power. A double-throw transfer switch must be installed so the generating equipment is isolated from incoming power lines at all times. This protects servicemen from any on-farm generated power feeding back over the supply lines and eliminates potential damage to the generating equipment when normal power is restored. The transfer switch also provides a convenient means to disconnect power to the entire farmstead for servicing and in case of an emergency.

Consult your local power supplier when planning and before using a standby power system. Both you and your power supplier benefit from cooperative planning to assure all needs are met.

25. **Surge Arrestors** — Surge or lightning arrestors are necessary to safely lead transient over-voltages to ground and to protect equipment. Such protection becomes increasingly important as the use of computers and other electronic equipment and controls increases. Install surge and lightning arrestors on the outside of boxes and panels.

26. **Lightning Protection** — Equip buildings, silos, feeding systems, etc., with a lightning protection system. A complete system includes air terminals ("lightning rods"), connecting cables and clamps, and grounding electrodes. Lightning protection system grounding electrodes may not be used as the required grounding of the electrical system. However, the lightning protection system grounding electrodes and cables must be bonded to any metallic equipment (e.g., building siding) within 6 feet of lightning protection system components. Do not allow aluminum grounding cables to come in contact with painted, galvanized, or bare steel roofing, elevator leg supports, etc. Aluminum cables may not be used within 18 inches of the soil surface. All lightning protection systems should be made with components bearing a UL label and installed by an installer qualified to apply for a UL "Master's Label" for the completed installation.
27. **Extraneous voltage** — In addition to good wiring practices, to reduce the possibility of extraneous voltage problems, in some instances a four-wire service for 230 volt single phase installation may be desirable. If a four-wire service is used, grounded neutral conductors and equipment grounding conductors must be kept electrically separated except at the main farm service disconnect. The grounding conductor must be copper if placed underground. A four-wire service is not recommended except where it has been shown to be appropriate through proper testing. However, service entrance panels at all individual buildings still require connection to a grounding electrode and the bonding of all branch circuit equipment grounding conductors to the grounding electrode. Equipping milking centers with an equipotential plane and voltage ramp will reduce the risk of extraneous voltage problems affecting cows during milking.
28. **Fences and Cow Trainers** — Locate electric fence chargers at least 10 feet away from buildings to reduce the risk of damage by lightning. Do not connect the output ground terminal of any charging device to the electrical system.

Summary

The practices advocated, while more stringent than *National Electrical Code* requirements, are intended to improve the serviceability and safety of the electrical system. The goal is to improve safety conditions for animals and personnel and simultaneously to reduce losses due to fire. The practices are the ones most commonly found to be adequate. A thorough understanding of *National Electrical Code* requirements and good wiring practices is still essential for the person doing the installing.

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H-5, Equipment, General

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