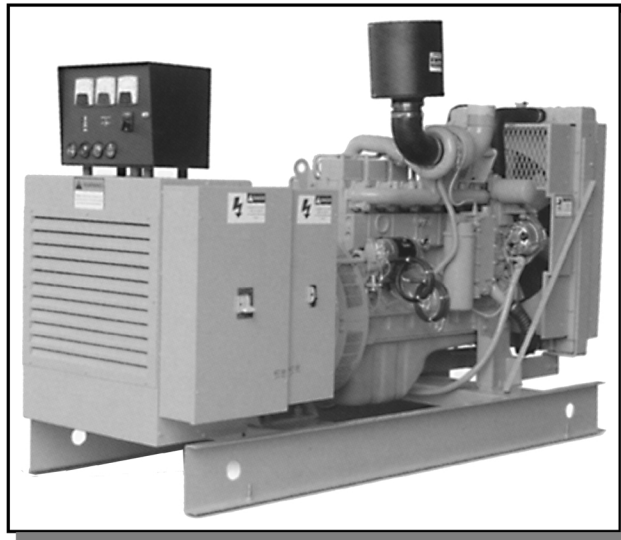


# Standby Electric Power Systems for Agriculture



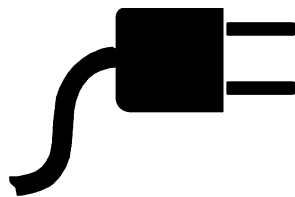
THE UNIVERSITY OF GEORGIA

**COOPERATIVE EXTENSION**

Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

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# Standby Electric Power Systems For Agriculture

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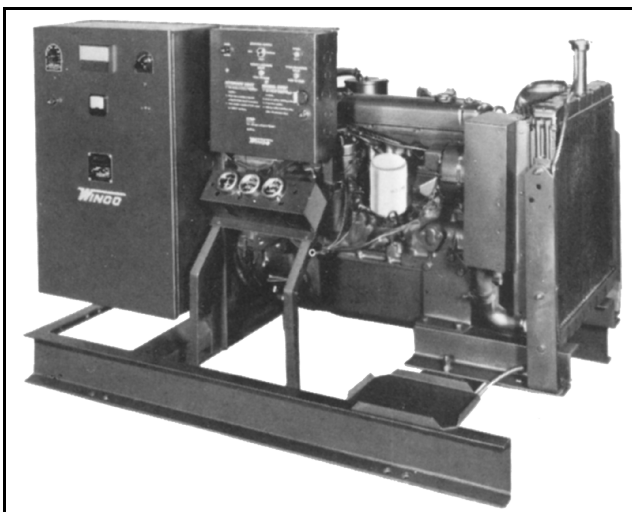
## Introduction

Few people realize how important a constant supply of electricity is until we lose power due to a storm or other unexpected event. For some people, standby electric power is very convenient. For others, it is an absolute necessity. In agriculture, electricity is utilized to control the environment and maintain the life of livestock, poultry, and plants, and to prevent food spoilage, avoid financial loss due to failures in harvesting and sorting, and as security of the farm capital investments.

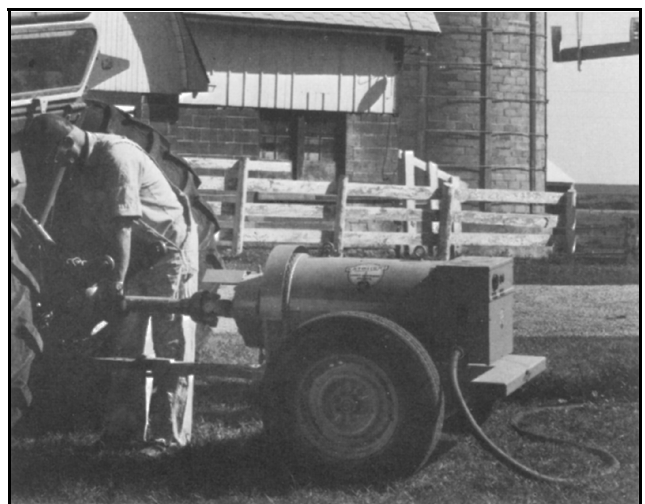
A standby power system should be considered as a form of insurance, with the cost of installation and maintenance compared with the potential loss as a result of an extended power outage. A properly sized, installed and maintained standby electric power system can eliminate most of the financial losses and inconveniences resulting from a power outage. When

an emergency standby power system is being considered, there is a tendency to cut corners on equipment based on the assumption that the system may never be needed. Equipment that cannot handle the job is little better than none at all. In fact, an under-sized, under maintained system may be worse than none at all because it gives a false sense of security. When standby power is needed, it is desperately needed. It must be ready to go at a moment's notice and must be capable of handling the loads applied to it. The best and most reliable equipment pays off at such times.

Equipment required for standby electric power service include (1) an alternator to produce the alternating current, (2) an engine to power the alternator and (3) a transfer switch. In addition to the required equipment, a power failure alarm may be desirable where an outage cannot be tolerated for more than a short time. Even with an automatic start system,



**(a)**



**(b)**

Figure 1. (a) Direct-connected engine driven alternator; (b) tractor PTO driven alternator.

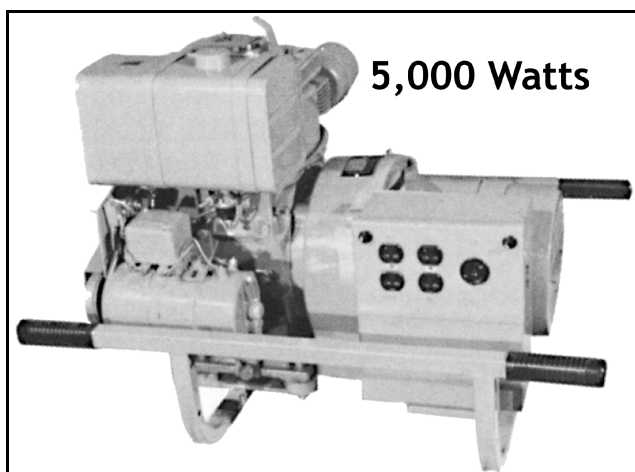


Figure 2. Portable engine driven alternator.

alarms and emergency ventilation systems should be considered for such applications as controlled environment livestock buildings. An electrical problem such as a tripped main breaker at the service entrance of a building may be undetected by the automatic power sensor. Even if it were, the situation would not be helped by turning the standby system on.

## Alternators

There are two types of alternators: direct-connected engine driven and tractor PTO driven (Figure 1a & 1b, page 3). The engine driven units can be started manually or automatically. Small units are generally portable engine driven and usually are available in sizes from 1 to 7.5 KW (Figure 2).

The alternator must be matched to the type of electrical service (single or three-phase) and voltage. Most farm and home electrical systems are single-phase with dual voltages of 120/240 volts. Some farms and businesses utilize a combination of single-phase and three-phase power. Generally, one alternator can be selected to provide both types of services.

For the frequency (60 Hz) and voltage to be correct, the alternator must operate at the proper speed (usually 3600 or 1800 revolutions per minute (RPM)). For tractor driven units, a gear box is usually included so the normal operating speed of the tractor will turn the alternator at the proper speed. Proper voltage is essential for safe operation of electrical

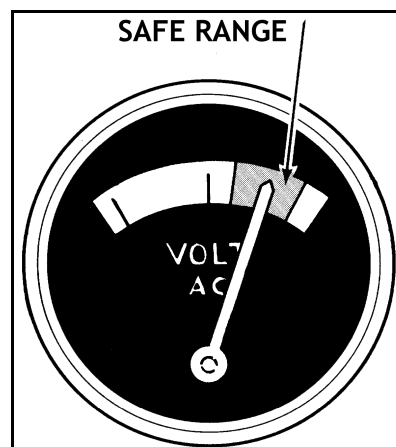


Figure 3. Make sure voltage falls within the "safe range" as indicated on the voltmeter.

equipment, particularly motors. The alternator should be equipped with a voltmeter to make sure the output voltage is within acceptable limits (Figure 3). Alternators must be protected against overload. It is easy to add more load than the alternator is designed to handle. Factory-installed circuit breakers on the alternator will protect the alternator against damage due to overloads.

## Mechanical Power Sources

Alternators are commonly powered by an internal combustion engine, either self-contained direct-connected or tractor PTO driven. The engine used to power the alternator must be of the proper size. The engine or tractor should develop at least 2 horsepower for each kilowatt of electric power produced by the alternator. An alternator with a continuous rating of 30 KW would require a minimum 60 horsepower engine (Figure 4, page 5).

### Tractor PTO Driven

The alternator operated from the power-take-off (PTO) of a tractor has the advantage of lower initial cost and of eliminating the care and maintenance of an additional engine. Trailer or three-point hitch mountings allow the alternator to be mobile (Figures 5a & 5b, page 5). This facilitates the use of arc welders and power tools in repairing equipment at any job location. One disadvantage is that the tractor powering the alternator will not be available for other



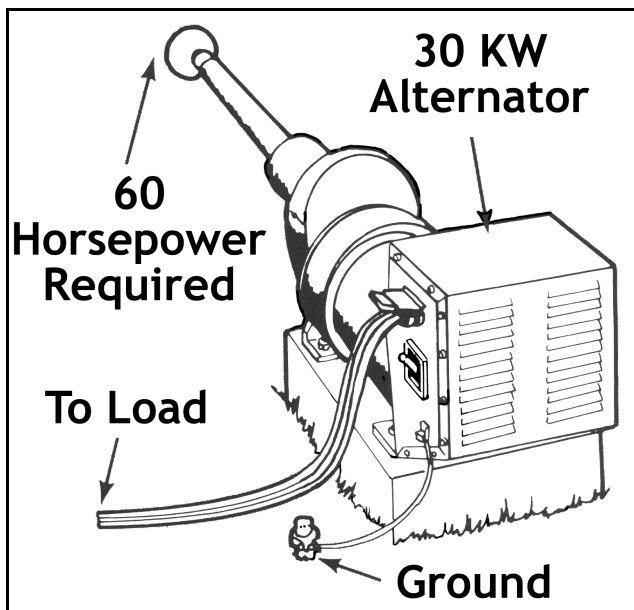


Figure 4. To produce 30 KW of electrical power, a power supply of 60 horsepower is required.

uses during a power outage. In addition, due to inconvenience, it is more likely that the unit will not be tested and exercised regularly, which could lead to problems when an emergency arises.

Alternators are designed to operate at a constant fixed speed (RPM); therefore, the tractor must have a tachometer to indicate when the correct speed has been obtained.

## Self-Contained Direct Connected

The direct connected engine-driven unit is ready to operate at a moment's notice, provided a scheduled maintenance program is followed. It is important to run these units periodically to make certain the engine will start in an emergency. These units can include automatic starting and an automatic transfer switch for rapid restoration of power, a highly desirable feature for livestock confinement buildings where a short term power outage can result in great loss of life.

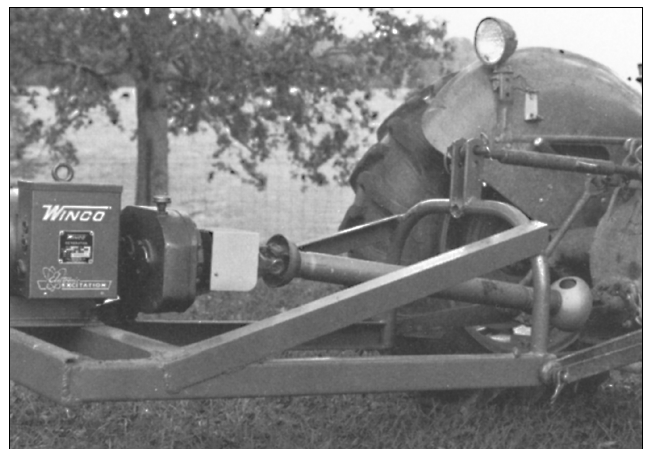
The choice of an engine is important for greatest efficiency. For alternators up to 15 kilowatts, an air-cooled engine is recommended because of the lower maintenance requirements. Gasoline, LP gas and diesel fueled engines are available for powering standby alternators. Generally, it is best to select an engine which uses the fuel type most commonly available at your location.

## Transfer Switch

A standby alternator must be connected to the electrical wiring system in a way that will prevent the accidental connection of the alternator to the utility company's lines. This is required by electrical



(a)



(b)

Figure 5. (a) A trailer-mounted alternator; (b) a three-point hitch-mounted alternator.

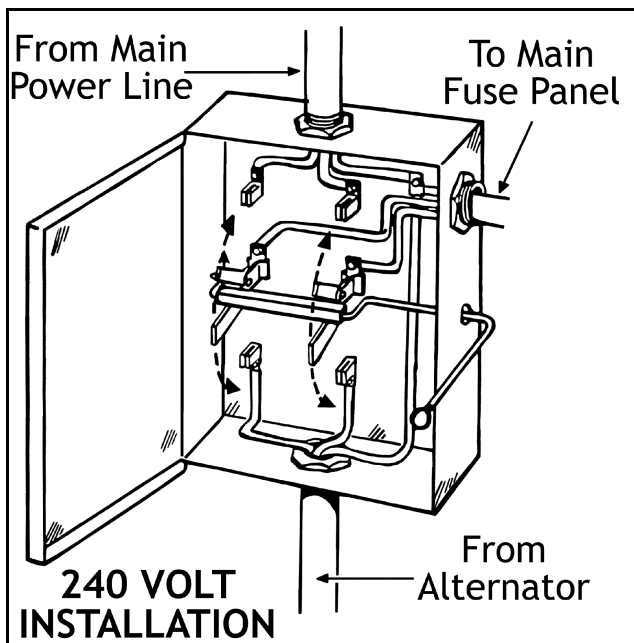


Figure 6. A typical manual transfer switch.

codes and all electrical power suppliers. A double-throw transfer switch is the most common method used to connect the alternator to the wiring system (Figure 6). Such a switch eliminates the danger of feedback onto the main lines and the subsequent

endangerment to those working on the lines. It also eliminates the possibility of the alternator being damaged when normal power is restored.

The capacity of the transfer switch must be matched to the rating of the service equipment and conductors supplying the normal load, not necessarily to the alternator or emergency load demand. Common capacity size of transfer switches are 100, 200, and 400 amperes.

The transfer switch, located at the central distribution pole or at the main service, will serve any electrical load on the farm. It also can be located at the service entrance of a particular building, but only that building will be served by the alternator.

In special applications where isolated motor loads require emergency power, a simple male-female electrical connection can be used in the absence of the transfer switch. **The male-female electrical connection must be installed between the service entrance panel and the motor load (Figures 7a & 7b).** Alternators without circuit breakers should be limited to supplying motors of  $\frac{1}{3}$  HP or less using the above application.

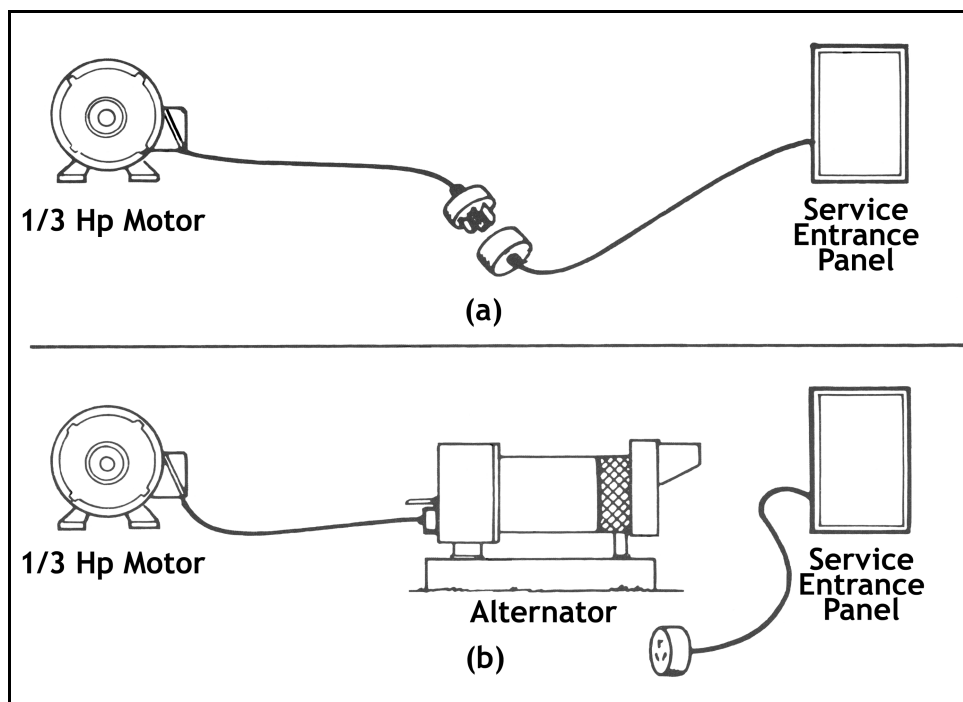


Figure 7. (a) Normally connected circuit; (b) emergency connected alternator circuit.

# Determining Alternator Size

Several methods are used for determining the proper size alternator for a particular application. Sizing alternators would be easier if it were not for electric motors which draw starting current of three to five times the running current. The alternator must be capable of supplying these short time high power demands.

Alternator size is usually expressed in kilowatts (KW). One kilowatt is equal to 1000 watts. Many small generator sets have two KW ratings. The lower rating is the continuous output. The higher rating, sometimes called “motor starting watts” is the short time overload capacity. Larger units are usually rated for either “intermittent” or “standby” service or for “continuous” or “Prime” service. Here continuous service refers to applications where a unit is to be used full time (such as in a remote location where no other source of power is available). Standby or emergency generator sets are sized using intermittent ratings even though they may run for several days at a time in the case of a severe ice storm. This rating has more to do with the expected operating life (in hours) of the machine than safe short-term operating conditions. The first factor to consider in sizing an alternator is whether it is manually or automatically started. If the alternator is manually started, and if all potential operators are trained to properly control the loads and bring them on line slowly, the alternator can be sized to operate only essential equipment. Even essential equipment, in some cases, need not all be operated at the same time. If the alternator is automatically started, the assumption must be made that all loads which can be operating at the same time will be operating when the power failure occurs, and thus the alternator must start and run all of these loads simultaneously. In either case, for a growing farm or business, it is not wise to size the alternator at the minimum requirement as it may be inadequate as future loads are added.

## Manually Operated Alternators

To size a manually operated alternator, list the essential lights and equipment which must operate during an outage. Not all of the essential equipment may need to be operated at the same time. For

example, the feeding operation on a small dairy farm might be delayed until after the milking is finished, but in this case, the water pump and milk tank compressor will probably continue to operate for some time after milking is completed. For a typical farm, two or three lists of equipment may need to be operated simultaneously. For each equipment list, determine the wattage requirement. Size the alternator to the largest wattage requirement.

The nameplate on most appliances and equipment, except motors, will give the wattage requirement. Table 1 lists the approximate starting and running wattages for common motors. If the wattage of equipment and appliances cannot be determined, Table 2 can be used to estimate the wattage. To determine the manually started alternator size for a farm, business or home, follow the following steps:

1. Starting wattage of largest motor. (If there are two or more motors of the same size, list the starting wattage of only one. Include the running wattage of the other motors in step 2.)
2. Running wattage of other motors.
3. Nameplate wattage of appliances and equipment.
4. Wattage of lights.

**Table 1. Approximate Power Requirements for Electric Motors**

Motor Horsepower	Starting Watts	Running Watts
$\frac{1}{6}$	860	215
$\frac{1}{4}$	1,500	300
$\frac{1}{3}$	2,000	400
$\frac{1}{2}$	2,300	575
$\frac{3}{4}$	3,350	835
1	4,000	1,000
1.5	5,000	1,500
2	7,500	2,000
3	11,000	3,000
5	15,000	5,000
7.5	21,000	7,000

**Table 2. Approximate Power Requirements for Household Appliances and Equipment**

Appliance	Approximate Power Required (Watts)
Range	12,000
Water heater	4,500-6,000
Clothes dryer	4,500-6,000
Automatic washer	600
Dishwasher	1,200
Waste Disposer	400
Freezer	400
Refrigerator	600
Water pump	1,000
Bathroom heater	1,500
Attic fan	500
Fuel-fired heating equipment	600
Electric heating	15,000-25,000
Air conditioner	3,000-15,000

**EXAMPLE 1: SIZING AN ALTERNATOR FOR A SMALL DAIRY FARM**

Milking Operation		Watts
Bulk Tank Compressor	5 HP	15,000
Vacuum Pump	5 HP	5,000
Bulk Tank Paddle	¼ HP	300
Ventilation Fans (4)	½ HP	2,300
Water Pump	1 HP	1,000
Water Heater	5,000 W	5,000
Lights	1,000 W	1,000
<b>Total Demand</b>		<b>29,600</b>
Feeding Operation		
Silo Unloader	5 HP	15,000
Bunk Feeder	5 HP	5,000
Elevator	1 HP	1,000
Bulk Tank Compressor	5 HP	5,000
Bulk Tank Paddle	¼ HP	300
Lights	1,000 W	1,000
<b>Total Demand</b>		<b>27,300</b>
Residence		
Water Pump	1 HP	4,000
Freezer	400 W	400
Refrigerator	600 W	600
Electric Furnace	15,000 W	15,000
Range (one surface unit)	1,500 W	1,500
Lights	1,000 W	1,000
<b>Total Demand</b>		<b>22,500</b>

The above example assumes that the farmer is willing to do without power to the residence during milking and feeding. Depending on the farm, that might include a significant amount of time and be unacceptable. Given this assumption however, the largest power demand occurs during the milking operation; therefore the alternator would be sized to this demand. An alternator with a continuous rating of 30-KW would handle this farm if properly operated. It would probably be wise to select a unit somewhat larger to provide room for growth. It is important to note that this system requires careful operation and some sacrifice.

**Automatically Started Alternators**

An automatically started alternator must start and operate all loads which might be operating at any given time. Assume that a power outage will occur at the worst possible time, when all loads are running. For this reason, the alternator should be sized by the following procedure:

- ❑ Add up all starting loads that might be on at the same time.
- ❑ Add up all running loads that might be on at the same time.
- ❑ Choose an alternator that will deliver the required starting watts at the “intermittent” or “standby” rating. This will usually result in a unit much larger than needed to operate the running load, so several steps can be taken to reduce the size depending on the nature of the loads and how much information is known about them.
  - Some motors are easier to start than others. If the code letter of the motor to be started is known, **and if precautions are taken to assure that replacement motors will have the same or better rating**, the actual starting load for the motor can be used in place of the table value.
  - Some automatic control systems in livestock buildings or greenhouses have the ability to

## EXAMPLE 2: SIZING AN AUTOMATIC-START ALTERNATOR FOR A FOUR-HOUSE POULTRY FARM

Equipment (per house)	Starting Watts	Running Watts
8, 1-HP Fans	32,000	8,000
2, ½-HP Fans	4,600	1,150
6, ¾-HP Feeder Motors	20,100	300
2, 1-HP Pumps for Foggers	8,000	2,000
50, 75-watt lights	3,750	3,750
<b>Total Demand per House</b>	<b>68,450</b>	<b>15,200</b>
4 Houses (4 x 68,450)	273,800	60,800 (4 x 15,200)
Water Pump (3-HP)	11,000	3,000
<b>Farm Total</b>	<b>284,800</b>	<b>63,800</b>

bring the loads up in stages instead of all at once. In this case, the required watts would be calculated by adding the starting watts for the last load added to the running watts for all other loads.

- More than one automatic transfer switch can be installed in order to bring the loads up in stages. For instance, on a four-house poultry farm, two houses could be placed on each of two switches with the second switch starting a few seconds after the first switch. The cost of the additional switch may be more than offset by a reduction in the required size of alternator.
- Most manufacturers allow a temporary dip in voltage during motor startup. In order to accurately size a unit at minimum size, most manufacturers have software packages available to fine tune requirements for automatic-start units.

Note that the lights were sized at 75 watts each even though 7 to 10 watt fluorescent bulbs are now used in many buildings. The same fixtures will accommodate lights from 4 to 100 watts, and it is a

good idea to design for the largest bulbs that can reasonably be expected to be used.

To start this whole farm simultaneously would require a significantly oversized unit (about 300 KW). By sequencing loads, using actual motor data, and allowing the voltage to dip temporarily as the last loads are brought on line, the farm could probably be run by a generator set with a rating in the neighborhood of 100 KW. Actual sizing must be done based on exact data for the farm and for the unit under consideration.

The purchase of a generator set of this size, along with the automatic transfer switch, is a major investment. It is always advisable to get more than one bid and carefully compare the equipment being proposed. It is possible that one manufacturer might allow a slightly larger voltage dip during startup, thus requiring a smaller unit to operate the load. If three bids are obtained, however, and one proposed unit is significantly lower than others, appropriate caution should be exercised to make sure the unit is not undersized. A generator set that fails in an emergency due to under sizing can be a very costly mistake.

## Auxiliary Equipment

Standby alternators can be equipped with many optional accessories, depending upon the intended use and kind of alternator selected. A power failure alarm senses the interruption of electrical service and sends out an alarm alerting you of the need for starting the standby alternator or, in the case of an automatic-start unit, the need to check to make sure it is operating properly. The alarm system is a must for farm equipment necessary to sustain the life of livestock. Additional alarm systems should be placed inside the building to sense temperature rise. Power failures from the power supplier are not the only thing that can cause a power outage in the barn. A tripped main circuit breaker can turn off all fans, and will not be corrected by the use of a standby power system.

Direct engine powered standby alternators equipped with electric start would benefit from having a battery charger installed to maintain the battery capacity for immediate use when needed.

The automatic transfer switch can be used with certain self-contained direct engine driven units to insure continuous uninterrupted electrical power. A remote start-stop switch also can be installed on certain units where the direct engine driven alternator is located away from the desired point of control.

## Installation

Wiring and equipment must be installed in accordance with the National Electrical Code, local ordinances and the requirements of the power supplier. Inspection by the local electrical inspector and power supplier is recommended in all cases and required in most. Check with your local power supplier and authority to make sure before installation.

The size of electrical wire needed to connect the alternator to the transfer switch depends upon the amount of current and the distances the current must be carried. It is desirable to locate the alternator within 25 feet of the transfer switch and preferably within sight. The wire must be sized according to the rating of the main circuit breaker on the alternator. Table 3 can be used as a general guide, but actual

size may vary depending upon the type of insulation and covering on the wire or cord. The attachment plugs must also have a current rating no less than the rated output of the alternator.

**Table 3. Guidelines for Selection of Wire to Connect Alternator to Transfer Switch (THW or equivalent insulation)**

Wattage		Wire Size (AWG)	
115v	230v	Copper	Aluminum
3,450	6,900	10	8
5,750	11,500	6	6
8,050	16,100	4	3
11,500	23,000	3	1
14,375	28,750	1	00
17,250	34,500	0	000

The alternator case must be properly grounded to prevent the possibility of electrical shock in the event of a malfunction in equipment. This grounding can best be accomplished at the transfer switch (Figure 8, page 11). **NOTE: This illustration should only be considered as a typical installation. Consult your electric utility and a licensed electrical contractor or qualified individuals.**

The alternator should be located in an atmosphere that is free from excessive dust, wind-blown particles, high temperatures and corrosive fumes. Allowance should be made for a minimum clearance of three feet around the unit for accessibility. Permanently installed, engine-driven alternators should be mounted on a concrete base. Vibration damping pads should be placed between the skid and the concrete base to minimize the transfer of vibration to other equipment. The exhaust must be vented to the outside in a manner which will not cause a fire hazard where the pipe extends through the wall (Figure 9, page 11).

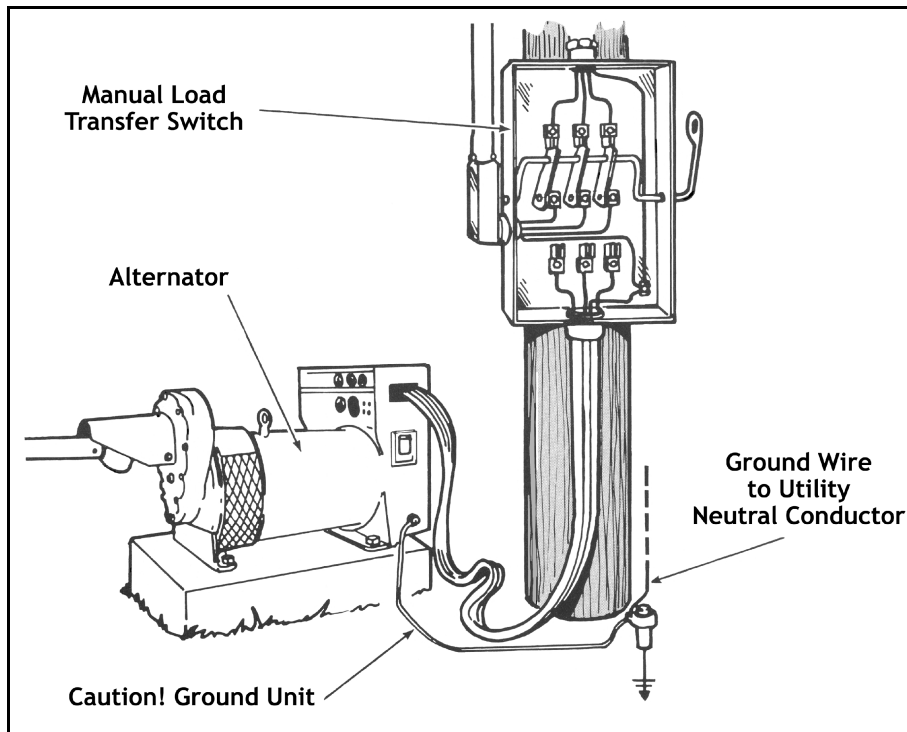


Figure 8. A properly grounded alternator.

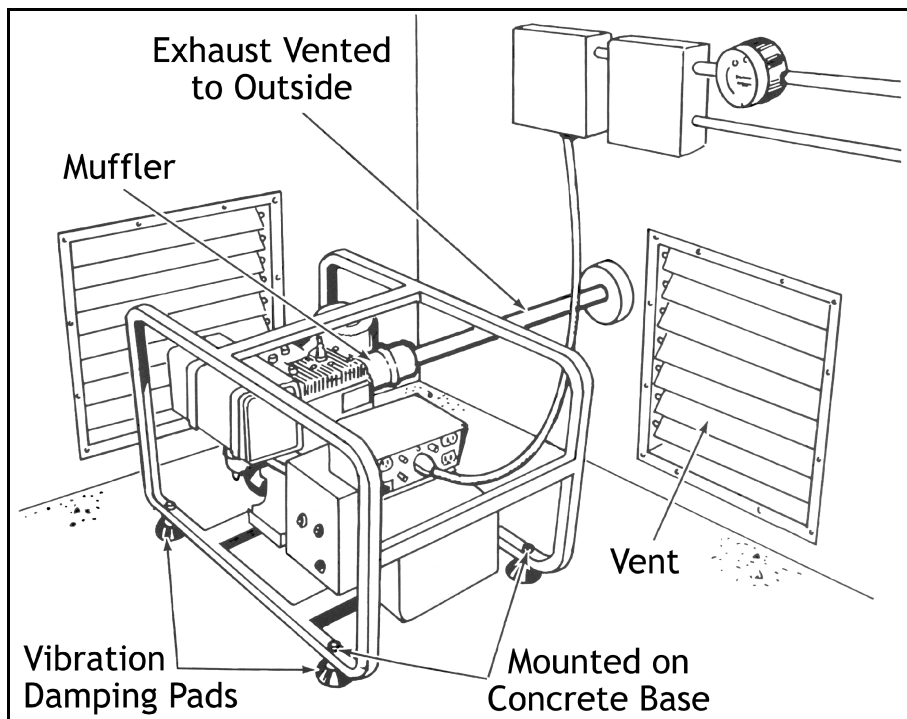


Figure 9. The exhaust of a permanently installed engine-driven alternator should be properly vented to the outside.

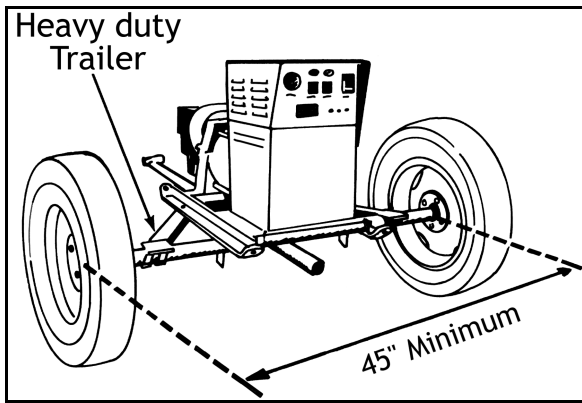


Figure 10. The trailer for an alternator mounting must be heavy duty, with wheels far enough apart to prevent overturning.

Tractor-driven alternators are generally stationary or mobile mounted on a trailer or a three-point hitch. If the alternator is to be permanently mounted at one location, the mounting platform must be on concrete, steel or heavy-duty wood beams. The surface of the platform must be level so the alternator mounting base will not allow the alternator to rock. Any alternator rocking or movement could result in damage to the alternator.

For mobile units, the mounting should be of sufficient size and stability to withstand pulling over rough terrain and to withstand torque or turning stresses experienced when full loads are applied. If the alternator is to be mounted on a trailer for maximum portability, the trailer must be a heavy-duty type with a rigid mounting platform suitable to handle the weight of the alternator (See Figure 10). A 45-inch hub-to-hub minimum measurement is required to prevent the alternator from flipping the trailer over during heavy torque loads when starting motors. If the trailer construction is too light-weight or the hub-to-hub minimum is too narrow, a rocking motion could occur during the operation, and this could be transmitted to the load, causing lights to flicker.

The alternator also can be mounted on a three-point hitch platform. When using the PTO alternator with a three-point hitch, a special PTO shaft must be used. These shafts are shorter in overall length when compared to the standard PTO drive shaft (See Figure 11).

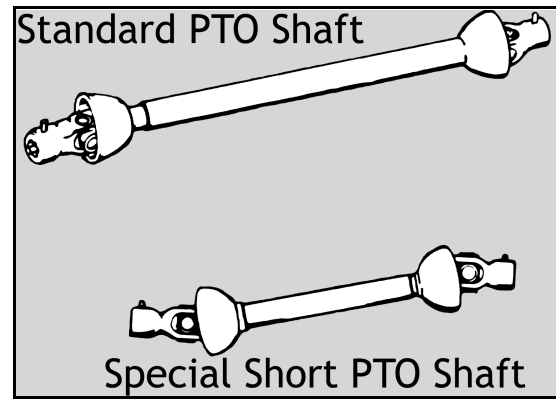


Figure 11. A special short PTO shaft must be used with a three-point hitch.

The alternator should be protected from the weather when possible. If the alternator is permanently mounted, the location should be under a roof or inside a building. Dusty and damp conditions should be avoided as much as possible. Rain and snow will not affect the alternator during normal operation but the unit must be protected as much as possible from the elements during operation. Excessive dust and dirt around the unit during operation will be sucked through the alternator and prolonged operation in such conditions could cause erratic operation and/or alternator damage.

## General Wiring Recommendations

- ❑ Consult your electric utility for advice on installation and materials (wires, sizes, transfer switch, etc.).
- ❑ Consult a licensed electrician or other qualified individual to perform the installation of the alternator and transfer switch.
- ❑ All wiring must comply with local electrical codes.
- ❑ Weather-protective fittings, couplings and wires should be utilized in the standby alternator installation.
- ❑ Install a load-transfer switch between the alternator and load.



- ❑ To avoid breakage due to vibration, the load wires (conductors) utilized between the alternator and the transfer switch should be stranded and have sufficiently heavy insulation.
- ❑ Each conductor must be connected to the proper location on the alternator.
- ❑ Insulate bare ends of ungrounded wires.
- ❑ **Alternator must be grounded by utilizing ground lug provided on the alternator control box.** This is an extremely important step. The alternator will operate without it, but it is extremely unsafe.

## Safety

- ❑ Gasoline and other fuels always present a hazard of possible explosion or fire.
- ❑ The output power voltage present in this equipment can cause a fatal electric shock.
- ❑ Use extreme care if operating unit under wet conditions. Check for proper grounding.
- ❑ Hot engine parts, moving parts and the output of the alternator set could cause serious injury to the operator. The operator must use caution and remain alert when using this unit.
- ❑ For repairs on alternator equipment, use only qualified personnel.
- ❑ Installing and wiring a standby power alternator system requires planning and installation by electrical contractors or other qualified individuals.
- ❑ If a tractor driven unit is used, connect the tractor to the alternator.
- ❑ Start the engine and bring the alternator up to the proper speed (1,800 or 3,600 RPM). Refer to the manufacturer's operating manual for voltage-speed adjustments.
- ❑ Check the voltmeter. It should register at least 230 volts for 120/240 volt service, or 115 volts for 120 volt service. When the voltage output is correct, the alternator is ready for the load.
- ❑ Put the transfer switch in the alternator position.
- ❑ Connect the electrical load. Start the largest motor first. Then start each successively smaller motor when the previous one has obtained full operating speed.
- ❑ When all of the motors have been started, add any other essential electric load, such as lights.
- ❑ As loads are added, check the voltmeter during operation to make sure the alternator is not being overloaded. The voltage will drop when too much electric load has been connected to the alternator.
- ❑ When normal power has been restored, switch off all electrical load, then put the transfer switch in the normal power position.
- ❑ Stop the alternator.
- ❑ Turn on electrical loads as needed.

## Operation

Everyone who might be called upon to operate the stand-by power equipment should be completely familiar with set-up and operating procedures. When a power outage occurs, the procedures for operating a *manual-start* standby power system are as follows:

- ❑ Turn off or disconnect all electrical equipment.
- ❑ Make all electrical connections including grounding.

## Maintenance

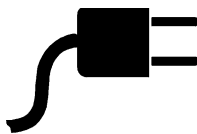
Keep the standby alternating unit clean and in good running order at all times, so it will be ready for immediate use in an emergency. Inspect alternators frequently and kept free of dust, corrosion and moisture.

Tractor-driven alternators should be operated at least once every four months. These units should be operated at rated speed and under load. The alternator should be covered and stored in a dry protected area. To prevent rusting, a light coating of protective oil or grease should be applied to the alternator PTO input shaft.

Automatic starting engine-powered units should be operated weekly under load and long enough for the engine to obtain normal operating temperature. Fluid levels should be checked each time the unit is exercised as with any internal combustion engine. In all cases, the manufacturer's installation, operating and maintenance manual should be thoroughly studied and followed.

## References

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- NFPA, 1995. 1996 National Electrical Code. National Fire Protection Association.





# Learning *for* Life

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