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Standby Electric Power

Michigan State University

Cooperative Extension Service

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June 1977

8 pages

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STANDBY ELECTRIC POWER

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Electricity has certainly become essential to farm operation and family living. Ventilating fans, water pumps, household furnaces and refrigerators, and other vital equipment require uninterrupted electrical service. Storms, accidents, or equipment failure at times cause power outages. A power outage that lasts very long can cause suffocation of animals in controlled environment shelters, food spoilage, frozen pipes, and loss of production. A properly sized, installed and maintained standby electric power system can eliminate most of the financial loss and inconvenience resulting from a power outage.

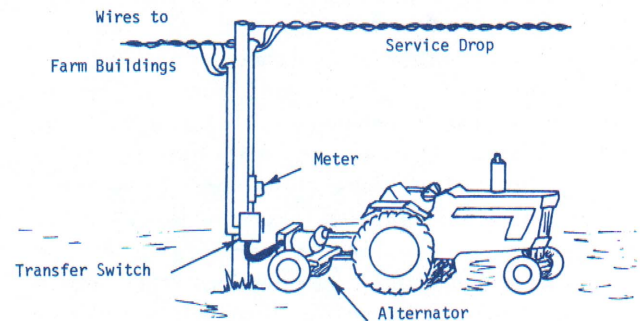


Fig. 1. Tractor powered alternator and transfer switch at a farm central distribution pole.

START UP

- Plug transfer switch cord into alternator
- Start alternator
- Turn off all electrical equipment and lights
- Put transfer switch in the alternator position
- Turn on electrical equipment as needed

SHUT DOWN

- Turn off all electrical equipment and lights
- Put transfer switch in normal power position
- Stop alternator
- Disconnect alternator from transfer switch
- Turn on all electrical equipment as usual

EQUIPMENT

You need an alternator, an engine or tractor to power the alternator, and a transfer switch. The transfer switch provides a safe way to connect the alternator to the farm or home wiring. Electrical power suppliers and electrical codes require a method of electrical load transfer which will prevent the accidental interconnection of the alternator to the power lines. Generally this is accomplished with a transfer switch. In addition to the necessary equipment, a power failure alarm may be desirable where an outage cannot be tolerated for more than a short time.

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. Some farms and businesses are so large and mechanized that operation is impossible without electrical power. In these cases, access to standby power is essential. An alternator (alternating current generator) will generally provide insurance for 20 years if it is operated and maintained properly.

**P. T. O. Portable Alternator
Alternator
Trailer
Power Take-off Shaft
Connecting Wire or Cord
Electrical Plug
Transfer Switch**

ALTERNATORS

There are two types of alternators; direct-connected engine drive, and tractor driven. The engine driven units can be started manually or automatically. Small units are generally engine driven and portable.

Alternator size refers to electrical power output. Ratings are usually expressed in kilowatts (KW). One kilowatt is equal to 1000 watts. Some manufacturers list two KW ratings on an alternator, the higher rating is the short time overload capacity, the lower rating is the continuous output. An alternator is sized for a load on the basis of the continuous or lower rating, but the overload capacity should be about 75 percent higher for starting motors. Electric motors draw three to five times as much current when they are starting as while running.

The alternator must be matched to the type of electrical service and voltage. Most farm and home electrical systems are single-phase with dual voltages of 115/230 volts. Units are available with outputs at 115 volts, and at 115/230 volts. Small portable engine-alternator units generally have outputs at 115 volts. Some farms and businesses are served with a combination of single and three-phase power. Generally one alternator can be selected to provide both types of service.

Rotation speed of the armature of the alternator depends upon design. Small alternators usually operate at 3600 revolutions per minute (rpm). These are two-pole alternators. Large alternators have four poles and therefore turn only half as fast (1800 rpm). The alternator must operate at the proper speed or the cycles per second (60 Hz) and voltage will not be correct.

Alternators must be protected against overload. It is easy to turn on more load than the alternator is designed to handle. Properly sized, factory installed circuit breakers on the alternator will protect against alternator damage due to overloads.

Some alternators have commutator and brushes, and others are solid-state. Direct current is required to create a magnetic field necessary for alternator operation. Commutator and brushes are required on many alternators to obtain the direct current. With some models, however, diodes are placed on the rotating armature and brushes are not necessary. A commutator and brushes require maintenance, but diodes are sensitive and subject to electrical damage.

Proper voltage is essential for safe operation of electrical equipment, particularly motors. The alternator should be equipped with a voltmeter to make sure the output voltage is within acceptable limits. Voltage should range between 110 and 120 volts or between 220 and 240 volts.

ENGINES AND TRACTORS

The engine used to power the alternator must be of the proper size. The engine or tractor should develop 2 ½ horsepower for each kilowatt of electric power

produced by the alternator. An alternator with a continuous rating of 30 KW would require a 75 horsepower engine. For alternators larger than 75 KW, 2 horsepower per KW is sufficient.

The alternator can be operated from the power-take-off (P.T.O.) of a tractor. This has the advantage of lower cost at the time of the initial investment, and it eliminates the care and maintenance of an additional engine. However, during a power outage, the tractor powering the alternator will not be available for other uses. Trailer mounting the alternator provides portability. Used with an arc welder and power tools, farm equipment could be repaired in the field.

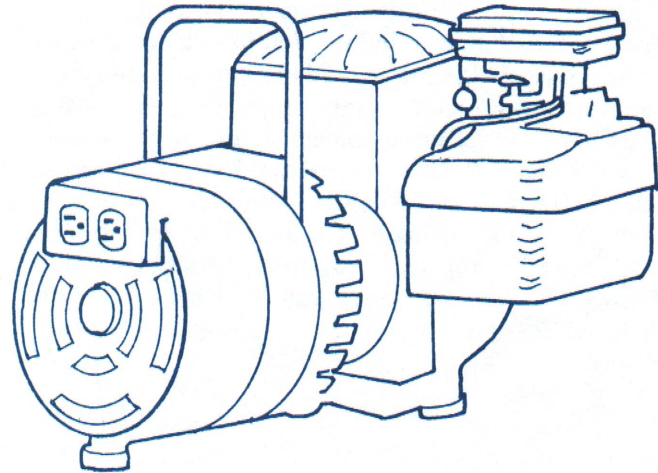


Fig. 2. A portable power plant producing up to several kilowatts can be used for individual home appliances or other limited loads.

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

The direct connected engine driven unit is ready to operate at a moment's notice. Because it is a complete unit it can be designed with automatic starting and automatic transfer switch if the need warrants the extra expense. It is important to test these units periodically to make certain the engine will start in an emergency.

The choice of engine is important for greatest efficiency and least care. For alternators up to 15 kilowatts, an air cooled engine is recommended because of the lower maintenance requirements. For alternators larger than 15 kilowatts, a liquid-cooled engine is necessary. Gasoline, LP gas, and diesel engines are available for powering standby alternators. LP gas is generally cleaner burning than gasoline. This tends to promote longer engine life and reduced frequency of maintenance. Also, gasoline forms a varnish in the system when in storage for long periods of time. This might keep the engine from starting in an emergency. This problem can be prevented with proper maintenance. Diesel units cost a lot initially, except in

the very large engines, but operating and maintenance costs are low. Generally it is best to select an engine, if available, which uses the fuel type most commonly available on the farm.

TRANSFER SWITCH

A standby alternator must be connected to the wiring in a way that will prevent the accidental interconnection of the alternator and the power lines. This is required by electrical codes and all electrical power suppliers. A double-throw transfer switch is generally the most practical way to connect the alternator to the wiring. The transfer switch will keep the alternator isolated from the power lines at all times, thus preventing feedback of alternator voltage on power lines, which would endanger the life of repairmen working on the lines. It also eliminates the possibility of the alternator being damaged when normal power is restored, thus protecting the investment of the alternator.

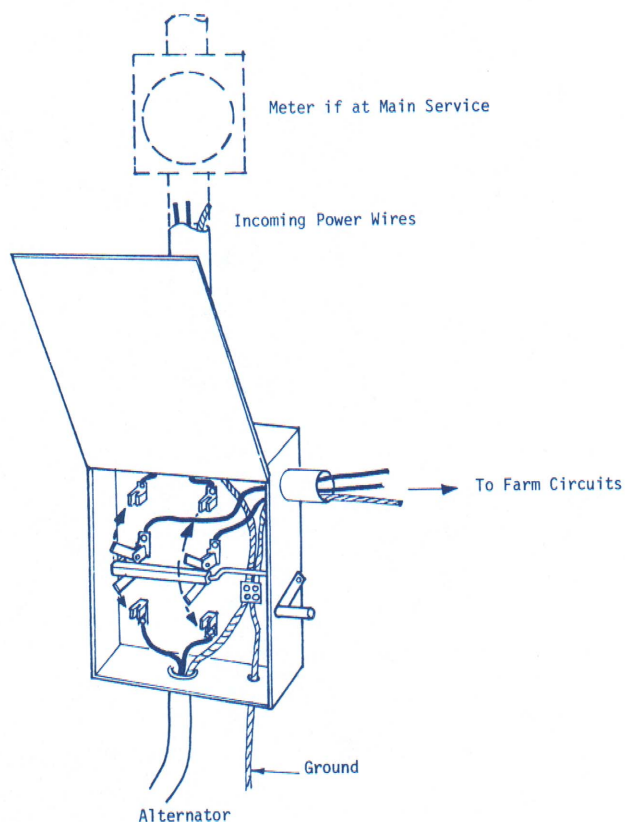


Fig. 3. A double-throw transfer switch will safely connect an alternator to the farm wiring.

The transfer switch, when located at the central distribution pole or at the main service, will serve any electrical load on the farm. Seldom is the standby alternator sized large enough to operate all loads as usual; therefore all but essential equipment should be turned off. The transfer switch must be sized according to the rating of the service equipment and wires where it is installed. Common sizes are 100, 200 and 400 amperes. Sometimes the lower transfer switch contacts for the alternator are sized adequate to handle alternator current, but smaller than the service contacts. The transfer switch can be located at the service entrance of a particular building, but only that building will be served by the alternator. It is also possible to wire one to several circuits within a building to be connected to the transfer switch if only those circuits need to be powered during an outage.

If a transfer switch is located at the main service, provide a way to determine when power has been restored. This can easily be accomplished with a power indicating pilot light (neon type) on the transfer switch.

SIZING THE ALTERNATOR

The alternator may be sized to power the entire electrical load on the farm, but generally only the most essential equipment and lights are considered. Even this essential equipment, in most cases, need not be operated at the same time. But for a growing farm or business, it is not wise to size the alternator at the minimum requirement, or in the future it may be inadequate.

Many methods are in use for determining the proper size alternator for a particular application. Sizing alternators would be easier if it were not for electric motors which draw three to five times as much current when they are starting as when they reach running speed. The alternator must be capable of supplying these short time high power demands. Table 1 may be used as a general guide for alternator selection, but remember this table is based upon averages, and the size may not be adequate for farms or homes with high electrical demands.

Table 1. Guide for selecting typical farm and home alternator. The residence is included as a part of each farm operation listed.

Dairy Farm		
40 to 50 cows	15-25	KW
60 - 100 cows	20-30	KW
120 - 200 cows	50 -	KW
Poultry Farm		
8 - 10,000 birds	15-20	KW
15 - 18,000 birds	20-30	KW
25 - 30,000 birds	30-50	KW
Hog Farm	15 - 25	KW
Beef Farm (mechanical feeding)	25 - 50	KW
Greenhouse (no refrigeration)	25 - 50	KW
Residence (non-farm)		
Without electric range	4 -	KW
With electric range and/or air conditioning	10 - 15	KW

To more accurately size the alternator, list the essential lights and equipment which must operate during an outage. Not all of the essential equipment will need to be operated at the same time. For example, the feeding operation on a dairy farm can 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, there will probably be two or three lists of equipment. 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. If the wattage of equipment and appliances can not be determined, then Table 2 can be used to estimate the wattage. Remember, motors have high power requirements when starting. Table 3 lists approximate starting and running wattages for common motors. To determine the alternator size for a farm, business or home, follow the steps listed below. This method will allow a small amount of extra alternator capacity for future equipment.

ESTIMATING ALTERNATOR SIZE

1. Starting wattage of largest motor.
2. Running wattage of other motors.
3. Nameplate wattage of appliances and equipment.
4. Wattage of lights.

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 item 2.

Example: Sizing an alternator for a dairy farm.

Milking Operation

Bulk tank compressor	5 h.p.	15,000 watts
Bulk tank paddle	1/4 h.p.	300
Ventilation fan	1/2 h.p.	575
Vacuum pump	2 h.p.	2,000
Water pump	1 h.p.	1,000
Water heater	5000W	5,000
Lights	500W	500
TOTAL DEMAND		24,375 watts

Feeding Operation

Silo unloader	5 h.p.	15,000 watts
Bunk feeder	5 h.p.	4,500
Elevator	1/2 h.p.	575
Bulk Tank compressor	5 h.p.	4,500
Bulk Tank paddle	1/4 h.p.	300
Lights	200W	200
TOTAL DEMAND		25,075 watts

Residence

Water pump	1 h.p.	4,000 watts
Freezer	1/3 h.p.	400
Refrigerator	1/4 h.p.	300
Furnace	1/4 h.p.	300
Range (one surface unit)	1400W	1,400
Lights	750W	750
TOTAL DEMAND		7,150 watts

The largest power demand occurred during the feeding operation; therefore the alternator would be sized to this demand. An alternator with a continuous rating of 25 KW would handle this farm adequately. Because alternators are generally designed to withstand short time overloads such as the starting of a motor, it would be possible to add limited additional equipment in the future without exceeding the capacity of this alternator.

Table 2. Electrical power requirements of household appliances and equipment.

Appliances	Watts	Horsepower
Refrigerator		1/4
Freezer		1/4 to 1/2
Water pump		1/2 to 2
Furnace oil burner		1/6
Furnace blower		1/4 to 1/2
Elec. clothes dryer	1500-5000	
Clothes washer		1/4 to 1/2
Water heater	1000-6000	
Electric range	3000-12000	
Small surface unit	1000-1400	
Large surface unit	1500-2400	
Oven	2500-4000	
Television	200-600	
Dishwasher (may have a booster heater)		1/6
Electric fan	75-300	
Electric heaters	500 & up	
Electric iron	500-1200	
Coffee maker	1000	
Mixer	100-175	
Electric skillet	1200	
Toaster	1100	
Incandescent lamps	(W on lamp)	
Fluorescent lamps ^a	(W on lamp x 1.2)	
Mercury yard lamps ^a	200, 300 or 450	

^a The fixture draws more power than the lamp wattage because of the ballast.

AUTOMATIC STARTING

If there is a building or operation with minimum supervision, but loss of power there cannot be tolerated for more than a few minutes, an automatic starting engine-alternator set may be necessary. This type of

system will require an alternator, engine, automatic engine starting controls and an automatic load transfer switch. Needless to say, this system is complicated, expensive, and must be designed and installed by trained personnel. To avoid the need for sizing the alternator large enough to start all of the electrical loads at once, time delay relays and circuit contactors may be installed to switch on each circuit in sequence. The cost of installing this sequencing equipment should be compared to savings resulting from reduction of alternator size.

Table 3. Power requirements of single-phase 115 and 230 volt electric motors.

Motor Horsepower	Starting (watts)	Running (watts)
1/6	860	215
1/4	1,500	300
1/3	2,000	400
1/2	2,300	575
3/4	3,350	835
1	4,000	1,000
1 1/2	5,000	1,500
2	7,500	2,000
3	11,000	3,000
5	15,000	4,500
7 1/2	21,000	7,000

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. The size of electrical wire needed to connect the alternator to the transfer switch depends upon the amount of current and the distance 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 4 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.

For permanent installations the alternator must be 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.

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 3 feet around the unit for accessibility. Permanently installed, engine-driven electric plants should be mounted on a concrete base. Vibration damping pads should be placed

Table 4. Guide for selection of wire to connect the alternator to the transfer switch. For THW insulation or equivalent.

Amperes	AWG, Wire Size, Copper	THW Insulation Aluminum
30	10	8
50	6	6
70	4	3
100	3	1
125	1	00
150	0	000

In accordance with American Society Agricultural Engineers recommendation 364, Installation and Maintenance of Farm Standby Power, December, 1973.

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.

Tractor-driven alternators are generally stationary or mobile mounted on a trailer or a three-point hitch. Stationary units should be mounted on a concrete base. 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.

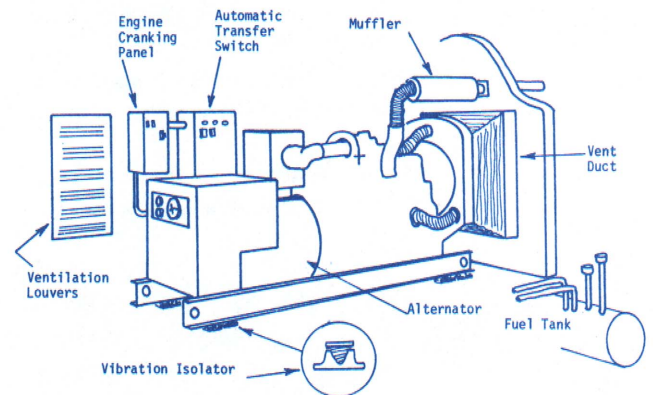


Fig. 4. Indoor alternator-engine installation with automatic controls. Manual start-up unit would be the same except for the automatic controls.

It is imperative that the engine and alternator have an adequate supply of air for combustion and cooling. Duct work from the radiator to the outside of the shelter should be used when necessary. There should be a flexible section of duct at the connection to the unit. The air inlet to the shelter must be larger than the air outlet. The air inlet should be two times the size of the radiator frontal area. Also, means must be provided to exhaust the engine to the outside.

OPERATION

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

1. Turn off or disconnect all electrical equipment.
2. If a tractor driven unit is used, connect the tractor to the alternator.
3. Start the engine and bring the alternator up to the proper speed (1,800 or 3,600 r.p.m.). Refer to the manufacturer's operating manual for voltage speed adjustments.
4. 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.
5. Put the transfer switch in the alternator position.
6. Connect the electrical load. Start the largest motor first.

Then start each successively smaller motor when the previous one has obtained full operating speed.

7. When all of the motors have been started, add any other essential electric load such as lights, etc.
8. 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.
9. When normal power has been restored, shut off all electrical load, then put the transfer switch in the normal power position.
10. Stop the alternator, and turn on electrical loads as usual.

All of the necessary equipment in the home or on the farm need not be operated at the same time. A smaller alternator can still do the job if first one appliance is operated, then turned off, and another appliance operated. For example, the refrigerator can be operated for about an hour at a time, keeping the door closed as much as possible. The furnace can be operated long enough to get the house temperature up to normal. A schedule can be worked out to run the water pump, cook the meals and perform the other household or farm chores.

Do not use the standby power system if the farm wire has been damaged or if it is defective. Also, if wind, ice or a farm accident has caused the outage, check the wiring before using the system.

For the 115/230 volt, three-wire electrical system it is important that the 115 volt loads are balanced. There are two windings in the alternator supplying these 115 volt loads, and the load should be as nearly equal as possible on each winding. An electrician can easily determine if the loads are balanced, and make changes if necessary to correct the problem.

MAINTENANCE

Keep the standby alternator clean and in good running order at all times so that it will be ready for immediate use. An accumulation of dust and dirt on the alternator can cause overheating during operation.

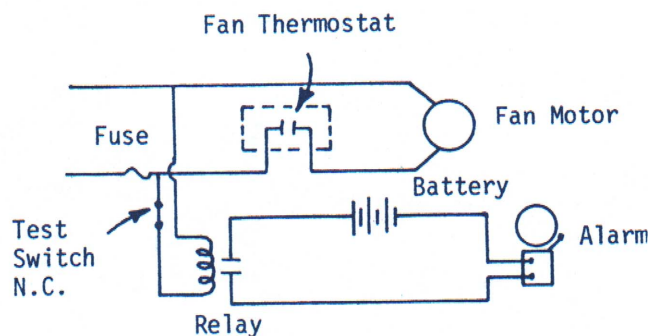


Fig. 5. Wiring diagram for an alarm that senses the loss of power in critical circuit.

Tractor-driven alternators should be operated at least every three months to blow out dust, to dry out moisture which may have entered the alternator, to remove oxidation from slip-rings, and to familiarize the operator with start-up procedures. If possible, the alternator should be operated under load.

Manually operated, engine powered units should be operated at least once per month under load if possible. It should be operated long enough to enable the engine to obtain normal operating temperature. An automatic engine-alternator set can be test operated with automatic controls. These units should be operated once each week.

POWER FAILURE ALARMS

Power failure alarms should be installed where manual start-up alternators are used and power outages cannot be tolerated for more than a few minutes, such as animal confinement housing. The alarm can be installed on critical electrical circuits to indicate directly the loss of power, or it can sense some adverse effect of the power outage such as a rise in temperature. The alarm system can be operated by a battery or a pressurized gas cylinder.

Sometimes an outage can occur in one building and not on the entire farmstead. In the event of this type of outage, an alarm in the residence would not sound. To be safe, an alarm should be installed in each building where it is critical that electric service not be interrupted.

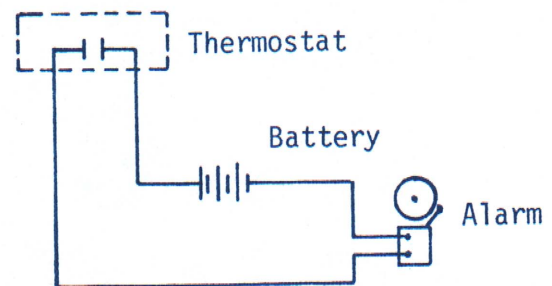


Fig. 6. A simple alarm using a cooling thermostat as the sensing element.

ACKNOWLEDGMENTS

Appreciation is expressed to the members of the Michigan Committee on Rural Electrification for their assistance in the preparation of this bulletin.