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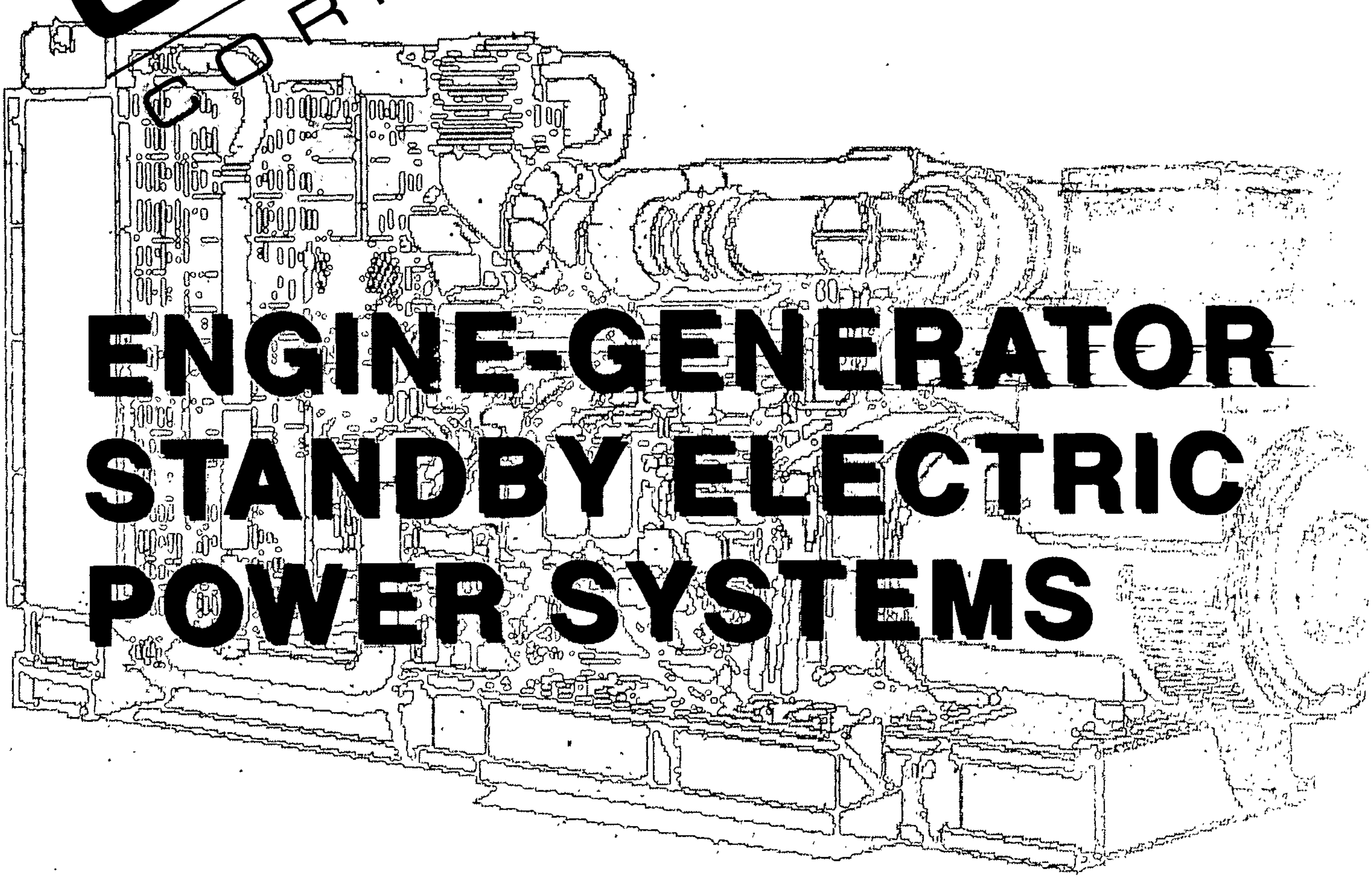

ENGINE-GENERATOR STANDBY ELECTRIC POWER SYSTEMS

Installer's Guide and Reference

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FOREWORD

Engine-generator power system usage in public buildings (such as schools, hospitals, airports, etc.) has been a fact for many years. In more recent years, the use of these systems have spread rapidly to other areas (such as farms, businesses and homes). The sales of engine-generator power systems have increased dramatically due to several factors:

1. The public's total dependence on electricity means that electrical blackouts and brownouts have become more costly.
2. Loss of electrical power at manufacturing facilities has resulted in more costly down times, due to a trend toward automation in manufacturing.
3. Building and safety codes have become stricter. For example, elevators in high rise buildings must be operable in the event of fire.

New developments in the design and application of engine-generator power system components are constantly surfacing. In addition, new problems are being created by the more sophisticated electrical systems being installed and used. As system components and accessories become more varied and complex, the selection of such components and accessories becomes more critical and more difficult.

Persons involved in the sales, distribution, installation and servicing of engine-generator power systems must be thoroughly familiar with the components that make up such systems. Additionally, national, state and local laws, codes and regulations pertaining to the installation and servicing of these systems have become more stringent. Installers and service technicians must not only be cognizant of existing laws, codes and regulations that apply to engine-generator power systems, but must keep themselves abreast of changes, additions and amendments to such laws, codes and regulations.

This "*INSTALLER'S GUIDE AND REFERENCE*" should prove to be a useful source of information for everyone involved with engine-generator power systems, including sales personnel, dealers, distributors, installers and service technicians. The user should not only become thoroughly familiar with its contents, but should keep it conveniently available as a quick reference to engine-generator facts and figures.

Table of Contents

The tenth revision to this Manual, dated 06/08/93, consisted of changes to Chapter 10 to reflect new Voltage Codes. In addition, Table 1 (Voltage Codes) on Page 42 of the manual was changed.

INTRODUCTION

Purpose and Scope of Manual

This *"INSTALLER'S GUIDE AND REFERENCE"* has been prepared especially fo rthe purpose of familiarizing personnel involved with engine-generator power systems with the installation requirements for such systems. Information and instructions contained herein are not intended to replace, supersede or supplement local, state or national safety, electrical and building codes pertaining to such a installations. Applicable laws, codes and standards must always take precedence over the recommendations contained herein.

It is not intended that this book should be used by any unqualified person(s) for the purpose of installing an engine-generator power system. Installation, inspection and testing of such system should be attepted only by competent, qualified electricians or installation contractors who are familiar with the equipment to be installed and with all installation requirements.

It would be extremely difficult and impractical to attempt a detailed coverage of every installation possibility. For that reason, much of the information contained herein is general in nature. Use this information as a guide only and not as a final installation blueprint. Illustrations of tyupical installations are not intended to serve as detailed installation plans.

Sources of Information

Installation information, requirements and recommendations on the following pages are derived from the following sources:

- Cognizant engineers, service technicians and service representatives.
- The National Electric Code (NEC)
- National Fire Protection Association (NFPA) codes and standards.
- Other sources as listed in the "Standards Index."

Standards Index

Applicable national, state or local laws, codes and regulations pertaining to the installation of engine-generator power systems must be strictly complied with. In the absence of pertinent local laws and standards, the following published booklets may be used as a guide:

1. THE 1990 National Electric Code available from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02169
2. NFPA 54, NATIONAL FUEL GAS CODE, obtainable same as Item 1.
3. NFPA No. 30, FLAMMABLE AND COMBUSTIBLE LIQUIDS CODE, obtainable same as Item 1.
4. NFPA No. 58, STORAGE AND HANDLING OF LIQUEFIED PETROLEUM GASES, obtainable same as Item 1.
5. NFPA No. 10, PORTABLE FIRE EXTINGUISHERS, obtainable same as Item 1.
6. NFPA No. 37, STATIONARY COMBUSTION ENGINES AND GAS TURBINES, obtainable same as Item 1.
7. NFPA No. 76A, ESSENTIAL ELECTRICAL SYSTEMS FOR HEALTH CARE FACILITIES, obtainable same as Item 1.
8. NFPA No. 220, STANDARD TYPES OF BUILDING CONSTRUCTION, obtainable same as Item 1.
9. NFPA No. 68, GUIDE FOR EXPLOSION VENTING, obtainable same as Item 1.
10. Article X, NATIONAL BUILDING CODE, available from the American Insurance Association, 85 John Street, New York, N.Y. 10038
11. A52.1, AMERICAN NATIONAL STANDARD FOR CHIMNEYS, FIREPLACES AND VENTING SYSTEMS, available from the American National Standard Institute, 1430 Broadway, New York, N.Y. 10018.
12. AGRICULTURAL WIRING HANDBOOK, obtainable from the Food and Energy Council, 909 University Avenue, Columbia, MO, 65201.
13. ASAE EP-364, INSTALLATION AND MAINTENANCE OF FARM STANDBY ELECTRICAL SYSTEMS, available from the American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, MI 49085

Chapter 1. ENGINE-GENERATOR POWER SYSTEMS

A Simple Engine-Generator System

Figure 1 is a schematic representation of a typical engine-generator power system. The system consists of (a) the NORMAL or UTILITY electrical power supply, (b) the STANDBY electrical power supply, (c) a TRANSFER SWITCH, and (d) interconnecting wiring.

NORMAL OR UTILITY POWER SUPPLY:
The NORMAL or UTILITY power source may be a utility power company, a second engine-generator set, or any other power source that normally supplies the LOADS in an electrical system.

STANDBY ELECTRICAL POWER SUPPLY:
The STANDBY electrical power supply is an engine-generator set, used to supply electrical power to the LOADS in the event that the NORMAL/UTILITY power source has failed or has dropped below an acceptable level.

TRANSFER SWITCH:
The usual method of isolating the NORMAL and STANDBY power sources from each other is by means of an approved transfer switch. These two power sources both connect to the transfer switch. The transfer switch must actually accomplish two tasks:

- ☐ The switch must positively prevent the NORMAL and STANDBY power supplies from feeding the LOAD circuits at the same time.
- ☐ The switch must positively isolate the LOAD circuits from the UTILITY power source while the engine-generator is supplying those circuits.

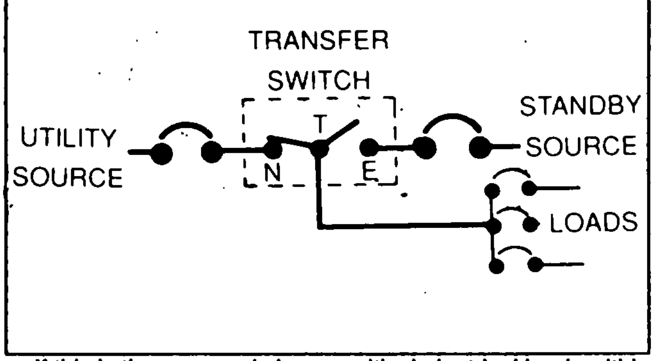
DANGER

CONNECTION OF ANY ENGINE-GENERATOR SET TO AN ELECTRICAL SYSTEM NORMALLY POWERED BY AN ELECTRIC UTILITY SHALL BE BY MEANS OF A DOUBLE THROW TRANSFER SWITCH, SO AS TO ISOLATE THE ELECTRIC SYSTEM FROM THE UTILITY DISTRIBUTION SYSTEM WHILE THE GENERATOR IS RUNNING (NEC 701). FAILURE TO ISOLATE THE SYSTEM BY SUCH MEANS WILL RESULT IN DAMAGE TO THE GENERATOR AND MAY ALSO RESULT IN INJURY OR DEATH TO UTILITY POWER WORKERS DUE TO BACKFEED OF ELECTRICAL ENERGY.

Emergency Circuit Isolation Method

It may become necessary to install and use an engine-driven generator set that does not have the wattage/amperage capacity to power all the loads in an electrical system at the same time.

Figure 1. A Simple Engine-Generator Power System



If this is the case, only key or critical electrical loads within the engine-generator's capacity can be powered during a NORMAL or UTILITY source outage. Such critical loads should be carefully selected based on their importance and need. These critical loads are then grouped together and wired into a separate "emergency distribution panel". Care must be exercised to ensure that the total power requirements of all loads does not exceed the engine-generator's wattage/amperage capacity. Such an arrangement, using the emergency distribution panel, is called the "emergency circuit isolation method". See Figure 2.

When the emergency circuit isolation method is used, the installed transfer switch must meet the following requirements:

- ☐ The transfer switch must have an ampere rating equal to the total ampere rating of the emergency distribution panel circuits.
- ☐ The transfer switch must be installed between the building's main distribution panel and the emergency distribution panel.

Total Circuit Isolation Method

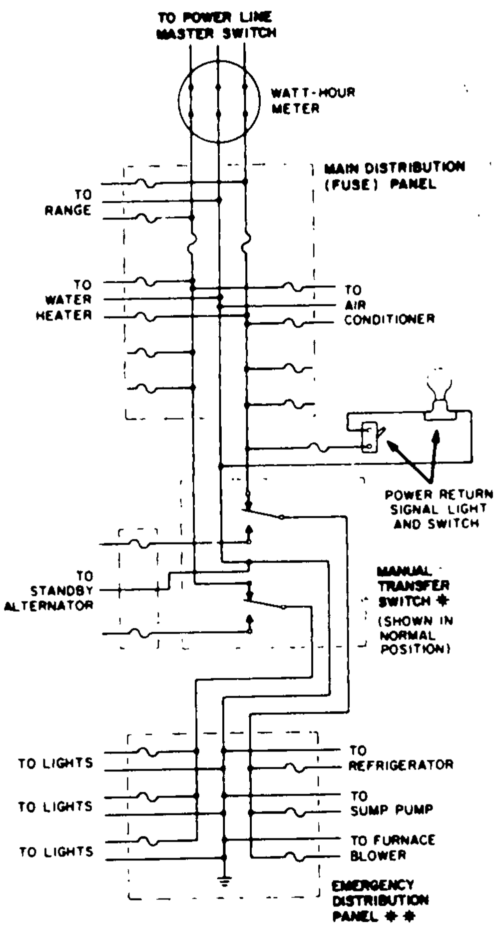
When all of the electrical loads in a system are to be powered by the engine-generator during a NORMAL or UTILITY power outage, the "total circuit" isolation method must be used (Figure 3). The installer must make sure the engine-generator will not be overloaded when this isolation method is employed. He must select an engine-generator that will deliver the required watts of power (or amperes of current), with an additional small reserve of power (in case one or more loads might be added to the system later).

When the total circuit isolation method is used, select and install the transfer switch as follows:

- ☐ The ampere rating of the transfer switch must equal the ampere rating of the normal incoming UTILITY service.
- ☐ The transfer switch must be installed between the UTILITY service entrance and the building distribution panel.

NOTE: A 120/240 volts, single phase electric service is being supplied by the utility service in Figures 2 and 3.

Figure 2. Emergency Circuit Isolation Method



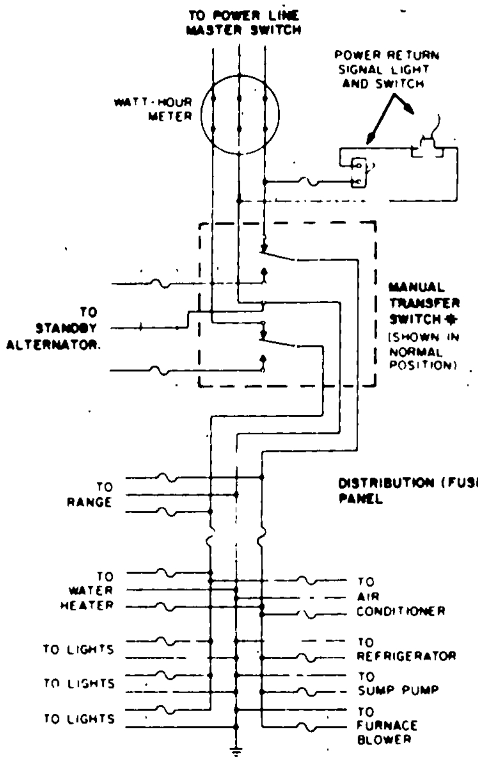
* AMPERE RATING MUST EQUAL OR EXCEED THE AMPERE RATING OF THE EMERGENCY DISTRIBUTION PANEL.

** AMPERE CAPACITY MUST NOT EXCEED THE ENGINE-GENERATOR RATING. ONLY THESE ITEMS WILL BE POWERED BY THE ENGINE-GENERATOR. IF THE ELECTRICIAN SIZES THE LOAD PROPERLY THE ENGINE-GENERATOR WILL NOT BE OVERLOADED.

ALL WIRING MUST CONFORM STRICTLY WITH THE NATIONAL ELECTRIC CODE AND/OR WITH STATE OR LOCAL CODES. CONSULT A QUALIFIED, LICENSED ELECTRICIAN.

THE ABOVE ILLUSTRATION ASSUMES THAT 120/240 VAC, 1-PHASE IS BEING SUPPLIED BY THE ELECTRIC UTILITY.

Figure 3. Total Circuit Isolation Method



*AMPERE RATING SHOULD BE EQUAL TO OR LARGER THAN THE MAIN (NORMAL) UTILITY SERVICE ENTRANCE AMPARAGE.

NOTE: CAUTION MUST BE USED TO AVOID OVERLOADING THE ENGINE-GENERATOR. TURN OFF UNNECESSARY LOADS TO PREVENT OVERLOADING.

ALL WIRING MUST CONFORM TO THE NATIONAL ELECTRIC CODE AND/OR STATE OR LOCAL CODES. CONSULT A QUALIFIED, LICENSED ELECTRICIAN.

THE ABOVE ILLUSTRATION ASSUMES THAT 120/240 VAC, 1-PHASE IS BEING SUPPLIED BY THE UTILITY.

Engine-Generators

A broad selection of GENERAC engine-generators is available. Units with diesel engines range from 8000 watts to 200,000 watts (8 to 200 kW) of AC power output. Models equipped with gasoline, natural gas, or LP gas fuel systems are rated from 12,000 to 100,000 watts (12 kW to 100 kW) of power. A listing of GENERAC engine-generator models can be found in the "*SPECIFICATIONS AND CHARTS*" chapter.

Transfer Switches

A complete line of automatic transfer switches is available, ranging from 100 to 2600 amperes. These switches can be equipped with one or more options and/or accessories, if desired. For information on transfer switches and related options/accessories, refer to the chapter entitled "*TRANSFER SWITCHES*".

Figure 4. Typical Installation with Engine-Generator Outdoors

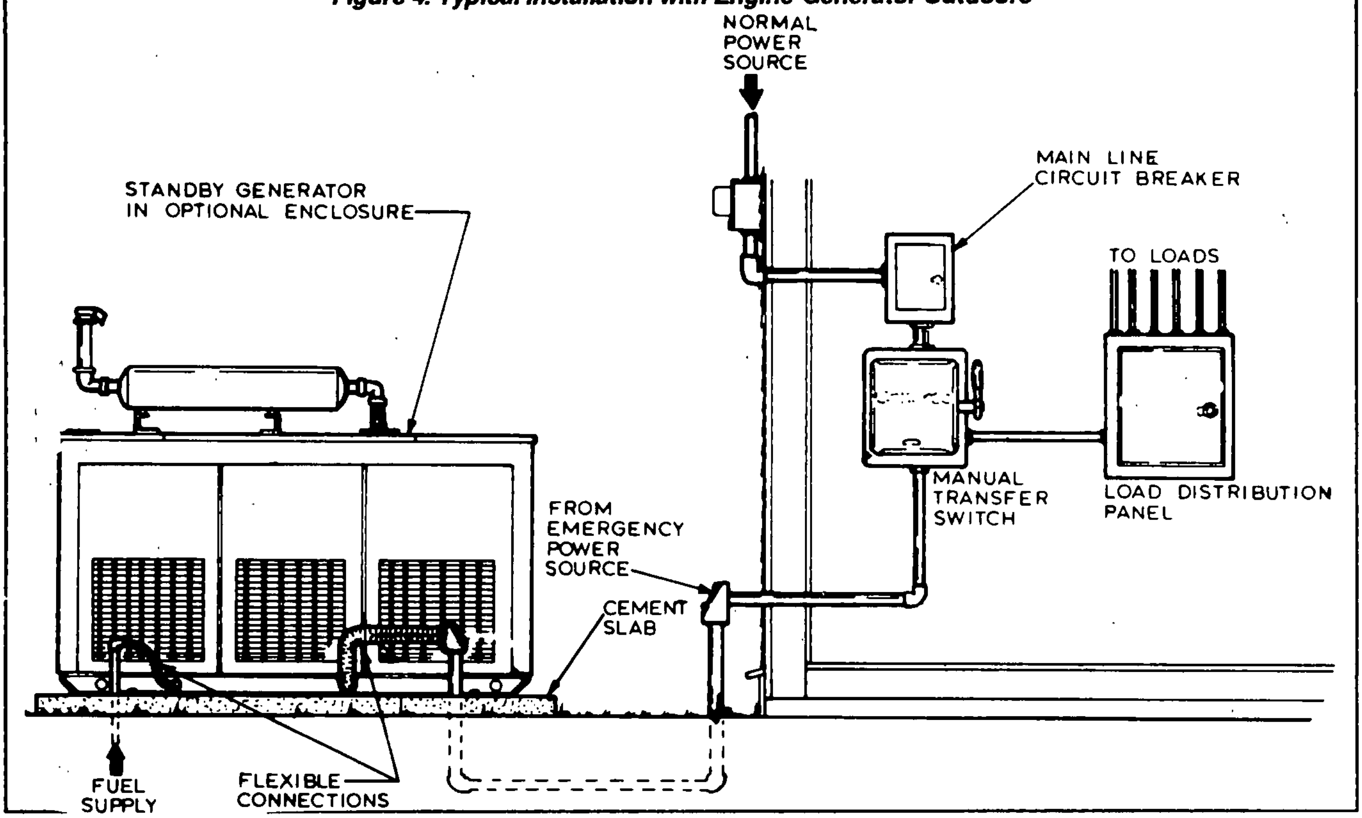
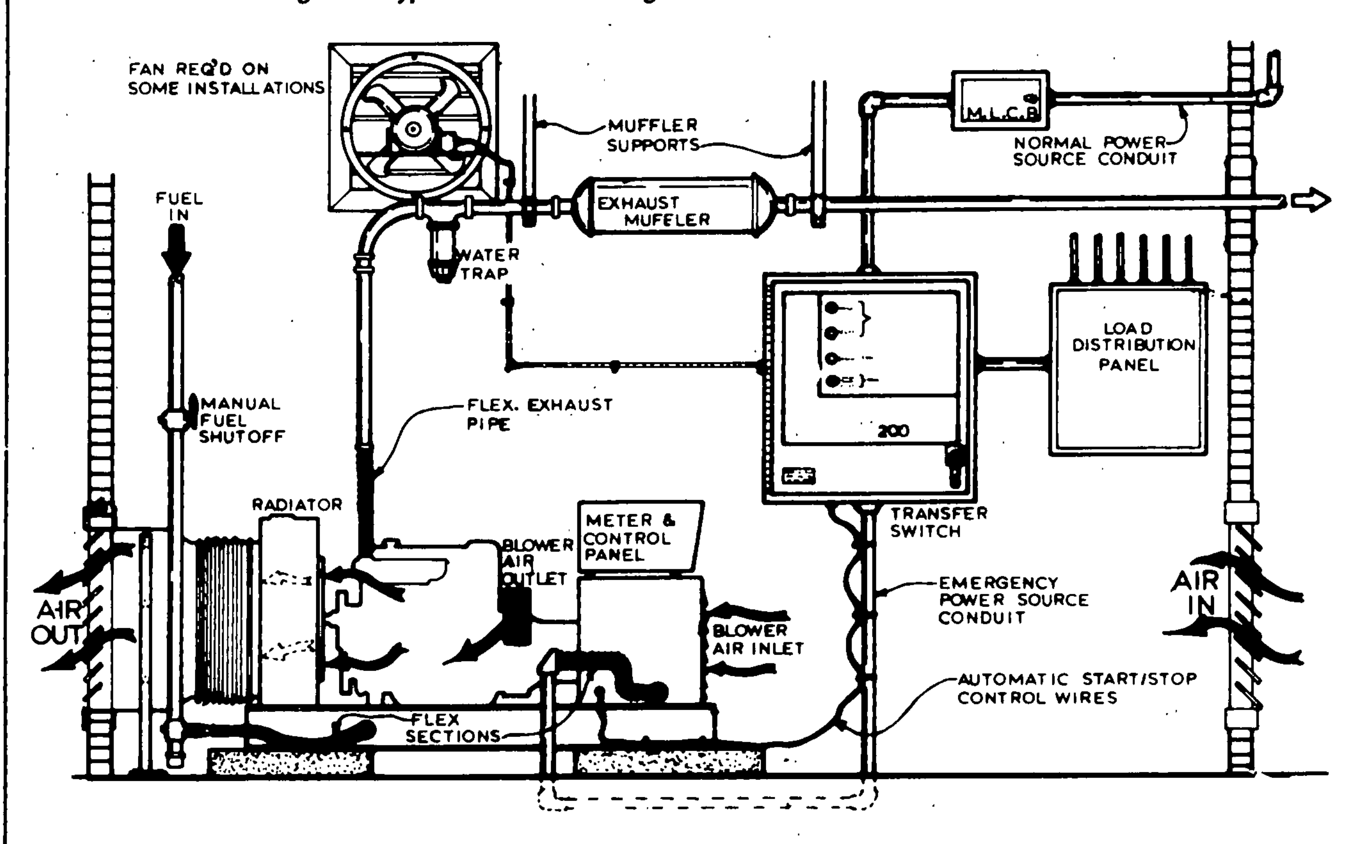


Figure 5. Typical Installation- Engine-Generator in a Detached Structure



Chapter 2. ENGINE-GENERATOR LOCATION & SUPPORT

General

The engine-generator set may be installed outdoors, outdoors on the roof of a structure, inside a detached structure, or in rooms within or attached to a structure. Wherever the location might be, all applicable codes, standards and regulations must be strictly complied with.

Selecting the Location

Proper planning for correct location of the engine-generator will make the difference between a good installation and a poor one. When planning the location, consider the following factors:

- ☐ The structure on which the engine-generator will rest must be strong enough to provide adequate support.
- ☐ The proposed site must be clean, dry and not subject to flooding.
- ☐ The location must permit noise and vibration to be effectively isolated.
- ☐ The site must provide easy access to the engine-generator for maintenance, servicing and repair.
- ☐ The location must permit engine exhaust gases to be piped safely away, to an area where people or animals will not be endangered.
- ☐ The site must permit an adequate fuel supply to be provided, at the least possible expense.
- ☐ The proposed location must permit sufficient cooling and ventilating air flow, with a minimum of ductwork.
- ☐ The engine-generator must be close to the transfer switch and to connected load circuits, so that wiring and conduit lengths are not excessively long.
- ☐ The proposed location must provide the best possible installation at the lowest possible cost.

Some Rules of Location

The following general rules are excerpted from NFPA No. 37, "STATIONARY COMBUSTION ENGINES AND GAS TURBINES":

OUTDOOR INSTALLATIONS:
See Figure 4, Page 5. Engine-generators that are installed outdoors, or outdoors on a roof, must be located at least 5 feet (1.5 meters) from openings in walls and at least 3 feet (0.9 meter) from structures having combustible adjacent walls.

INSTALLATIONS IN A DETACHED STRUCTURE:
Detached structures that house an engine-generator must be of non-combustible or fire resistant construction, in accordance with NFPA No. 220, "STANDARD TYPES OF BUILDING CONSTRUCTION".

ALL INSTALLATIONS:
The engine-generator should be installed in a clean, dry, dust-free area, away from corrosive vapors. In addition, the area must allow adequate normal and emergency lighting to be provided.

Supporting the Engine-Generator

VIBRATION:
Generac engine-generator sets are supported on steel rails. Vibration isolators are installed between the engine-generator and the rails, to drastically reduce the amount of vibration that is transmitted to the surrounding structure.

A SUPPORTING BASE:
Modern engine-generators with multi-cylinder, medium speed engines do not require massive concrete foundations. Fabricated steel bases have been proven to be quite satisfactory for engine-generator sets. Such steel bases require no special foundation, other than a floor or other structure that will accommodate the weight.

Concrete, however, does offer advantages in cost and in maintaining alignment of equipment. Like the steel base, the concrete base must be well isolated from the supporting floor or sub-floor. Fiber glass blocks are effective as isolation material for concrete blocks.

Concrete bases must be thick enough to prevent deflection. Bases that are too thick increase sub-floor or soil loading. An engine-generator base or foundation should never rest directly on natural rock formations to avoid the transmission of vibration.

A CONCRETE BASE:
When designing a concrete base, some guidelines that should be followed are:

- ☐ The length and width of the concrete base should exceed the length and width of the engine-generator by a minimum of at least 12 inches (0.305 meters) on all sides.
- ☐ The foundation depth should be sufficient to give the concrete base a weight that is equal to the engine-generator set weight.

To calculate the depth of the concrete base, the following formula may be used:

$$\text{Depth of Base} = \frac{W}{150 \times B \times L}$$

W= Total wet weight of engine-generator set in pounds (kg).

150= Density of the concrete (pounds per cubic foot).

2400= Density of concrete (kilograms per cubic foot).

B= Foundation width in feet (meters).

L= Foundation length in feet (meters).

Suggested mixture of concrete (by volume) is 1:2:3 of cement, sand and aggregate with a maximum four inch (100mm) slump with a 28 day compression strength of 3000 psi (200 MPa).

The concrete base should be reinforced with No. 8 gauge steel wire fabric, or equivelent, horizontally placed on 6 inch (150mm) centers.

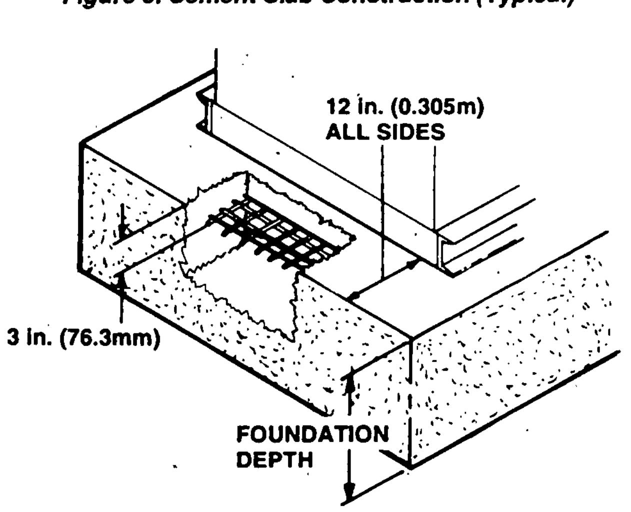
An alternate reinforcement method is to place No. 6 reinforcing bars on 12 inch (300mm) centers horizontally. Bars should clear the foundation surface a minimum of 3 inches (75mm).

OTHER CONSIDERATIONS:

The floor or structure on which the engine-generator rests must be able to support 125% of the engine-generator's weight.

If the engine-generator is to operate in parallel with other units, it is possible that out-of-phase paralleling might occur. Such out-of-phase parallėling can cause severe torque reactions and demand a stronger foundation. For that reason, when units are operated in parallel, their foundation must be designed to hold twice the unit's wet weight.

Figure 6. Cement Slab Construction (Typical)

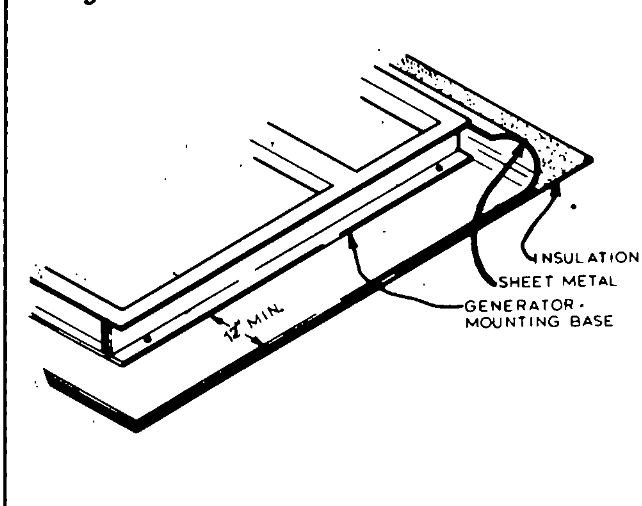


Combustible Floor & Roof Protection

If the engine-generator must be installed on any combustible floor or roof, comply with the following rules:

- ☐ Place a layer of non-combustible insulation, followed by a layer of sheet metal, beneath the unit's mounting base rails.
- ☐ Both the layer of insulation and the shet metal must extend beyond the engine-generator base, to a distance of at least 12 inches (30.5cm) on all sides.

Figure 7. Combustible Floor & Roof Protection



Chapter 3- AIR FLOW REQUIREMENTS

Introduction

Engine-generators require a supply of clean, fresh air for (a) cooling, (b) combustion, and (c) ventilation. Without an adequate flow of cooling and ventilating air into the unit, as well as unrestricted heated air flow away from the unit, serious problems will quickly develop.

The first noticeable effect of inadequate air flow may be overheating of the engine-generator. This may include excessively high coolant temperatures on water-cooled engine units. Inadequate air flow through the generator portion of the unit can result in overheating of the generator itself. Finally, without sufficient air flow for engine combustion, the engine may run rough, lose power, or simply not run at all.

Overtemperature Protection

Generac engine-generators are equipped with devices which protect the engine against damaging high engine coolant temperatures. These devices include (a) a high coolant temperature switch, and (b) a low coolant level sensor. In the event of either a high engine coolant temperature or a low coolant level (or both), the engine will shut down automatically. Refer to the OWNER'S MANUAL for your engine-generator model for additional information on these protective devices.

NOTE: Cooling, ventilation and combustion air requirements for most Generac engine-generators may be found in Chapter 13, "SPECIFICATIONS AND CHARTS".

Air Flow Through a Water-Cooled Engine-Generator

As a general rule, most Generac water-cooled engine-generators are equipped with a pusher type engine cooling fan. This type of cooling fan draws air around the engine and generator, then expels that air outward through the engine radiator. See Figure 8. Air flow across the radiator keeps the engine cool by extracting heat from the engine coolant. Any fumes given off by the engine breather system will be picked up and expelled by engine cooling fan action, as well.

In addition to the engine cooling fan, a centrifugal blower is attached to and driven by the generator rotor. This fan draws cooling air into the generator through louvered or slotted openings in the generator's AC connection (lower) panel, pulls the air through the generator interior, and then expels the heated air outward through a blower air outlet duct on the side of the generator. The air from the blower air outlet duct joins with engine cooling fan air flow, to be expelled away from the unit through the radiator.

Outdoor Installations

If the engine-generator is to be installed outdoors, one having an all-metal, weatherproof enclosure is recommended. Use of a unit with the correct factory installed compartment will generally ensure that cooling and ventilation needs are met. However, such factors as climatic conditions and the direction of the prevailing wind must be considered. The following general rules apply:

- ☐ Where strong prevailing winds are anticipated, face the generator's air inlet end (opposite end from engine radiator) into the wind.
- ☐ Plan the installation carefully, to prevent air openings in the compartment from becoming clogged with grass, leaves, snow, etc.

NOTE: In some cases, use of a windbreak might be required, to prevent air openings from becoming blocked.

Figure 8. Air Flow In a Typical Engine-Generator

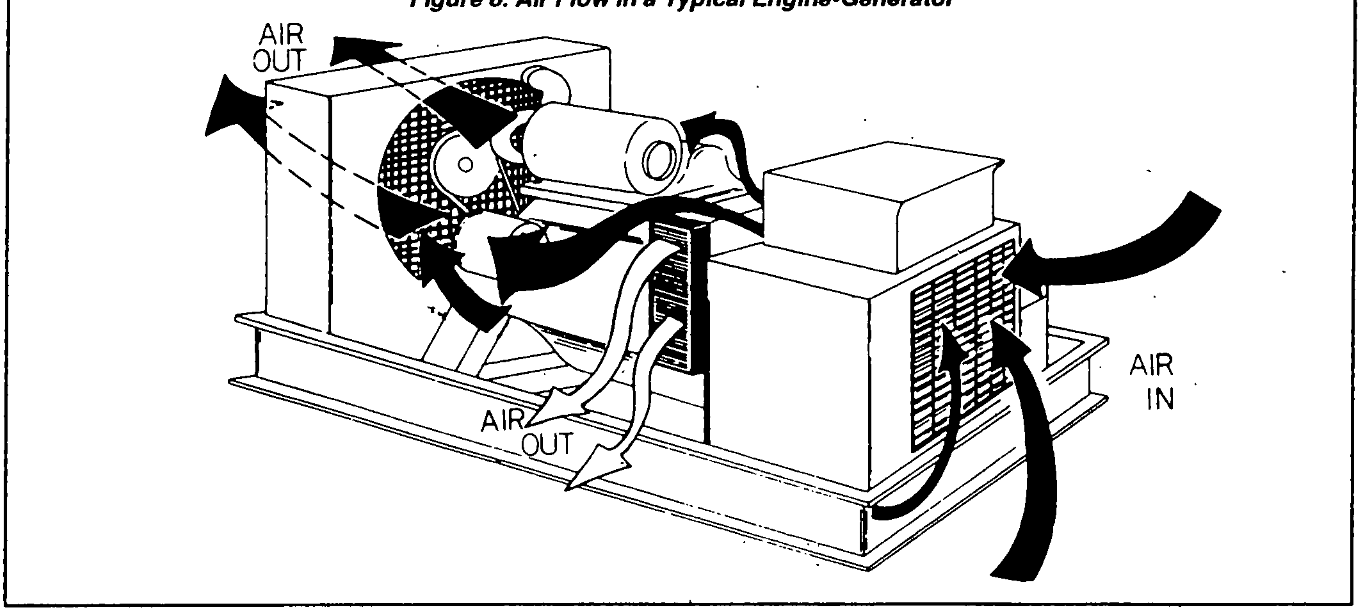
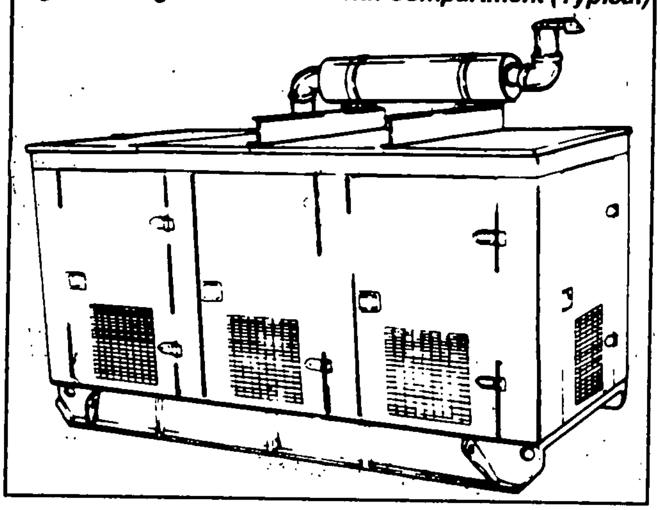


Figure 9. Engine-Generator with Compartment (Typical)



Air Flow for Indoor Installations

If the engine-generator is to be installed and operated inside a structure, the structure must be provided with (a) air inlet openings, (b) air outlet openings, and (c) ventilation openings. The following general rules apply:

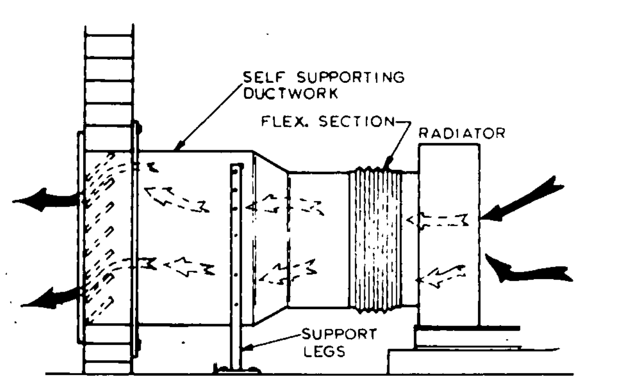
- ☐ Whenever possible, position the radiator air outlet opening so that air flows directly and horizontally to the outdoors. Use ductwork only when necessary (see "DUCTING OF AIR").
- ☐ The radiator air outlet opening in the building that houses the engine-generator must be at least as large as the radiator air duct.
- ☐ An air inlet opening must also be provided in the structure. This opening should be at least as large as the building's air outlet opening and preferably larger.
- ☐ Locate air openings in the structure such that already heated air and exhaust gases will not be drawn back into the structure.
- ☐ Louvers, screening, expanded metal and other materials used to cover air openings in a structure offer a restriction to the flow of air. Such restriction must be compensated for by making the actual air opening correspondingly larger.

Ducting of Air

The engine cooling fan moves a large volume of air during operation, This air must be properly ducted to the outside of the structure housing the engine-generator. The following rules apply to the ducting of air:

- ☐ Whenever possible, use no ductwork at all. Simpl position the engine-generator's radiator air duct so that heated air will be blown directly and horizontally to the building exterior (outdoors).
- ☐ If ductwork must be used, keep such ductwork as short as possible with a minimum number of bends.
- ☐ Recommended construction for air outlet ductwork is self-supported sheet metal. Use a flexible length of ductwork betwen the radiator air duct and rigid ductwork. This will help prevent damage that might otherwise be caused by vibration, shifting or settling.
- ☐ Engine cooling fans produce noise and expel a large volume of air. The air outlet opening in a structure must never be close to any adjacent structure or noise will be greatly amplified.

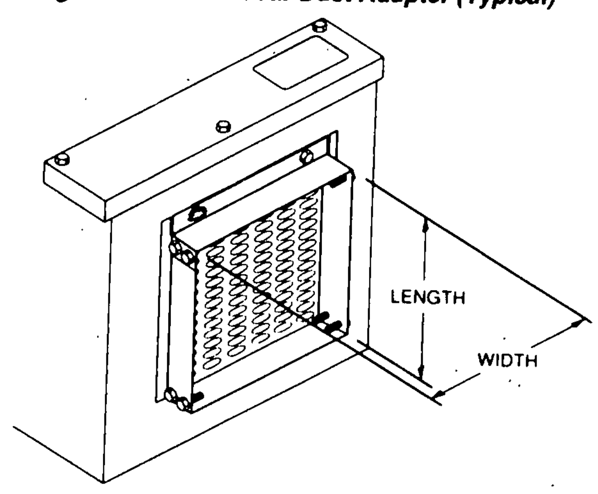
Figure 10. Air Outlet Ductwork (Typical)



Radiator Air Duct Adapters

When ductwork must be attached to the radiator air outlet of an engine-generator, a radiator air duct adapter is required. This adapter provides an extension around the outer periphery of the radiator, for attachment of ductwork. A typical air duct adapter is shown in Figure 11.

Figure 11. Radiator Air Duct Adapter (Typical)



Louvers, Screening, Expanded Metal

Louvers, screening or expanded metal may be used to cover air openings in a building housing an engine-generator. These materials offer a restriction to the free flow of cooling air. Such restriction must be compensated for by making the actual opening size proportionately larger.

LOUVERS:

Either fixed or moveable louvers may be installed on air openings in a building. To determine the number of louvered openings required, proceed as follows:

1. Multiply the length of the engine-generator's radiator air duct by its width, to obtain the actual air opening size required in square inches.
2. Multiply the length of a single louvered opening by the width of the louver, to find the area (in square inches) of a single louver.
3. Divide the actual air opening size required (Step 1) by the area of a single louver (Step 2), to find the number of louvered openings required.

EXAMPLE: The area of a generator's radiator air duct is 100 square inches (length times width). The area of a single louvered opening is 5 square inches (length times width of a single louver). Divide 100 by 5 to find the number of louvered openings needed. In this case the air opening must have at least 20 louvered openings.

SCREENING AND EXPANDED METAL:

These materials also offer a restriction to air flow. This restriction must be compensated for by making the actual air opening larger. Both materials are usually given a "Free Air Inlet Area" value by the manufacturer, given as a percentage. To find the actual size of an air opening (inlet or outlet) when screening or expanded metal are to be used, proceed as follows:

1. Find the area of the engine-generator's radiator air duct by multiplying its length times its width.
2. Determine the "Free Air Inlet Area of the screening or expanded metal to be used. This percentage value is available from the screening or expanded metal manufacturer.
3. Divide the radiator air duct area (Step 1) by the "Free Air Inlet Area" of the material to be used (Step 2), to determine the actual area of the air opening.

EXAMPLE: The radiator air duct of an engine-generator measures 20 by 20 inches, giving it an area of 400 square inches. Screening having a "Free Air Inlet Area" of 70 percent is to be used to cover air openings in the structure. Divide "400" by "0.70", to obtain an actual minimum air opening size of 571.43 square inches. An air opening measuring 24 by 24 inches will meet this requirement (24 x 24=576 square inches).

Exhaust Fans

Some indoor installations may require that one or more exhaust fans be used, to provide adequate ventilation. Such fans must have the proper rated flow rate and must be located where exhaust fumes will not be drawn into the structure.

Figure 12. Air Opening with Fixed Louvers

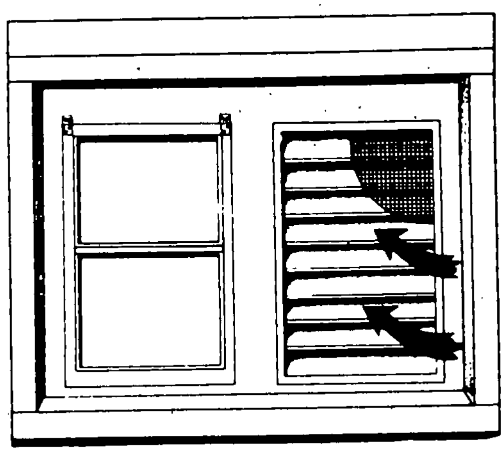


Figure 13. Air Opening with Moveable Louvers

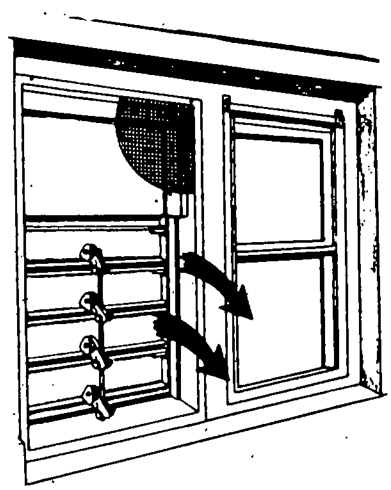
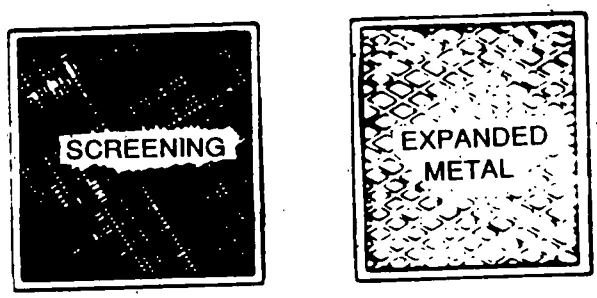


Figure 14. Screening and Expanded Metal



Chapter 4. REMOTE RADIATOR SYSTEMS

Introduction

In some instances, the engine-generator set must be located inside a structure where air openings cannot be provided. For example, an underground or basement installation where air, ductwork would be excessively long. Such an installation might require the use of a remote radiator system.

When a remote radiator system is used, the engine-mounted radiator and cooling fan are generally omitted. Instead, an electrically operated cooling fan is installed in conjunction with the remote radiator. Engine coolant is circulated through the engine water jacket, where it picks up heat from the engine. The heated coolant is then pumped to the remote radiator, circulated through the radiator where it is cooled by air flow, and then returned to the engine.

NOTE: The amount of heat rejected to the engine coolant will vary depending on a variety of factors. Heat rejection to coolant ranges from approximately 40,000 BTU's per hour for some smaller water-cooled units to about 600,000 BTU's per hour for larger engines. A "BTU" (British Thermal Unit) is the amount of heat required to raise the temperature of one (1) pound of water 1° Fahrenheit.

Figure 15. Typical Vertical Remote Radiator

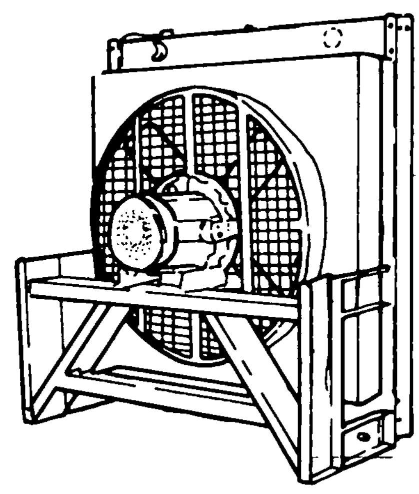
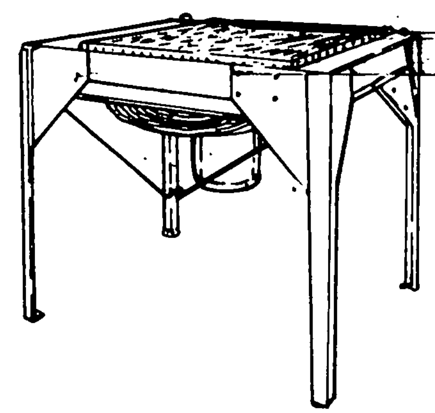


Figure 16. Typical Horizontal Remote Radiator



Types of Remote Radiators

The remote radiator used in any given installation must have an adequate cooling capacity for the specific installed engine-generator. The installer should work closely with the engine-generator manufacturer and the remote radiator supplier, to ensure that the proper remote radiator is installed.

Two different major types of remote radiator are available, i.e., vertical or horizontal. The type selected will depend on the requirements of the specific installation. Figure 15 shows an example of a typical VERTICAL remote radiator. Figure 16 is a typical HORIZONTAL remote radiator.

General Rules for Remote Radiators

The following general rules apply to remote radiator installations:

- ☐ In some installations, the engine coolant pump can provide adequate coolant flow to the remote radiator and no other pump is required.
- ☐ If the length and restrictions of cooling system lines results in a pressure drop greater than 2 psi (pounds per square inch), use of an AUXILIARY pump is required.
- ☐ If the remote radiator must be installed more than 21 feet above the engine water pump, use of a "Hot Well" is recommended. See "HOT WELL".
- ☐ The top of the remote radiator must be the highest point in the system or the remote radiator system will not function properly.
- ☐ The remote radiator's electric fan should be connected to the engine-generator's AC output. When this is done, the electric fan will operate only when the engine-generator is running.
- ☐ Proper sizing of the remote radiator is necesary, to meet the needs of the specific engine-generator.
- ☐ Always test the remote radiator fan for correct direction of rotation, as specified by the radiator manufacturer.
- ☐ Hoses and piping used in any remote radiator system must be externally supported and not hung on the radiator.
- ☐ Use FLEXIBLE lengths of hose at the engine-generator connection and at the remote radiator.
- ☐ Install a strainer or sediment trap in the coolant line to the remote radiator.

General Rules for Remote Radiators (Continued)

- ☐ Be sure to fill the remote radiator system with the recommended coolant mixture. See "RECOMMENDED COOLANT MIXTURE".
- ☐ The remote radiator is often overlooked during periodic inspections. For this reason, the installer may wish to consider use of "low coolant level alarms" or "automatic coolant makeup" controls.

A Simple Remote Radiator System

A simple remote radiator system is shown in Figure 17. The radiator is equipped with a radiator pressure cap, for filling the system and for venting air from the system. A strainer is provided in the radiator inlet line, to trap dirt, scale and impurities. An AUXILIARY PUMP is required if line restrictions result in a pressure drop greater than 2 psi (0.141 kg/cm^2). Rigid coolant lines may be used, except at engine and remote radiator connection points. Maximum vertical height of the remote radiator above the engine water pump is 21 feet (6.4 meters).

Remote Radiator System with Surge Tank

When the remote radiator is NOT the highest point in the system, use of a SURGE TANK is required. See Figure 18.

The surge tank provides fill, vent and surge functions for the system. Equip the surge tank with a coolant level sight gauge, pressure cap, vent and with coolant makeup. Notice that a vent line is required between the engine-to-radiator line and the surge tank if the engine is higher than the radiator.

The arrangement shown in Figure 18 allows radiator and engine de-aeration and provides a positive pressure at the engine water pump inlet. A strainer is used in the line between the remote radiator inlet and the engine coolant outlet. Be sure to elevate the surge tank sufficiently to overcome line restrictions between the radiator and the engine water pump. If the engine water pump is higher than the remote radiator, a VENT LINE is required.

Remote Radiator with Heat Exchanger

See Figure 19. In this type of remote radiator system, the remote radiator is used to cool heat exchanger water. The remote radiator is NOT the highest point in the system. A surge tank is installed in an elevated position and is used to provide fill, vent and surge protection. Provide the surge tank with a glass sight gauge, overflow tube, pressure cap, a vent, and with coolant makeup connections. The "Fill and Vent Line" from bottom of surge tank connects to the top of the radiator. Elevate the surge tank sufficiently to overcome the restrictions between the remote radiator and the engine water pump.

Figure 17. A Simple Remote Radiator System

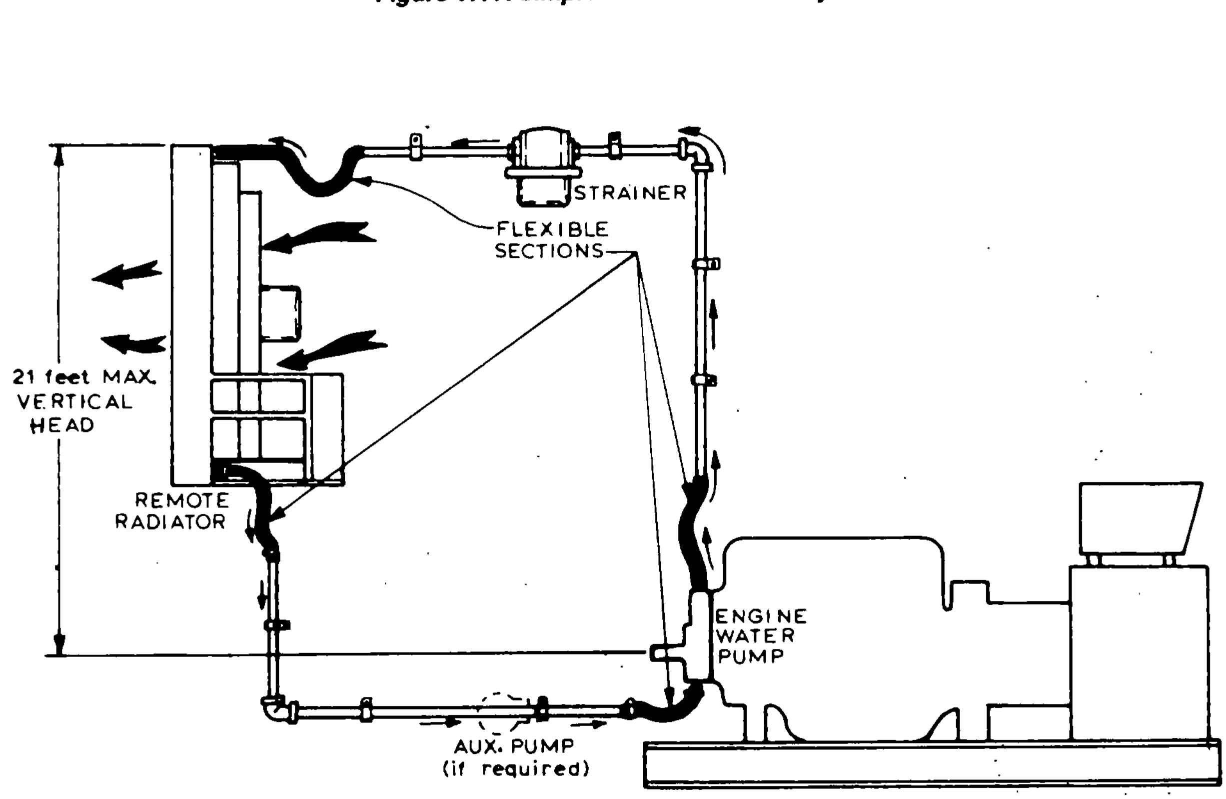


Figure 18. Remote Radiator System with Surge Tank

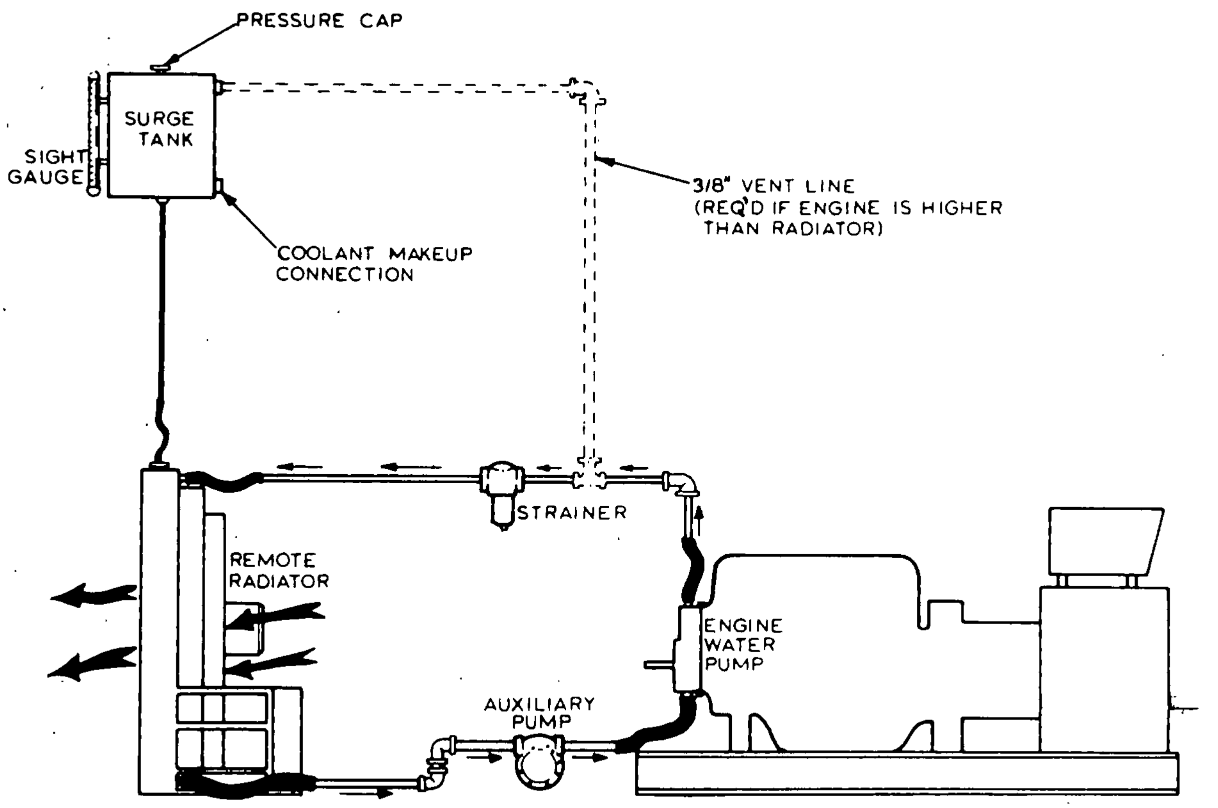
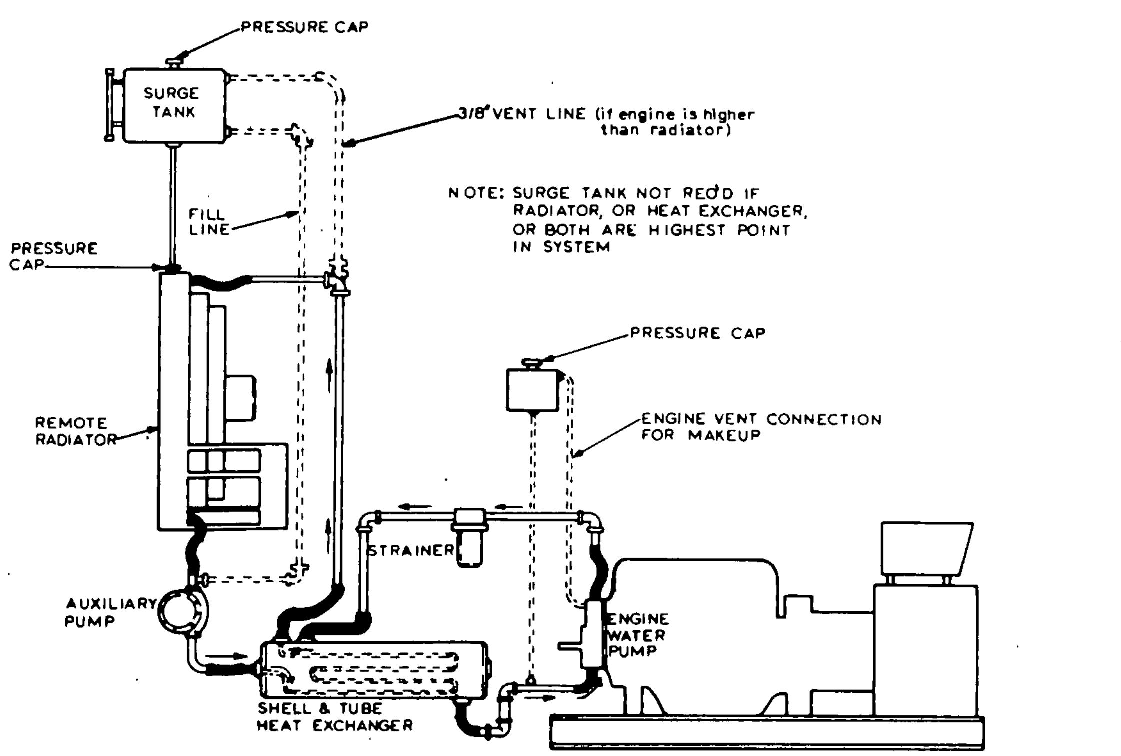


Figure 19. Remote Radiator System with Heat Exchanger



Hot Wells

If the remote radiator must be installed more than 21 feet (6.4 meters) above the engine-generator water pump, a hot well is required. The hot well prevents engine gaskets and hoses from leaking due to excessive head pressure. Locate the hot well at the same level as the engine (Figure 20). Head presures are confined to the hot well and coolant is circulated through the engine at normal temperatures and pressures.

A hot well is divided into a "hot" and a "cold" side. Heated coolant from the engine water pump is delivered to the hot side of the well. The hot coolant is then drawn off by an auxiliary pump and delivered to the remote radiator, where it is cooled by air flow across the radiator. From the remote radiator the coolant flows back to the cold side of the hot well and, from the cold side, back to the engine weater pump.

Ventilating and Combustion Air

Use of a remote radiator system does NOT eliminate the need for adequate air flow into the structure housing the engine-generator. Air must be provided into the structure for engine combustion, generator cooling, and for heat and fumes removal. Air inlet openings into the room or structure that houses the unit must be of adequate size. In addition, one or more exhaust fans may be needed to move the required volume of air. In some cases, water-cooled exhaust manifolds may be needed to reduce the amount of radiated heat.

Recommended Coolant Mixture

Recommended coolant mixture is a 50-50 mixture of low silicate, ethylene glycol base anti-freeze and soft water. The soft water should be slightly alkaline, having a pH factor of "8" or more. If desired, a high quality rust inhibitor may also be added to the mixture. However, the rust inhibitor used must be compatible with ethylene glycol base anti-freeze.

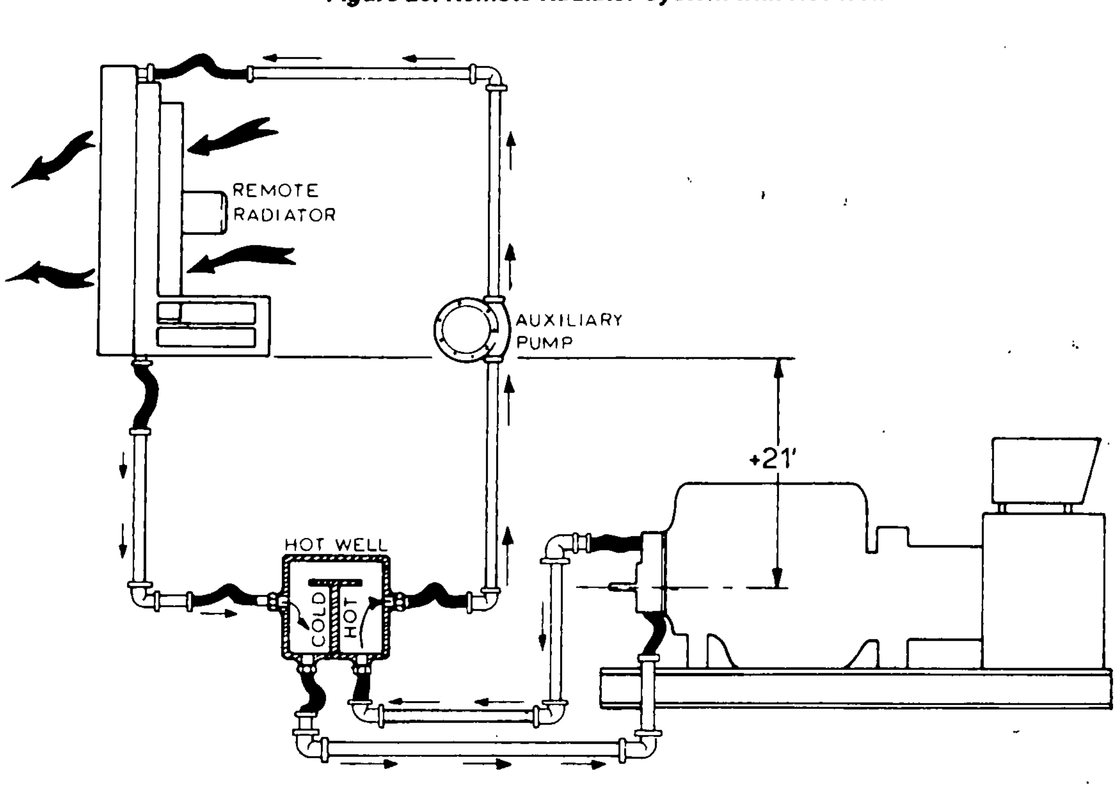
Some more commonly used rust inhibitors are chromates, borates, nitrates, nitrites and soluble oil. DO NOT use any chromate base inhibitor with ethylene glycol base anti-freeze, or the formation of "chromium hydroxide" will result. Chromium hydroxide is often called "green slime". Its presence in the engine cooling system will adversely affect the heat transfer rate and cause overheating. Systems that have been operated with a chromate base inhibitor must be chemically cleaned before adding ethylene glycol base anti-freeze.

NOTE: Borate-nitrite solutions are compatible with ethylene glycol base anti-freeze and can be used to replenish the original rust inhibitors in the anti-freeze.

Radiator Selection & Installation

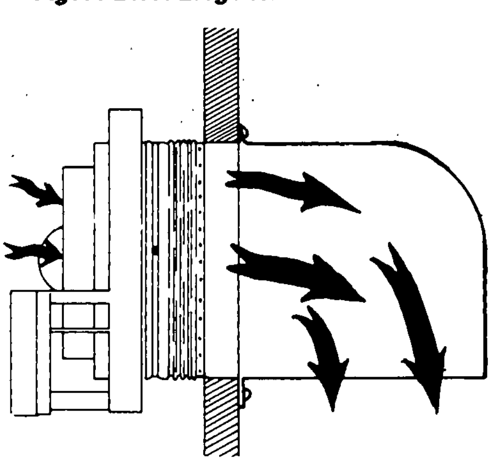
Radiators should be installed so that a continuous supply of fresh air will be available to the radiator and so that recirculation of air will be prevented.

Figure 20. Remote Radiator System with Hot Well



When a radiator, with its cooling fan, is installed in an opening of the building wall, the direction of prevailing wind should be given considerartion. If the wind direction is changeable, provide an air duct outside the wall to direct the air inlet or outlet (as the case may be) in a vertical direction. Use a large radius "L" air duct to avoid restricted flow or air turbulence. Horizontal remote radiators using vertical air flow are often used to nullify the effects of changing wind direction.

Figure 21. A Large Radius "L" Air Duct



Radiators should be sized to accommodate the necessary air flow required at the given altitude. When altitudes are above sea level, air flow (in cubic feet per minute) should be increased to maintain the equivalent air flow per unit of time required at sea level. Radiators should be sized to accommodate a heat rejection load at least 15 percent greater than the established heat rejection of the engine.

***NOTE:** Heat rejection ratings of many Generac engine-generators may be found in Chapter 13, "SPECIFICATIONS AND CHARTS".*

Heat Exchanger Selection and Location

<u>SELECTION:</u>

As with radiators, heat exchangers should be sized to accommodate a heat rejection rate approximately 15 percent greater than the established engine heat rejection.

The selected heat exchanger should accommodate raw water temperature and flow sufficient to cool the engine when operating at maximum anticipated load. The temperature differential between jacket water in and out of the heat exchanger should not exceed 20° F. (11° C.), and should not be less than 10° F. (6° C.). The temperature of coolant entering the engine should not be below the usually recommended 180° F. (82° C.).

<u>LOCATION:</u>

Heat exchangers should always be located at a lower level than the coolant level in the surge tank, preferably several feet lower. The surge tank must be the highest level in the circuit and must be located downstream from the heat exchanger.

Coolant Line Sizes

Cooling system lines must be large enough to flow sufficient coolant to and from the engine, and throughout the entire system. In addition, the number of elbows or bends in the system must be kept to a minimum. If lines are too small or if too many elbows are used, the volume of coolant flowing through the system will be inadequate.

Chapter 13, "SPECIFICATIONS AND CHARTS", contains charts which list the coolant flow of many Generac engine-generators, in cubic feet per minute.

Chapter 5. CITY WATER COOLING SYSTEMS

A Simple City Water Cooling System

See Figure 22. The simple city water cooling system shown uses water from the city water system. The water circulates through the engine water jacket. An equal volume of water is forced into a sewer drain. A "thermostatic control valve" maintains desired operating temperature by mixing the water.

City Water System with Heat Exchanger

A more uniform control of operating temperatures may be achieved by means of a "shell and tube" heat exchanger. Colant in this system is circulated from the engine water pump and through the engine water jacket, where heat is picked up from the engine. Heated coolant from the water jacket flows to a surge tank, through the heat exchanger, and then back to the engine water pump.

City water is ported through tubes in the heat exchanger. Heated engine coolant is ported around the tubes. The city water absorbs heat from the engine coolant. The hot city water is then piped to a sewer drain, as regulated by a thermostatic control valve.

Flexible Hoses

Install a flexible length of hose between the engine-generator connection and rigid city water system piping. This will help prevent line breakage that might otherwise be caused by vibration, shifting or settling of the engine-generator. The flexible hoses must comply with the following:

- ☐ The hoses must be approved for use with engine coolant.
- ☐ The hoses must be able to withstand the temperatures and pressures to which they will be subjected.
- ☐ All piping, flexible or rigid, must be tested for leaks. No leakage is permitted.

Ventilating and Combustion Air

Use of a city water cooling system does not eliminate the need for adequate air openings into the building for generator cxooling, ventilaticn and engine combustion. Such air openings must be of adequate size. In addition, one or more exhaust fans might be required to move the required volume of air through the room housing the engine-generator.

Figure 22. A Simple City Water Cooling System

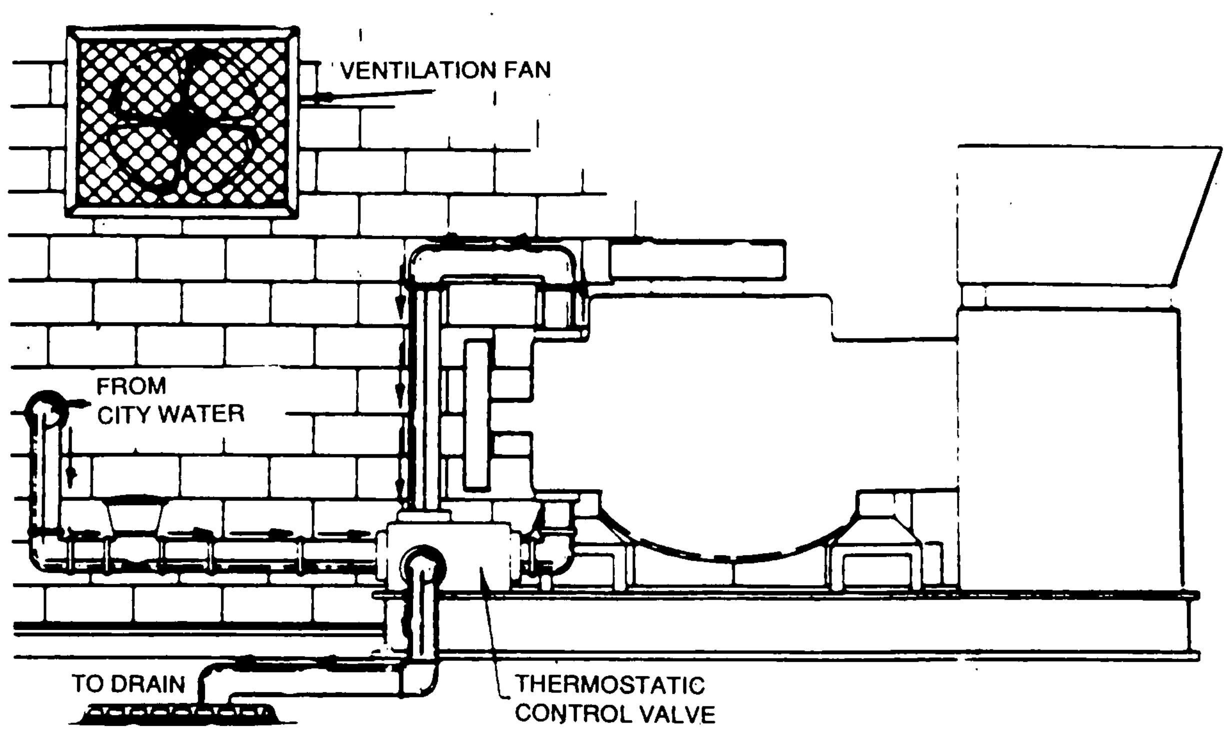
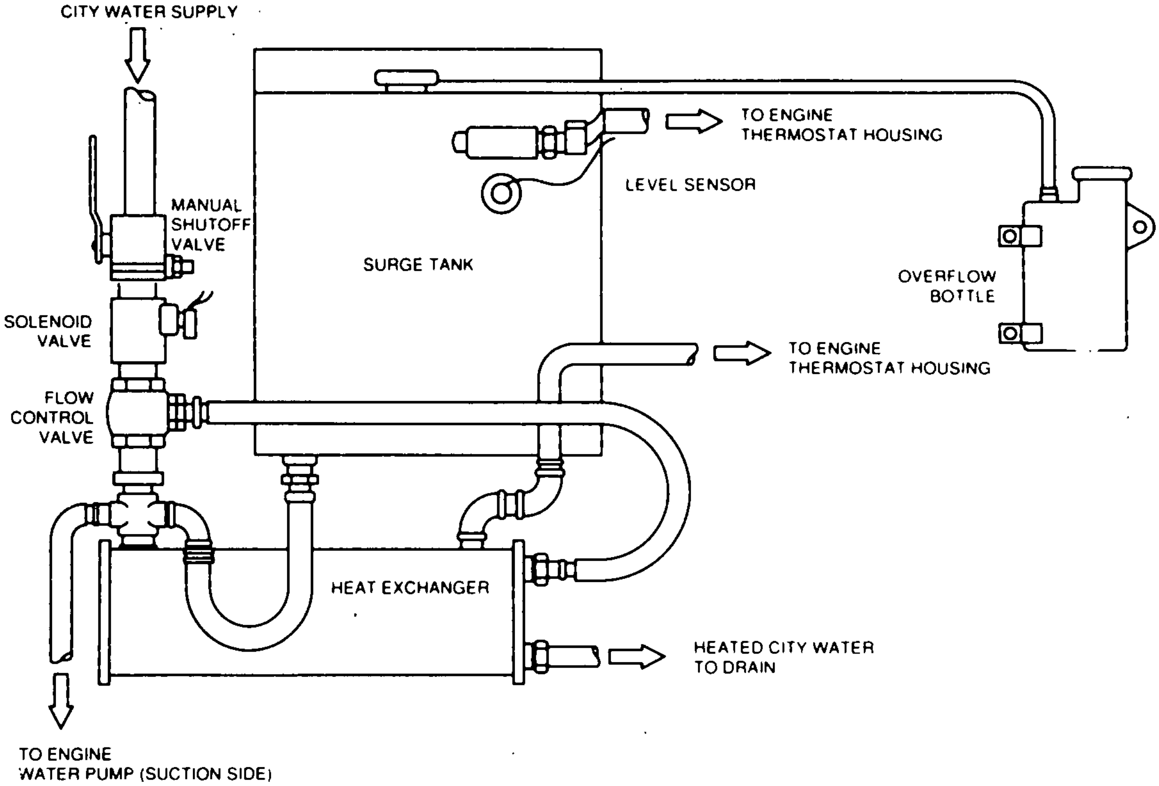


Figure 23. City Water System with Heat Exchanger and Surge Tank



Chapter 6. THE COOLING TOWER

General

The "cooling tower" method of cooling is especially designed for use in extremely dry, arid climates. The system uses the evaporization method of cooling.

Description

TWO SEPARATE SYSTEMS:

The cooling tower consists of two separate systems, as follows:

- ☐ **The Engine System:** Includes the engine water pump, water jacket and a heat exchanger.
- ☐ **The Raw Water System:** Consists of a cooling tower, auxiliary water pump, and the tube portion of the heat exchanger.

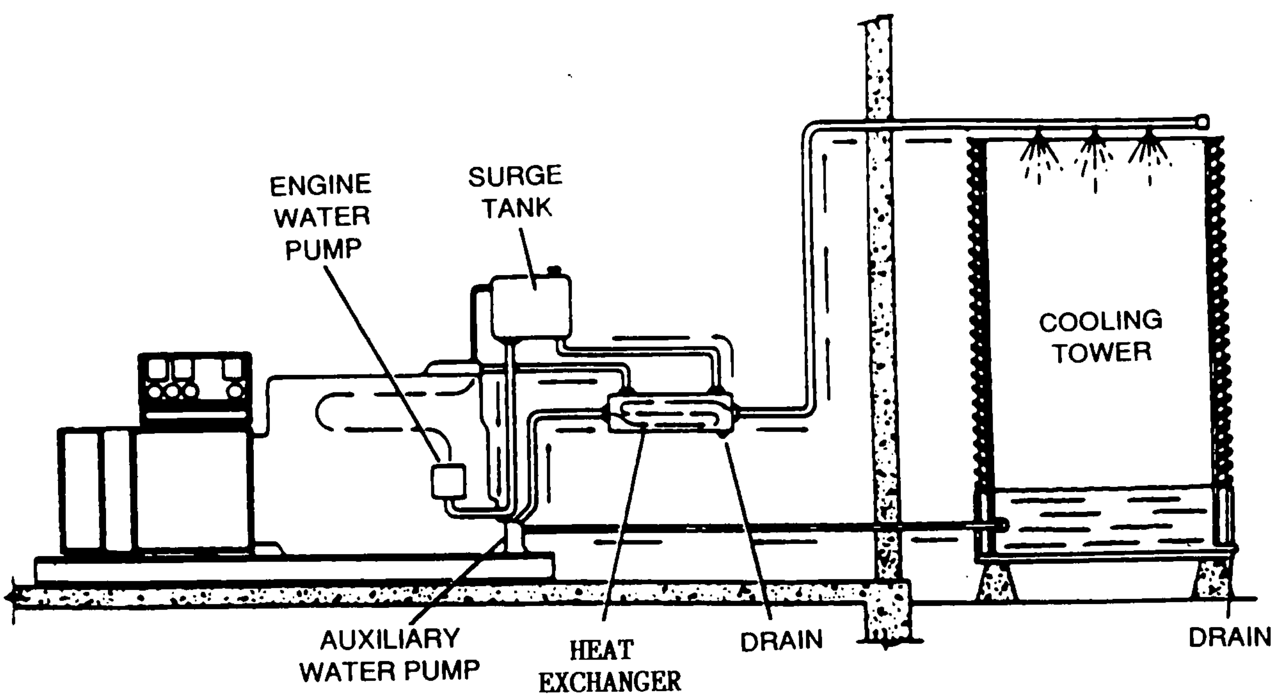
OPERATION:

Raw water circulates through the heat exchanger tubes, to absorb heat from the engine coolant that flows through the shell portion of the heat exchanger.

Heated raw water then flows to the top of the cooling tower and is sprayed down into the towerTower construction permits air to flow through the spray, thus cooling the sprayed water. Some eveporation will occur. However, some water collects at the base of the tower and is recirculated.

Because of the evaporation process, water makeup must be provided.

Figure 24. Typical Cooling Tower



Chapter 7. ENGINE-GENERATOR EXHAUST SYSTEMS

Introduction

Engines used to drive generators give off deadly carbon monoxide gas through their exhaust systems. This dangerous gas, if breathed in sufficient concentrations, can cause unconsciousness or even death. For that reason, engine exhaust gases must be piped safely away from any structure housing an engine-generator and to a well ventilated area where people or animals will not be endangered.

In addition to the dangers of carbon monoxide poisoning, exhaust piping becomes extremely hot during operation. The piping tends to remain very hot for a long time after shutdown. For that reason, the following precautions are necessary:

- ☐Avoid contact with hot engines, engine exhaust manifolds, exhaust piping and mufflers. Contact with any of these can result in serious burns.
- ☐Where exhaust piping must pass through combustible walls or ceilings, special precautions must be taken to prevent heat damage.
- ☐The precautions outlined under "GENERAL RULES FOR EXHAUST SYSTEMS" must be strictly complied with.

General Rules for Exhaust Systems

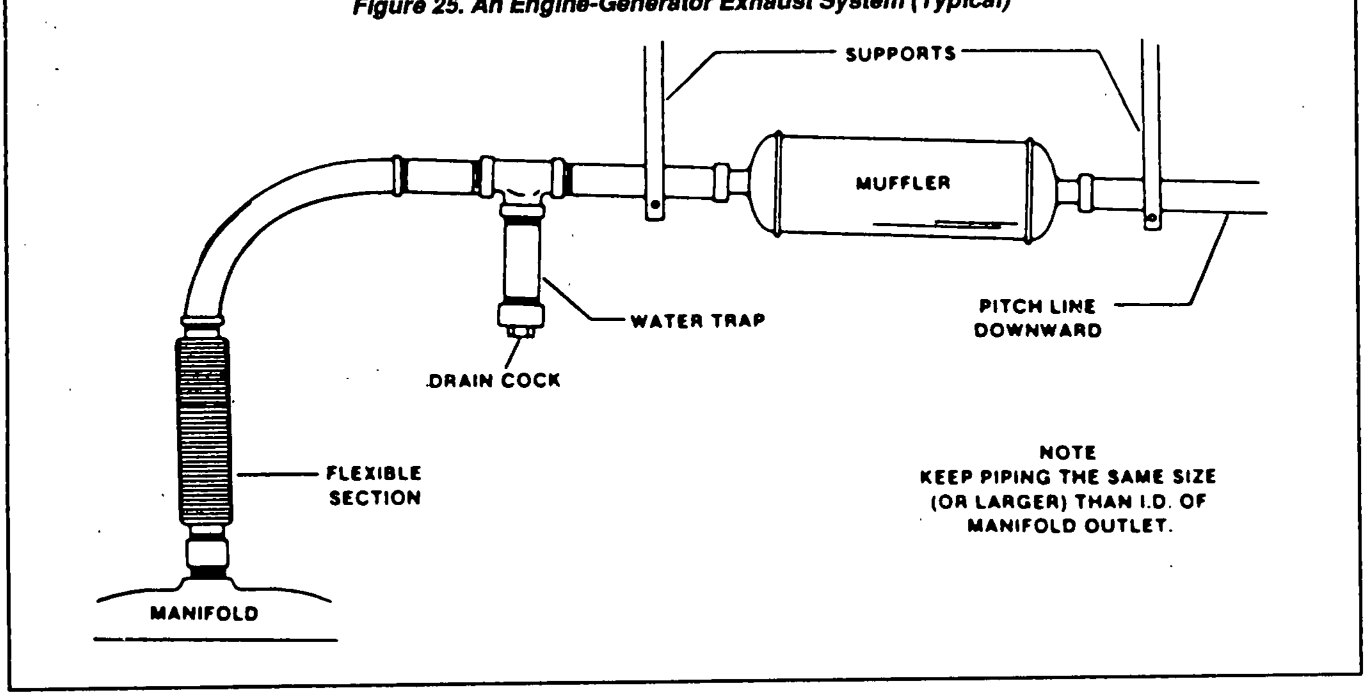
When installing an exhaust system for an engine-generator, the following general rules should be considered:

- ☐Exhaust piping should be constructed of wrought iron or steel having adequate strength and durability.
- ☐Exhaust FITTINGS may be of cast iron.
- ☐Low points in horizontal runs of piping should be provided with condensate traps, as well as suitable condensate drains.
- ☐Exhaust piping and mufflers must be properly supported and connected.
- ☐Use a flexible length of exhaust pipe between the engine exhaust manifold and rigid exhaust piping. This will help prevent breakage that might be caused by vibration, shifting or settling.
- ☐Exhaust piping must be properly terminated outside a structure housing an engine-generator, in such a manner that hot gases or sparks will be discharged harmlessly and will not blow against any combustible surface or material.
- ☐Exhaust piping must not terminate under loading platforms, structures, or near any opening in a building.
- ☐Where necessary, exhaust piping should be guarded to prevent burns.
- ☐Provide a clearance of at least nine (9) inches (22.9cm) between exhaust piping and any combustible surface.
- ☐Keep exhaust piping well clear of fuel tanks, fuel lines, etc.

Routing Piping Through Combustible Walls

If exhaust piping must be routed through any combustible wall or partition, the piping must be guarded at the point of passage by either of the following methods:

Figure 25. An Engine-Generator Exhaust System (Typical)



1. A ventilated metal thimble that is at least 12 inches in diameter larger than the exhaust piping, OR
2. Metal or burned fire clay thimbles built in brickwork that provides not less than eight (8) inches (20.3cm) between the clay thimble and any combustible material.

Routing Piping Through Combustible Roofs

Exhaust piping that passes through any combustible roof must be separated from the roof by a ventilated metal thimble that is at least 6 inches (15.2cm) larger in diameter than the piping. The thimble must extend at least 9 inches (22.9cm) above and below roof construction.

Preventing Excessive Back Pressure

Excessively high back pressure in an engine exhaust system will prevent the complete emission of exhaust gases. This, in turn, will result in incomplete combustion on the subsequent power stroke and engine performance will be adversely affected.

High back pressure in an exhaust system can be caused by one or more of the following:

1. Exhaust piping diameters that are too small.
2. Too many bends in the exhaust piping.
3. Exhaust piping runs that are excessively long.
4. Restrictions in exhaust piping.

As a general rule, the maximum allowable exhaust system back pressure on Generac water-cooled engines is 1.5 inches Hg (mercury).

As the length of exhaust piping runs increases, pipe diameters must be increased to prevent excessive back pressure.

NOTE: A "Recommended Exhaust Pipe Diameter" chart may be found in Chapter 13, "SPECIFICATIONS AND CHARTS".

Figure 26. Routing Exhaust Piping Through a Combustible Wall

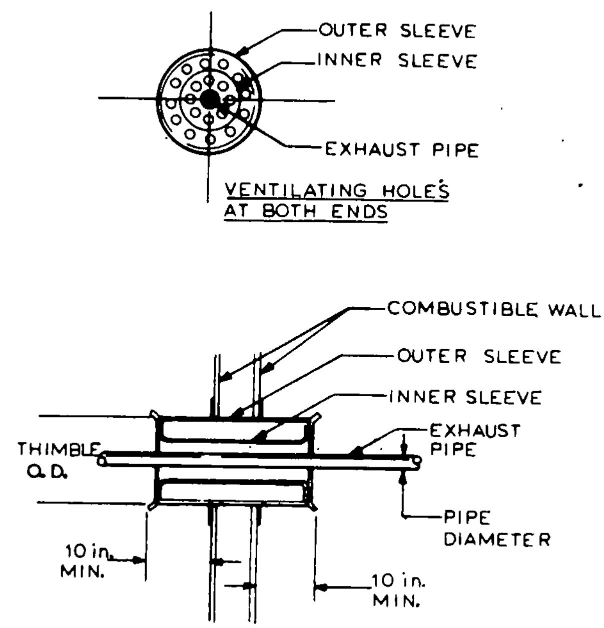
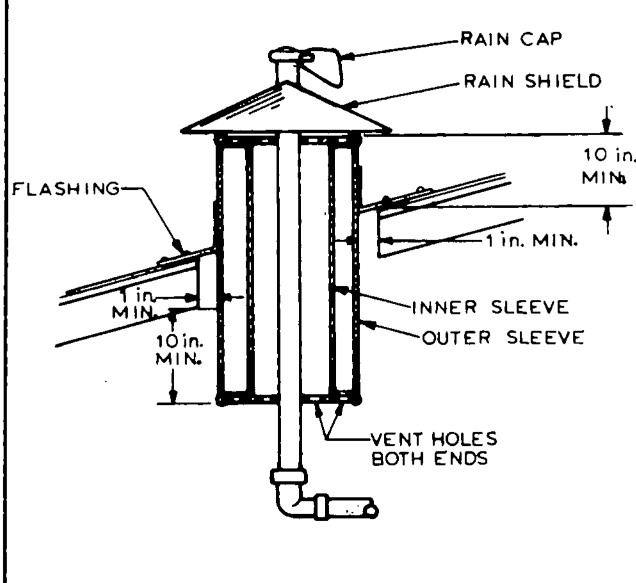


Figure 27. Routing Exhaust Piping Through a Combustible Roof



Chapter 8. DIESEL FUEL SYSTEMS

Introduction to Diesel Fuel Systems

Diesel fuels are less volatile than gasoline or gaseous fuels and, for that reason, are considered safer than such fuels. Some localities permit diesel fuel tanks of considerable size inside a building.

Because diesel fuel is relatively safe, careless installation practices often result, which can lead to serious problems with engine-generator performance and reliability. A good fuel system installation can often mean the difference between good and poor engine performance.

One common problem in diesel fuel systems is the failure to tighten fuel supply lines properly. An improperly tightened fuel line or fitting may show no indication of leakage, but can permit air to enter the fuel lines. Air that is present in the system will result in hard starting and rough engine operation.

The installer must ensure that all codes, standards and regulations pertinent to diesel fuel systems are strictly complied with. Then, following installation, the system must be inspected and tested periodically to make sure all components are in good working order.

Recommended Diesel Fuels

Generac recommends the use of Grade No. 2D diesel fuel when ambient temperatures are above freezing; and Grade No. 1D diesel fuel when temperatures drop below freezing. In addition, the fuel used should have a "Cetane" number as follows:

- ☐A Cetane number of at least "50" for units capable of automatic start.
- ☐A Cetane number of at least "40" for units that will be cranked and started manually (electrically).

Diesel fuel properties are defined by the "American Society of Testing and Materials" (ASTM).

Diesel Fuel System Piping

Use black iron pipe or steel tubing in the diesel fuel supply system. Install a flexible length of fuel line between the generator fuel connections and rigid piping. This will help prevent breakage or leaks that might otherwise be caused by vibration, shifting or settling. The flexible fuel line must be APPROVED for use with diesel fuel.

!CAUTION!

DO NOT use any galvanized piping or tanks in the diesel fuel system. Diesel fuel will react chemically with the galvanized coating, causing the coating to "flake". Such "flaking" will clog filters or cause injection pump failure.

Diesel Fuel Supply Tanks

The best location for diesel fuel supply tanks is at the same general level as the engine's fuel injection pump, but lower than the fuel injectors. If the main supply tank is located near the engine-generator, and vertical lift is 40 inches (1 meter) or less, the engine's fuel injection pump will be able to deliver sufficient fuel to the engine. However, if vertical lift exceeds 40 inches (1 meter) and long horizontal piping runs are used, an auxiliary pump or a day tank may be required.

NOTE: As a general rules, an auxiliary pump will be neded when dynamic suction and static head exceed 6 inches or Hg (mercury).

The fuel tank must be properly vented to allow air and gases to escape. The vent system must prevent entry of dust, dirt and moisture back into the tank.

Fuel return lines should enter the tank at least 12 inches (30.5cm) from the fuel pickup or fuel dip tube, to prevent air bubbles from entering the fuel supply line.

Allow at least 5 percent of the tank capacity for fuel expansion- DO NOT OVERFILL.

Day Tanks

A DAY TANK is a diesel fuel tank located inside a structure that supplies diesel fuel to the engine-generator.

Day tanks that range in size from 5 to 100 gallons (21.1-422.7 liters) are available from Generac. Unless otherwise specified, Generac day tanks are equipped with a pump having a 2 GPM (gallons per minute) flow rate and an 18 foot (5.5 meter) lift capacity.

The day tank draws fuel from the main supply tank and delivers it to the engine fuel system.

NOTE: Piping diameters that are too small, bends and other restrictions can reduce the lift capacity of the day tank pump considerably. If the installation requires a lift in excess of 18 feet (5.5 meters), use of a remote pumping unit is required.

Generac supplied day tanks may be equipped with a "Pump Running" light, as well as a "Fuel Level" gauge. Other day tank options are also available. For example, where long piping runs (100-150 feet or 30.5-45.7 meters) are used between the main supply tank and the day tank, use of a SOLENOID VALVE in the day tank and a FOOT VALVE in the main supply tank are recommended. These two options help prevent the day tank from having to evacuate a large amount of air during startup. Use of an optional fuel strainer, between the main and day tanks, is also recommended.

Day Tanks (Continued)

When installing a day tank, either of two installation methods may be used. These are illustrated in Figures 30 and 31. The two installation methods are (a) main tank above the day tank with gravity feed, and (b) main tank below the day tank.

Base Mounted Diesel Fuel Tanks

Diesel powered engine-generators are available with base mounted fuel tanks. These tanks mount directly below the generator set and are attached to the engine-generator mounting rails. Tank sizes and capacities depend on the engine-generator model on which the tank is installed. An example of a typical base mounted tank is shown in Figure 32.

Figure 28. A Simple Diesel Fuel System

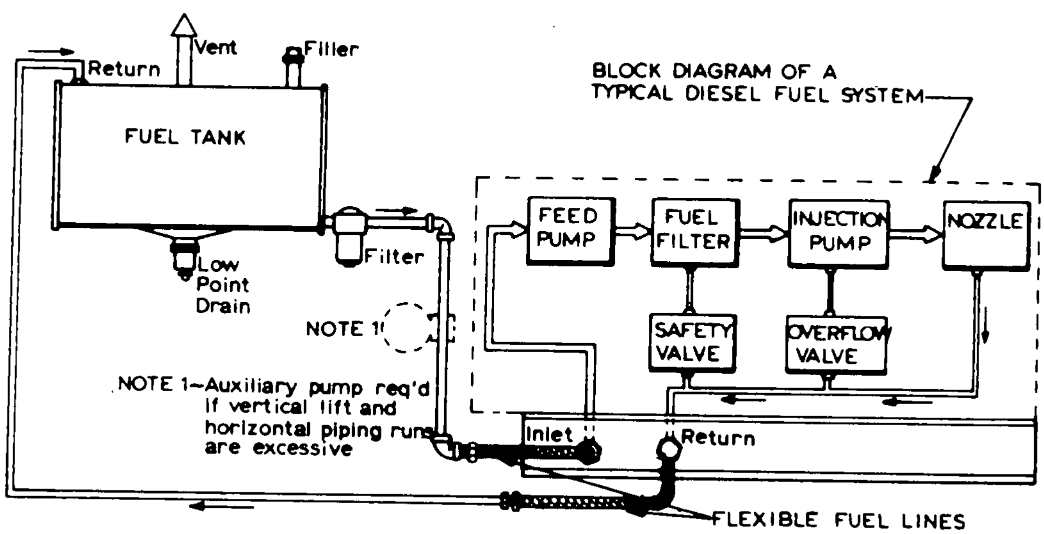


Figure 29. A Typical Day Tank

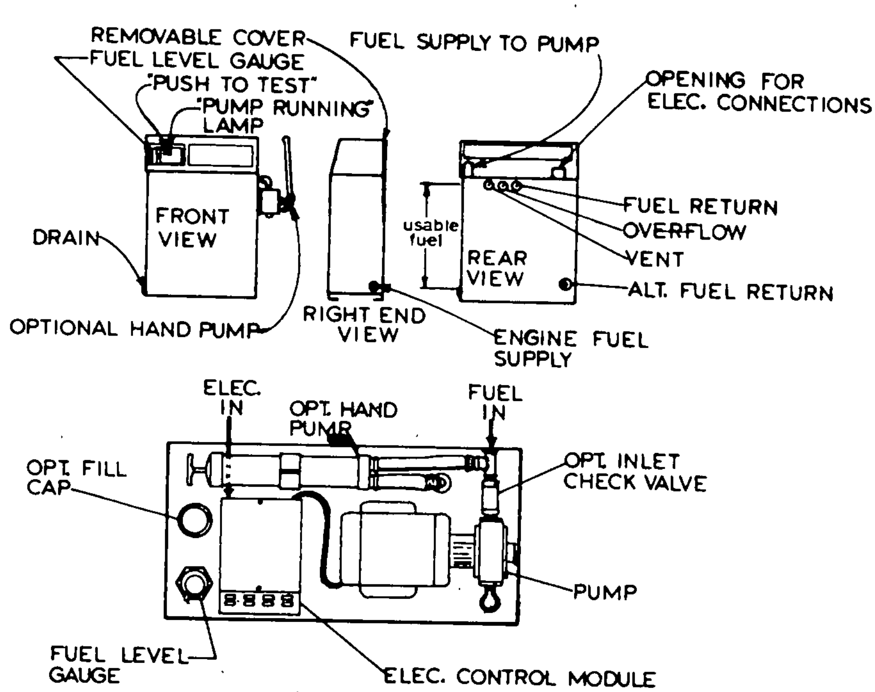


Figure 30. Main Tank Above the Day Tank with Gravity Feed

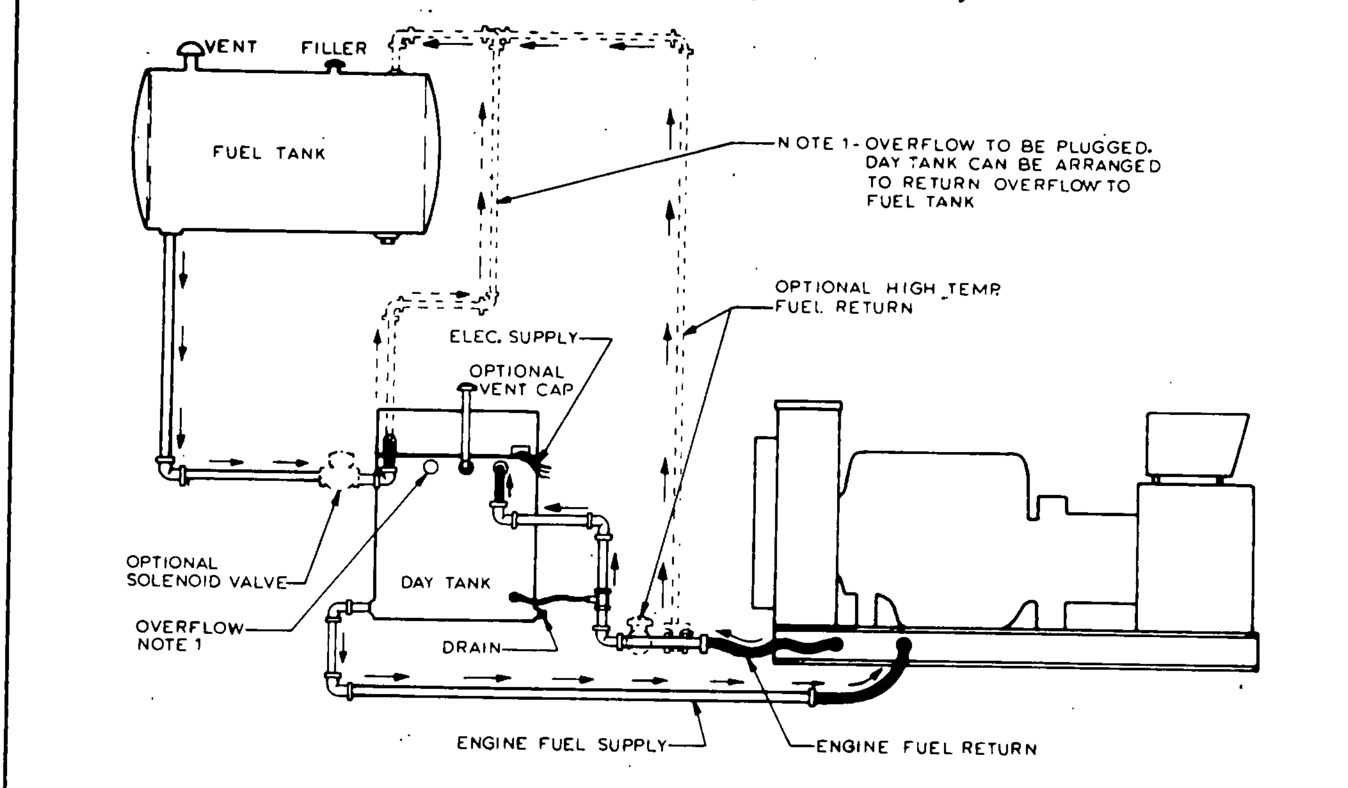


Figure 31. Main Tank Below the Day Tank

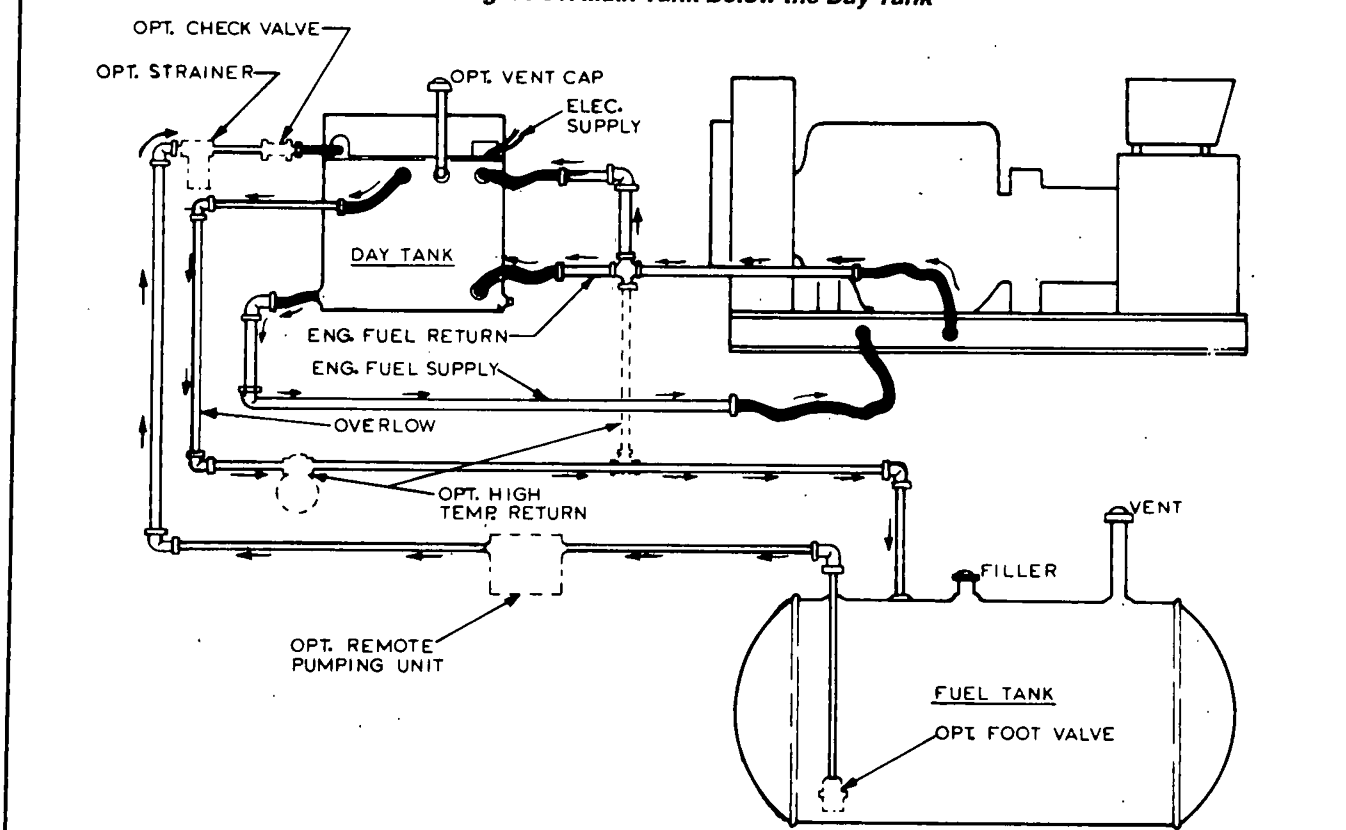
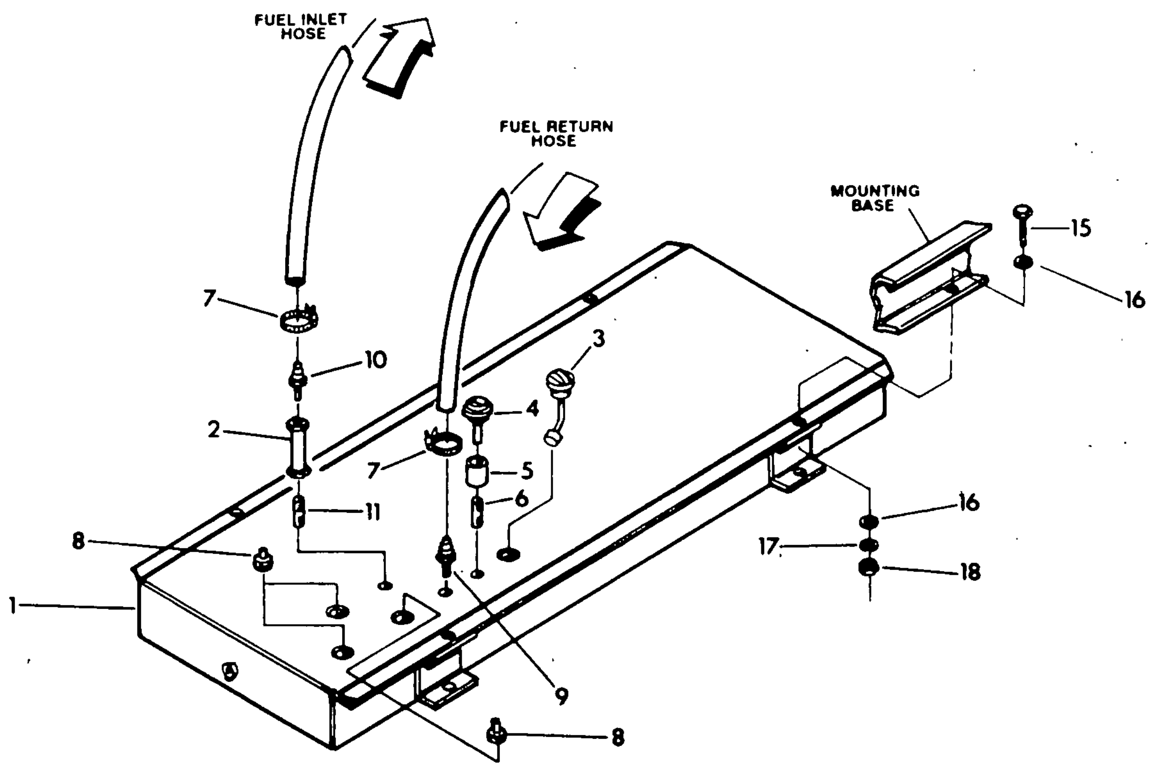


Figure 32. A Typical Base Mounted Diesel Fuel Tank



ITEM	QTY	DESCRIPTION
1	1	Base Tank (85 gallon tank shown)
2	1	Check Valve
3	1	Fuel Gauge
4	1	Breather
5	1	Pipe Coupling
6	1	Pipe Nipple
7	2	Hose Clamp
8	3	Pipe Plug
9	1	Barbed Fitting

ITEM	QTY	DESCRIPTION
10	1	Barbed Fitting
11	1	Nipple
15	4	Capscrew
16	8	Flatwasher
17	4	Lockwasher
18	4	Hex Nut

Chapter 9. GASEOUS FUEL SYSTEMS

Introduction to Gaseous Fuel Systems

Some engine-generators are equipped with fuel systems that utilize liquefied petroleum (LP) or natural gas as a fuel. These fuels are highly volatile and can be dangerous if handled or stored carelessly.

DANGER

GASEOUS FUELS, SUCH AS LP AND NATURAL GAS, ARE HIGHLY VOLATILE AND THEIR VAPORS ARE EXPLOSIVE. LP GAS IS HEAVIER THAN AIR AND WILL SETTLE IN LOW AREAS. NATURAL GAS IS LIGHTER THAN AIR AND WILL SETTLE IN HIGH AREAS. EVEN THE SLIGHTEST SPARK CAN IGNITE THESE FUELS AND CAUSE AN EXPLOSION. THE USE OF LEAK DETECTORS IS RECOMMENDED WHEN GASEOUS FUELS ARE USED. WHEN LP GAS IS USED, INSTALL LEAK DETECTORS LOW IN A ROOM; FOR NATURAL GAS, INSTALL THEM HIGH IN A ROOM. FOR SAFETY, ALL CODES, STANDARDS AND REGULATIONS PERTAINING TO THE INSTALLATION AND USE OF GASEOUS FUELS MUST BE STRICTLY COMPLIED WITH.

Local fuel gas codes may vary widely. For that reason, it is recommended that a local gas distributor or installer be consulted when installing a gaseous fuel supply system.

In the absence of local fuel gas codes and regulations, booklets published by the National Fire Protection Association (NFPA) may be used as sources of information. See "STANDARDS INDEX" on Page 2.

Advantages of Gaseous Fuels

The use of natural and LP gas may result in a slight power loss, as compared to gasoline. However, that disadvantage is usually compensated for by the many advantages of gaseous fuels. Some of these advantages are:

- ☐ A low residue content, resulting in minimum carbon formation in the engine.
- ☐ Reduced sludge buildup in the engine oil.
- ☐ Reduced valve burning as compared to gasoline.
- ☐ No "washdown" of engine cylinder walls during cranking and startup.
- ☐ Excellent anti-knock qualities.
- ☐ A nearly homogeneous mixture in the engine cylinders.
- ☐ Fuel can be stored for long periods without breakdown.

Gaseous Fuel System Variations

Any one of four different types of gaseous fuel system may be installed by the factory on engine-generators. These are:

- ☐ An LP gas vapor withdrawal type system.
- ☐ An LP gas liquid withdrawal type system.
- ☐ A natural gas system.
- ☐ Dual natural and LP gas system.
- ☐ A combination gas-gasoline system.

Properties of Gaseous Fuels

<u>NATURAL GAS:</u>

Natural gas is lighter than air. It is found in the gaseous state at normal ambient temperatures and pressures. It is highly explosive and can be ignited at the slightest spark. For that reason, fuel lines must be free of leaks and adequate ventilation is absolutely essential.

Local fuel-gas codes usually dictate the maximum pressure at which natural gas can enter a structure. In order to reduce the gas pressure to that required by law, a PRIMARY REGULATOR is required.

<u>LP GAS:</u>

Liquefied petroleum (LP) gas is heavier than air. The gas vapors are explosive and, like natural gas, can be ignited by the slightest spark.

LP gas is generally supplied in pressurized tanks as a liquid. However, it is found in gaseous form at normal temperatures and pressures.

The gas may consists of (a) butane, (b) propane, or (c) a mixture of the two gases. The following facts apply:

- ☐ In some cases, fuel in its liquid state is piped to the engine-generator. This is called a "liquid withdrawal" type system.
- ☐ In some installations, gas vapors that form above the liquid fuel in the tank are piped to the engine. This is called a "vapor withdrawal" type system.
- ☐ Butane may not provide sufficient vapor pressure in cold weather. Propane may have to be mixed with the butane, to improve the vapor pressure.
- ☐ The ratio of butane to propane becomes especially important when a large outdoor supply tank is used. Because the tank is outdoors, it is exposed to cold temperatures which reduces the vaporization rate. Vaporization itself reduces temperature- this is especially critical in larger tanks.
- ☐ LP gas MUST be converted to its vapor state before it enters the engine carburetor.

The Natural Gas System

A typical natural gas system is shown in Figure 33, below. Ther maximum pressure at which the gas can enter a building is established by code and may vary from area to area. A primary regulator is required, to reduce gas supply pressures to the required safe level before the gas enters a structure.

The primary regulator may or may not be provided by the gas supplier. The gas distribution company will usually provide piping from the main distribution line to the engine-generator site. It is the responsibility of the gas supplier to ensure that sufficient gas pressure is available to operate the primary regulator.

From the primary regulator, gas flows to the engine-generator connection. A flexible length of gas line is required between rigid piping and the gas connection at the engine-generator. The engine-generator fuel system consists of (a) an electrical fuel shutoff valve, (b) a secondary regulator or pressure reducing valve, and (c) the gas carburetor.

The secondary regulator, often called a pressure reducing valve, reduces gas pressure to about 5 inches of water column before the gas is delivered to the carburetor.

NOTE: Gas pressure from the primary regulator to the engine-generator's fuel shutoff valve should not exceed approximately 0.75 psi, or 20 inches of water column. Optimum gas supply pressure to the shutoff valve is 11 inches of water column. Depending on the characteristics of the specific shutoff valve in use, the valve may or may not function at supply pressures greater than 0.50 psi (14 inches water column).

NOTE: A "FUEL COMPARISON CHART" may be found in Chapter 13, "SPECIFICATIONS AND CHARTS".

LP Gas Vapor Withdrawal System

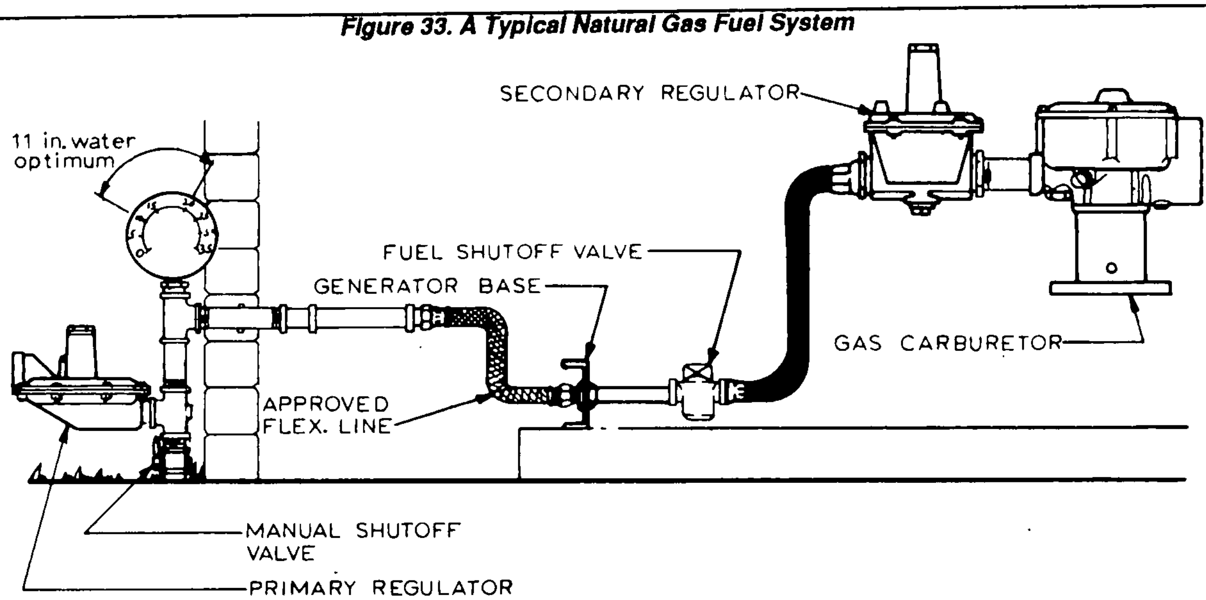
See Figure 34. This type of system utilizes the vapors formed above the liquid fuel in the supply tank. Approximately 10 to 20 percent of the tank capacity is needed for fuel expansion from the liquid to the vapor state. The vapor withdrawal system is generally more suited for smaller engines that require less fuel. The installer should be aware of the following:

- ☐The Generac natural gas and LP gas systems are similar. However, the natural gas system delivers a pressure of approximately 5.0 inches (water column) to the carburetor. The LP gas system delivers a slightly negative pressure (about -1 inch) to the engine carburetor.
- ☐When ambient temperatures are low and engine fuel sonsumption is high, the vapor withdrawal system may not function efficiently.
- ☐Ambient temperatures around the supply tank must be high enough to sustain adequate vaporization or the system will not deliver the needed fuel volume.
- ☐In addition to the cooling effects of ambient air, the vaporization process itself provides an additional cooling effect.

LP Gas Liquid Withdrawal System

As its name implies, this system delivers gas in liquid form to the engine-generator. The liquid fuel must then be vaporized before being delivered to the carburetor. Generac liquid withdrawal systems usually employ a "Vaporizer-Regulator" to convert the liquid to its gaseous state.

Figure 33. A Typical Natural Gas Fuel System



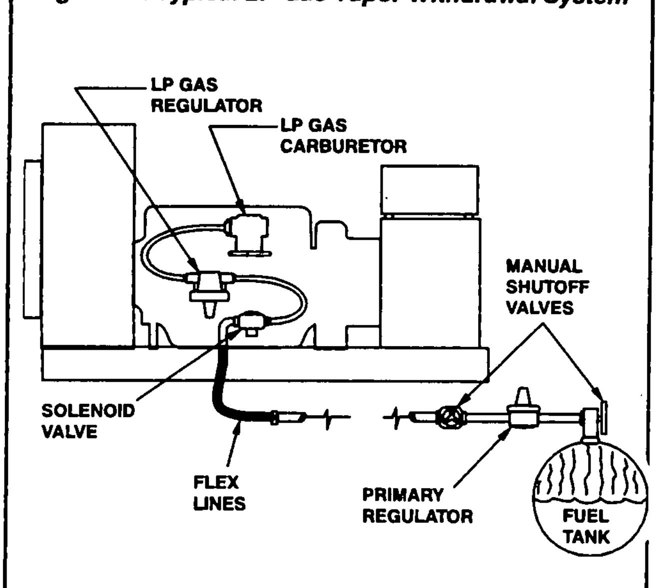


Figure 34. Typical LP Gas Vapor Withdrawal System

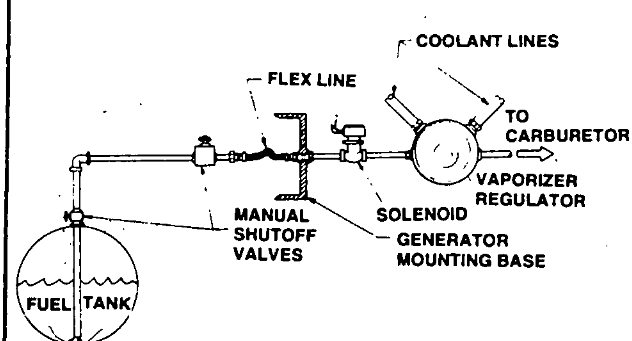


Figure 35. LP Gas Liquid Withdrawal System (Typical)

One type of vaporizer-regulator uses heated engine coolant to vaporize the liquid fuel. The engine coolant is kept heated even when the engine is not running, by means of an engine coolant heater powered by the Normal (Utility) electrical plower source.

NOTE: It is the policy of Generac to include an electrical engine coolant heater (block heater) on all engine-generators equipped with a liquid withdrawal type LP gas fuel system, unless the buyer specifically requests that such a heater not be installed. Optional "annunciator" panels are available which include a "Low Coolant Temperature" warning, should the engine coolant heater fail to keep the coolant above a preset temperature. See "OPTIONS AND ACCESSORIES" in Chapter 12.

Dual Natural Gas/LP Gas System

See Figure 36. In some areas, the cost of natural gas may be reduced considerably by procuring the gas on "interrupted service" rates. Such rates can be obtained by using LP gas as an emergency fuel when natural gas is not available.

Automatic changeover can be accomplished by using two regulators, a line pressure regulator for natural gas and a vacuum operated regulator for LP gas. The differences in pressures compensates for the greater BTU value of LP gas.

During operation on natural gas, a 5 inch (water column) pressure exists in the common line to the carburetor. This pressure closes the LP gas regulator and prevents the flow of LP gas. Loss of the natural gas pressure results in loss of the line pressure. The LP gas regulator then opens to admit LP gas into the system. A separate power mixture adjustment in the LP gas line provides precise control of air/fuel ratios for each of the two fuels. Changeover is automatic when the engine is running.

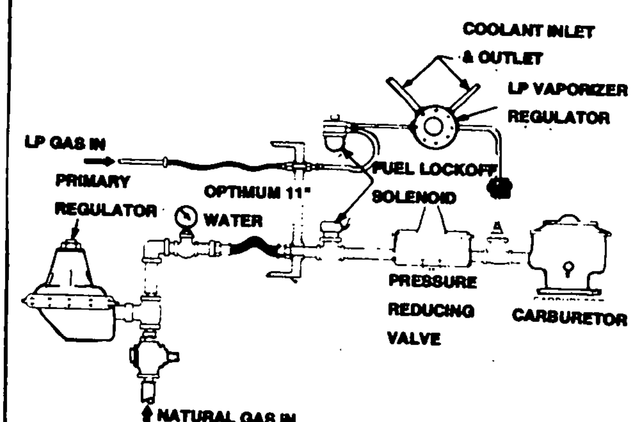


Figure 36. Dual Natural and LP Gas System

Gaseous Fuel System Piping

The following general rules apply to piping used in gaseous fuel systems:

- ☐ The piping should be of black iron, rigidly mounted and protected against vibration.
- ☐ Install an approved length of flexible hose between the engine-generator connection point and rigid piping.
- ☐ Piping must be of the correct size to maintain the required supply pressures and volume flow under varying conditions, especially when fuel is supplied in vapor or faseous form.

Gaseous Fuel System Piping (Continued)

- ☐ Installed piping must be properly purged and leak-tested, in accordance with applicable codes and standards.
- ☐ Use an approved pipe sealant or joint compound on all threaded fittings, to reduce the possibility of leakage.

NOTE: In the absence of local purging and leak test standards, NFPA No. 54 may be used as a guide. See "Standards Index" on Page 1.

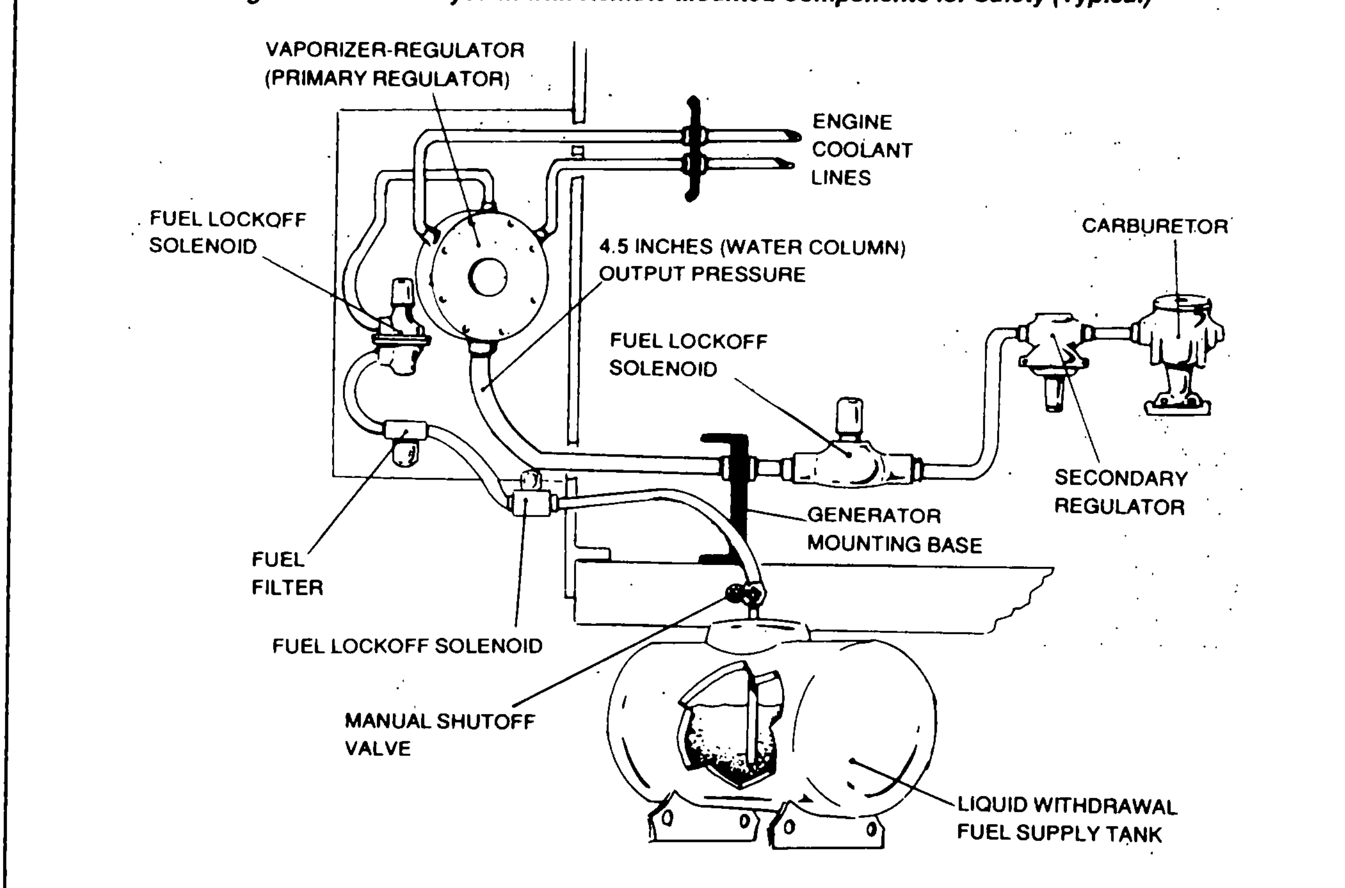
Gaseous Fuel Pipe Sizes

A "Gas Flow-Pipe Size Chart" is included in Chapter 13, "SPECIFICATIONS AND CHARTS". The chart may be used to determine the correct diameter for pipes used in gaseous fuel systems, where the fuel is delivered to the generator in gaseous state. Instructions for use of the chart are also included. To calculate the pipe sizes required the installer must know (a) the length of the gas piping run, and (b) the cubic feet of gas needed to sustain engine operation under full load.

LP Gas System with Remote-Mounted Components

LP gas is highly explosive. The gas is heavier than air and tends to settle in low areas. If leakage occurs in a structure, the slightest spark can cause an explosion. Some installers may wish to provide protection against gas leakage and possible explosion. One method of accomplishing such extra safety is shown in Figure 37. A fuel filter, fuel lockoff solenoid and primary regulator are housed in a compartment that is external to the structure housing the engine-generator. A second fuel lockoff solenoid is installed between the supply tank and the filter. Engine coolant lines are routed from the engine-generator to the remote primary regulator, to vaporize the fuel before it enters the structure. Gas enters the structure at a reduced presure of about 4.5 inches (water column). One of the fuel lockoff solenoids will close on engine shutdown, to prevent entry of gas into the structure during non-operating periods. A leak detector, mounted low inside the structure, can be connected so as to close the second fuel lockoff solenoid on occurence of a gas leak. The leak detector can also be wired in such a way that engine-generator cranking and startup will not be possible if leakage exists inside the structure.

Figure 37. LP Gas System with Remote-Mounted Components for Safety (Typical)



Chapter 10. GENERATOR AC CONNECTION SYSTEM

General

Generac engine-generators may be equipped with any one of several different stator configurations. The electrician who installs a standby generator, as well as service technicians, must be familiar with these different stator configurations and the various stator connection systems.

Each generator is assigned a "Voltage Code" which indicates the rated voltage, phase and frequency of the generator. Many of the "Voltage Codes" currently in use are listed in the "*Voltage Codes and Stator Connection Systems*" chart at the bottom of this page. Each Voltage Code uses a specific stator connection system to obtain a certain Voltage Code.

Single and 3-phase stator windings are connected in a specific manner, in order to obtain a specific rated AC output voltage. The final voltage setting is then established within the desired range by adjusting the AC voltage regulator.

Generator AC Connection Panel

On a typical standby generator, the AC connection panel is that sheet metal enclosure directly below the control panel. See Figure 1. It is often called the "lower panel". The AC output leads are routed out of the stator can and into this "lower panel".

Either four (4) or twelve (12) stator leads are brought out into the lower panel. This section deals with how the stator leads are connected to deliver a certain voltage. Connection of the stator leads should be accomplished in accordance with the appropriate connection diagram. Use the diagram that is appropriate for the number of leads and the voltage range required.

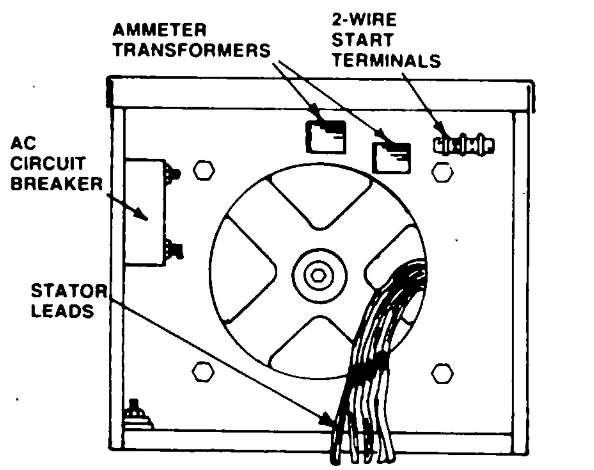


Figure 1. Generator AC Connection Panel (Typical)

Notes for Chart

* Voltage Codes "B" and "C" are obsolete but were used prior to 1988.

** Stators with Voltage Code "D" can supply 1-phase output at up to the full capacity of the generator. Do NOT reconnect these units to 277/480 volts (High Wye).

Voltage Codes and Stator Connection Systems

VOLTAGE CODE	RATED VOLTS	PHASE	HERTZ	NO. OF WINDINGS	NO. OF LEADS	TYPE OF STATOR CONNECTION SYSTEM
A	120/240	1	60	2	4	Dual voltage, 3-wire, 1-phase
B*	120/208	3	60	6	12	Low Wye (Parallel Wye)
C*	240/416	3	60	6	12	High Wye (Series Wye)
D**	120/240	1 & 3	60	6	12	Delta
G	120/208	3	60	6	12	Low Wye (Parallel Wye)
H	240/416	3	60	6	12	High Wye (Series Wye)
J	120/240	3	60	6	12	Delta
K	277/480	3	60	6	12	High Wye (Series Wye)
L	600	3	60	6	4	Wye Connected
M	110/220	1	50	2	4	Dual voltage, 3-wire, 1-phase
N	115/200	3	50	6	12	Low Wye (Parallel Wye)
P	100/200	3	50	6	12	Delta
R	231/400	3	50	6	12	High Wye (Series Wye)
S	480	3	50	6	12	Wye Connected

Generator AC Connection Panel (Continued)

*Stators with six windings and twelve leads coming out are usually connected by means of "bolted junctions". The customer load leads brought out from these bolted junctions may or may not be connected to a panel-mounted circuit breaker. If a main circuit breaker is installed, the installer need only connect the load leads to the breaker (unless reconnection is necessary). If required, the installer will have to install a main circuit breaker.

Dual Winding, 1-Phase Stators

See Figure 2, below. Units with Voltage Codes "A" and "M" have stators with dual windings. Two leads are brought out of each winding and routed into the AC connection panel, for a total of four (4) leads. The leads are numbered 11, 22, 33 and 44. Leads No. 11 and 44 are the two "hot" leads (E1 and E3). The junction of leads 22 and 33 form the "Neutral" connection (00).

Each winding can supply a 120 volts AC output at 60 Hertz, or a 110 volts output at 50 Hertz. When the two windings are connected in series, a 240 volts, 60 Hertz (or 220 volts, 50 Hertz) AC output results.

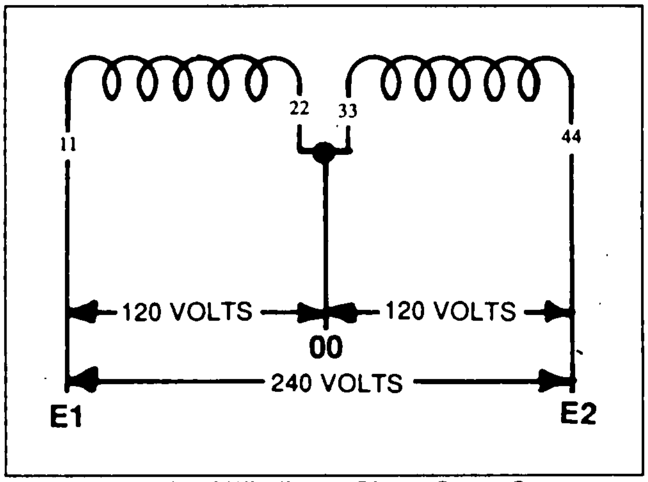


Figure 2. Dual Winding, 1-Phase Stator System

Parallel Wye or Low Wye Stator

See Figure 3. Parallel (or Low Wye) stators have six windings and twelve (12) leads brought out into the lower panel. This type of stator system can be used to supply the voltages indicated in the following CHART.

VOLTAGE			CONNECT	L1	L2	L3	NEUTRAL
	L-L	L-N					
60 HZ	190	110	S10-S11-S12	E1	E2	E3	S10-S11-S12 S4-S5-S6
	208	120	S4-S5-S6				
	220	127					
	230	133	S1-S7				
	240	139					
50 HZ	190	110	S2-S8				
	200	115					
	208	120	S3-S9				

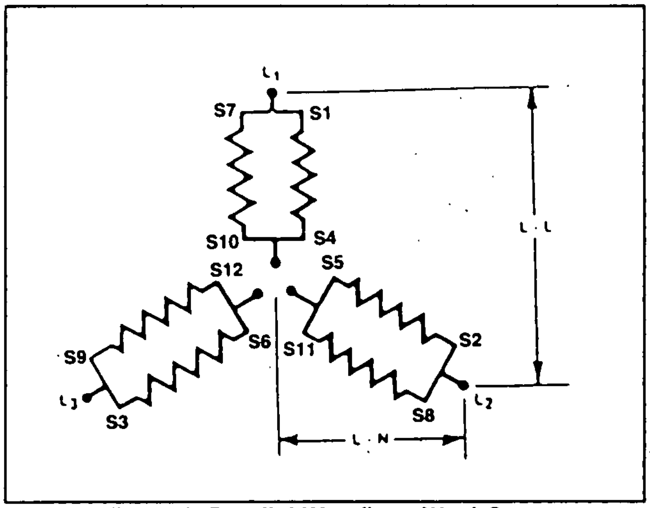


Figure 3. Parallel Wye (Low Wye) Stator

High Wye (Series Wye) Stator

Figure 4 shows a "High Wye" or "Series Wye" stator connection system. The stator has six (6) windings, with twelve (12) leads brought out into the lower panel. The following CHART indicates how the twelve leads are connected to form output feeder lines L1, L2, L3 and "Neutral".

VOLTAGE			CONNECT	L1	L2	L3	NEUTRAL
	L-L	L-N					
60 HZ	380	219	S10-S11-S12	E1	E2	E3	S10-S11-S12
	416	240					
	440	254	S5-S8				
	460	266					
	480	277	S6-S9				
50 HZ	380	219	S4-S7				
	400	231					
	416	240					

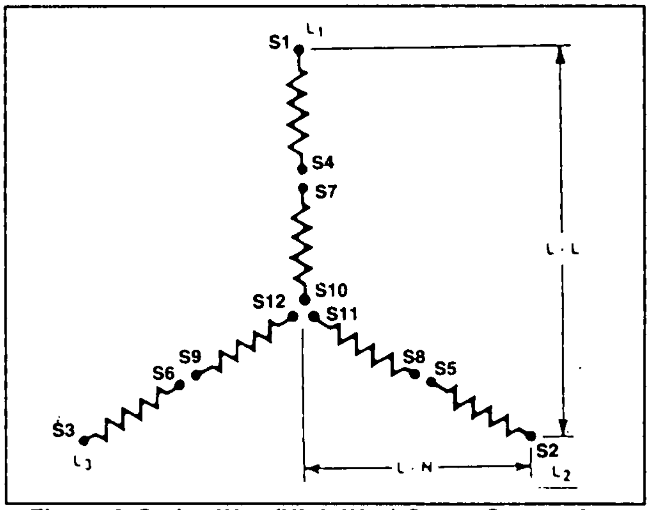


Figure 4. Series Wye (High Wye) Stator Connections

High Delta Connection System

See Figure 5. This stator has six (6) windings with twelve (12) leads brought out into the lower panel.

VOLTAGE	L-L	L-N	CONNECT	L1	L2	L3	NEUTRAL
60 HZ	240	120	S4-S7				
	277	139	S5-S8				
			S6-S9	E1	E2	E3	S4-S7
50 HZ	200	100	S1-S11				
	220	110	S2-S12				
	240	220	S3-S10				

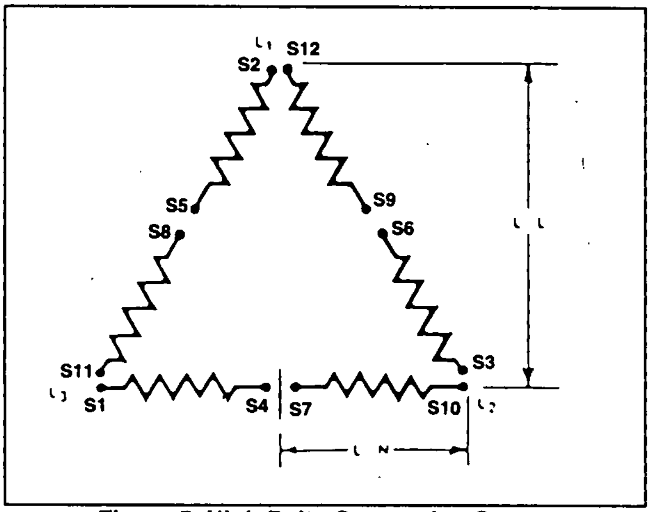


Figure 5. High Delta Connection System

Low Delta Connection System

Units with 6-coil, 12-lead stators can be reconnected to form a "Low Delta" system, shown in Figure 6. This type of connection system can deliver the voltages shown in the following CHART.

VOLTAGE	L-L	CONNECT	L1	L2	L3
60 HZ	120	S1-S7-S6-S12			
	139	S2-S8-S4-S10	E1	E2	E3
50 HZ	100	S3-S9-S5-S11			
	120				

The Zig-Zag Connection System

Units having twelve lead, reconnectable stators can be reconnected to form a "Zig-Zag" connection system (see Figure 7).

The Zig-Zag system can be used to supply a line-to-line voltage of 240 volts, or a line-to-neutral voltage of 120 volts as indicated in the following CHART.

VOLTAGE	L-L	CONNECT	L1	L2	NEUTRAL
60 HZ	120 240	S3-S9			
		S1-S6-S7-S12	E2	E3	S4
		S2-S8			
		S4-S10-S5-S11			

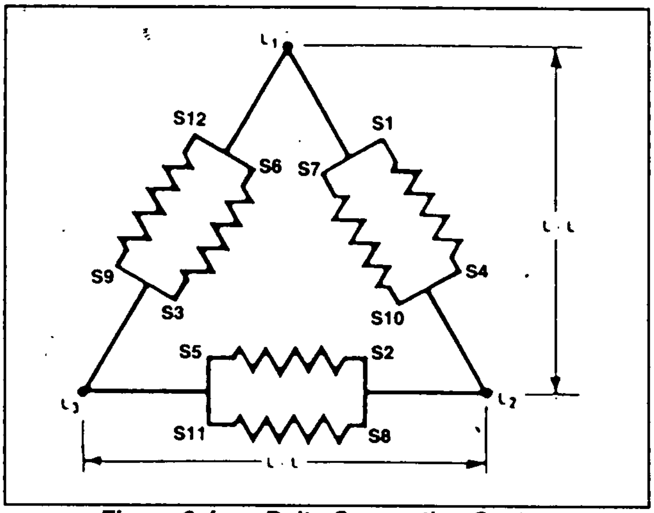


Figure 6. Low Delta Connection System

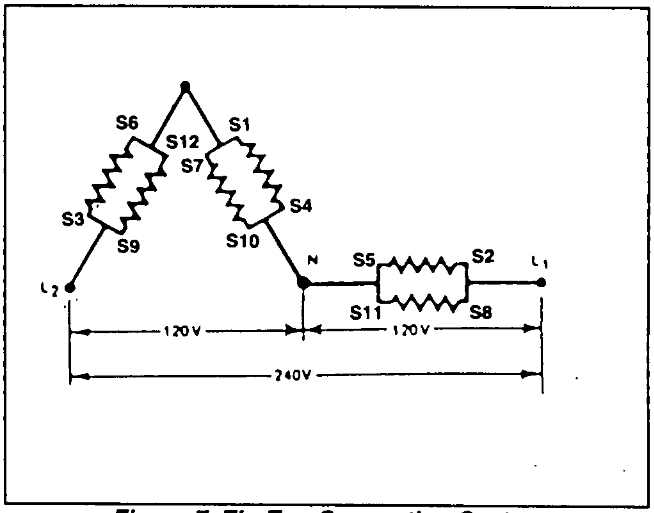


Figure 7. Zig-Zag Connection System

Multi-Voltage Changeover Boards

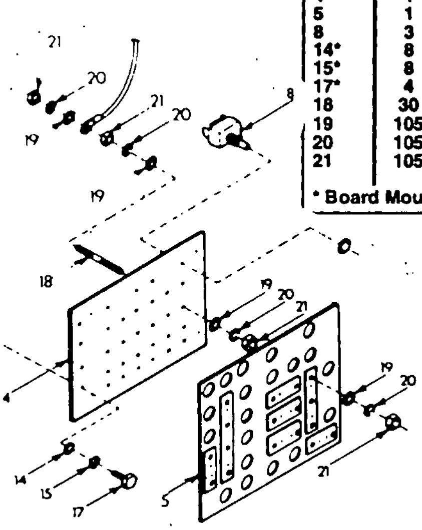
GENERAL:

Some engine-generators with 12-lead, reconnectable stators may be equipped with a voltage changeover board. Such a board permits the installing electrician to reconnect the 12 stator leads quickly and easily. By reconnecting the leads to the proper connection system configuration, the rated voltage and phase can be changed. The use of changeover boards is especially desireable in rental or other applications where AC output voltage needs to be changed frequently.

Multi-Voltage Changeover Boards (Continued)

DESCRIPTION:

A typical voltage changeover board consists of (a) a STUD BOARD, and (b) a STRAPPING BOARD as shown in Figure 8. The stator's twelve (12) AC output leads connect to studs on the stud board. By changing the position of the strapping board on the stud board, the connection system and the unit's rated voltage can be changed. Terminal studs are provided for the connection of customer load leads E1, E2, E3 and Neutral.



ITEM	QTY	DESCRIPTION
4	1	Stud Board
5	1	Strapping Board
8	3	Switch
14*	8	Flatwasher
15*	8	Lockwasher
17*	4	Capscrew
18	30	Stud
19	105	Flatwasher
20	105	Lockwasher
21	105	Hex Nut

* Board Mounting Hardware

Figure 8. A Typical Voltage Changeover Board

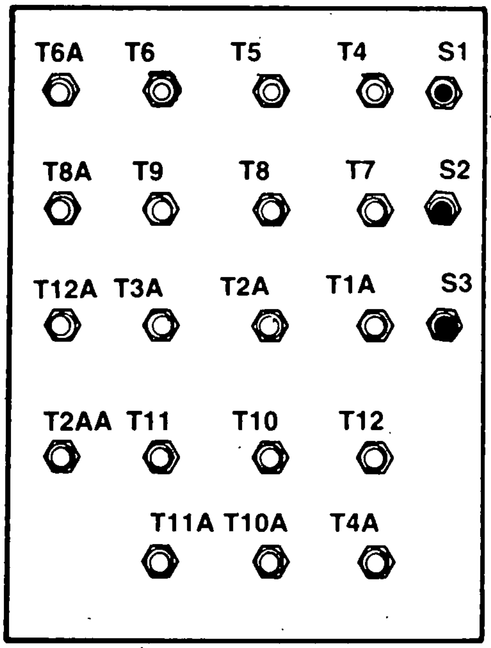


Figure 9. A Typical Stud Board

High Wye Strapping Board
Position on Stud Board
Switch 1 & 2 Depressed

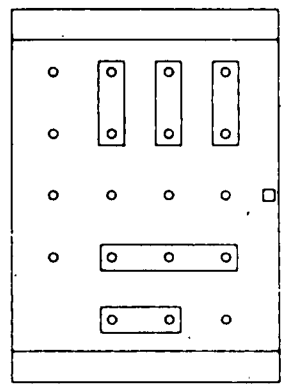


Figure 10. High Wye Strapping Board

THE STUD BOARD:

See Figure 9. The stud board has 19 studs. The board also mounts three (3) switches, identified as "S1", "S2" and "S3". Numbers adjacent to each stud identify the stator lead that attaches to the stud.

THE STRAPPING BOARD:

Strapping boards are available which permit the system to be reconnected (a) High Wye, (b) Low Wye, (c) High Delta, or (d) Zig-Zag configuration. These are shown in Figures 10 through 13.

HIGH WYE STRAPPING BOARD:

See Figure 10. Notice that certain holes in the strapping board are linked together by metal strips. Also, notice the small square "window" at the center right side of the board. When the High Wye strapping board is installed over the studs of the stud board, a "High Wye" connection system results as discussed on Page 30. See *"High Wye (Series Wye) Stator"* on that page. The small square window on the board prevents switch "S3" from being depressed when the board is installed. Switches "S1" and "S2", however, will be depressed by strapping board installation.

LOW WYE STRAPPING BOARD:

Installation of the "Low Wye" strapping board onto the stud board results in a "Low Wye" connection system. See *"Parallel Wye or Low Wye Stator"* on Page 30. When the Low Wye strapping board is installed, Switches S1 and S2 are NOT depressed; Switch 3 is depressed.

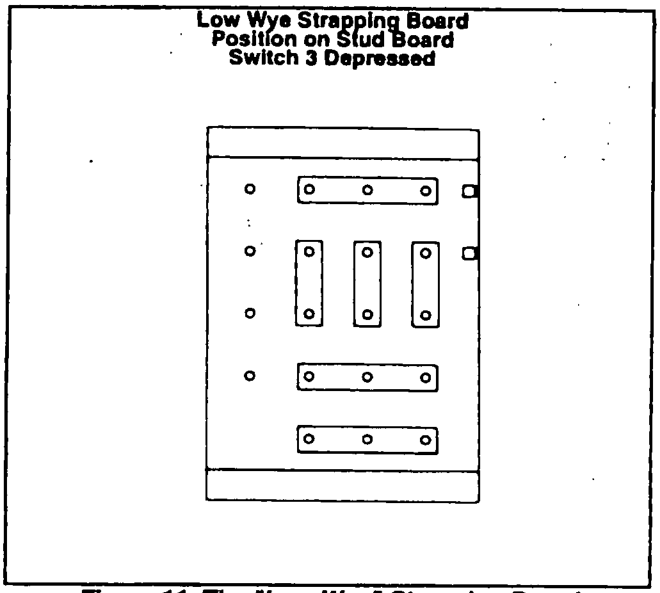


Figure 11. The "Low Wye" Strapping Board

HIGH DELTA STRAPPING BOARD:

See Figure 12. Also see "*High Delta Connection System*" on Page 31.

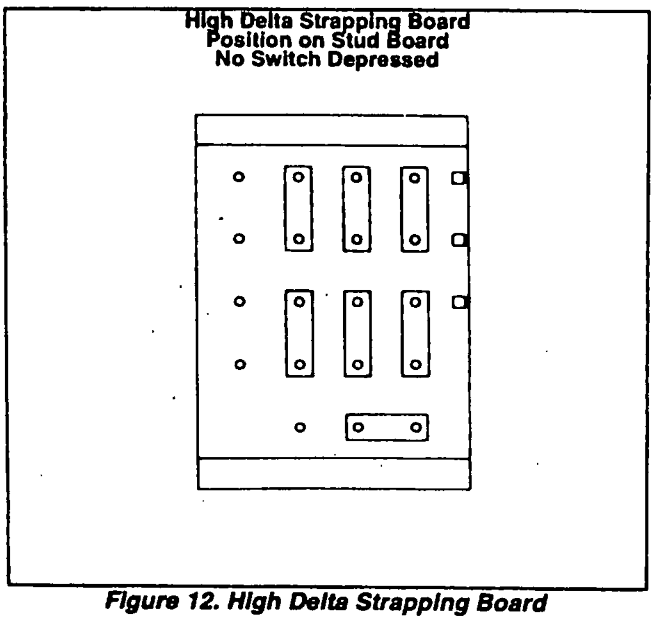


Figure 12. High Delta Strapping Board

ZIG-ZAG STRAPPING BOARD:

The zig-zag strapping board is discussed under "*The Zig-Zag Connection System*" on Page 31. Figure 13 shows the board position on the stud board. The three small, square windows on the board indicate that no switch is depressed.

NOTE: The installer must ensure that the selected voltage and phase are compatible with the load voltage and phase, and that all leads are properly connected.

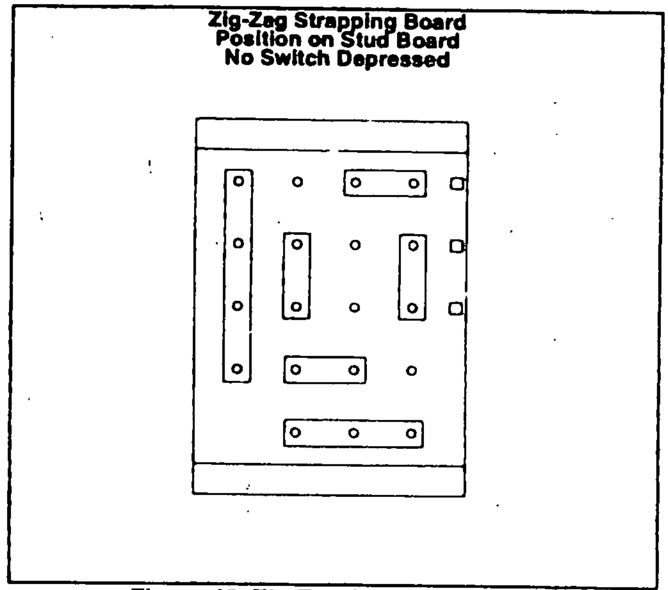


Figure 13. Zig-Zag Strapping Board

Voltage-Phase Selector Switches

Some engine-generator models may be equipped with a VOLTAGE-PHASE SELECTOR SWITCH. See Figure 14. The desired voltage and phase can be selected by (a) actuating the switch to the desired position, and (b) connecting the generator's AC output leads properly for the desired voltage and phase. The unit may be equipped with either a 2-position or 3-position switch.

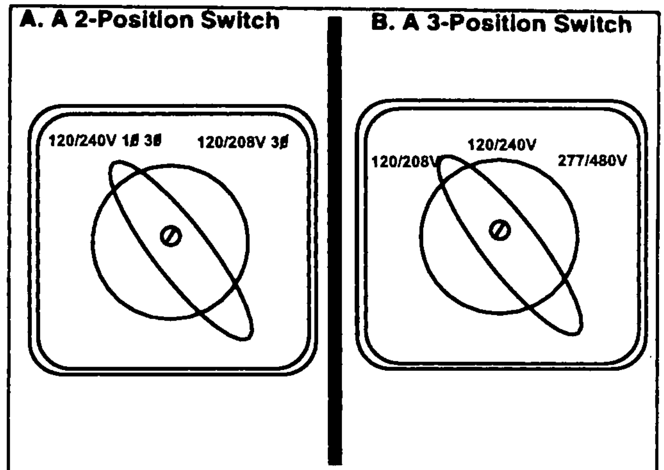


Figure 14. Voltage-Phase Selector Switches (Typical)

Some Other Stator Connection Systems

GENERAL:

The stator connection systems indicated in the CHART on Page 29 and discussed in the pages that follow are standard systems. From time to time, installers or technicians will encounter some other types of stator connection systems. Some of these other connection systems may be identified as follows:

- ☐ The 10-Lead High Wye System.
- ☐ The 10-Lead Low Wye System.
- ☐ The 6-Lead Wye Connected System.
- ☐ The 6-Lead Delta Connected System.
- ☐ The 4-Lead Wye Connected System.
- ☐ The 3-Lead Delta Connected System.

THE 10-LEAD HIGH WYE SYSTEM:

See Figure 15. These are dual voltage engine-generators having six windings in their stator. There are either 12 or 24 cables coming out of the stator.

VOLTAGE	L-L	L-N	CONNECT	L1	L2	L3	NEUTRAL
60 HZ	190	110	T4-T5-T6	E1	E2	E3	T10-T11-T12 T4-T5-T6
	208	120					
	220	127	T10-T11-T12				
	230	133	T1-T7				
50 HZ	240	139					
	190	110	T2-T8				
	200	115	T3-T9				
	208	120					

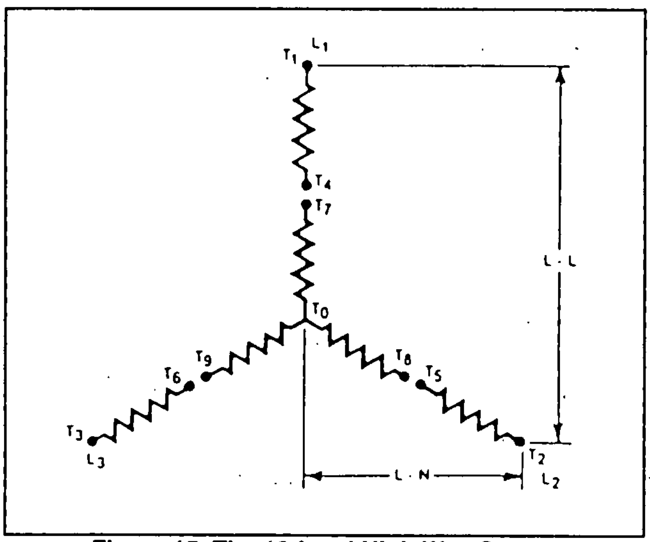


Figure 15. The 10-Lead High Wye System

THE 10-LEAD LOW WYE SYSTEM:

These are dual voltage units having a stator with six windings. Either 12 or 24 cables are brought out of the stator. See Figure 16. Voltage and cable connections for this type of system are listed in the CHART that follows.

VOLTAGE	L-L	L-N	CONNECT	L1	L2	L3	NEUTRAL
60 HZ	190	110	T10-T11-T12 T4-T5-T6	E1	E2	E3	S10-S11-S12 S4-S5-S6
	208	120					
	220	127	T1-T7				
	230	133	T2-T8				
	240	139	T3-T9				
50 HZ	190	110					
	200	115					
	208	120					

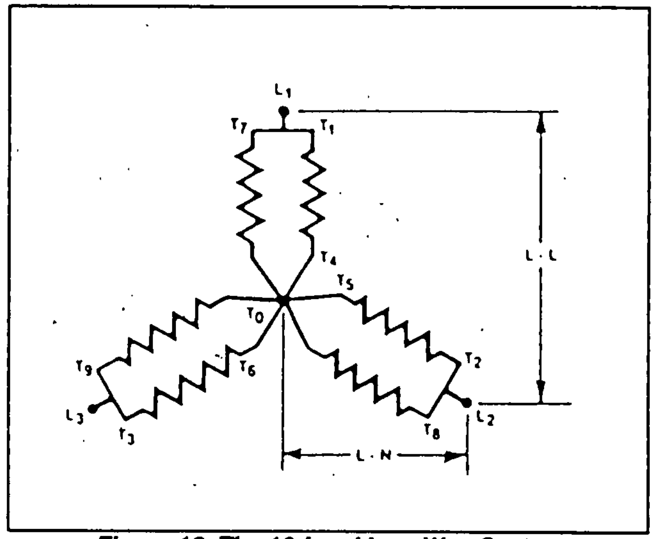


Figure 16. The 10-Lead Low Wye System

THE 6-LEAD WYE CONNECTED SYSTEM:

This system has a stator with six (6) windings and either 6 or 12 leads coming out of the stator. See Figure 17.

VOLTAGE	L-L	L-N	CONNECT	L1	L2	L3	NEUTRAL
60 HZ	190	110	T4-T5-T6	E1	E2	E3	T4-T5-T6
	203	120					
	220	127					
	230	133					
	240	139					
50 HZ	190	110					
	200	115					
	208	120					

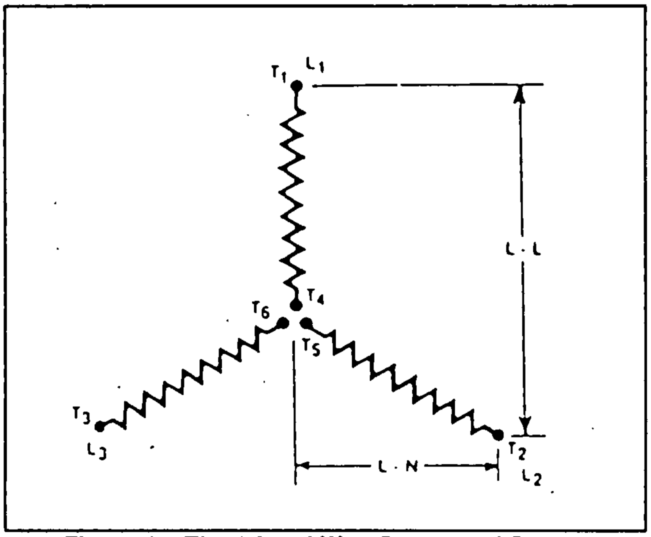


Figure 17. The 6-Lead Wye Connected System

THE 6-LEAD DELTA SYSTEM:

This system has a 3-winding group in its stator, with either 6 or 12 cables brought out into the lower panel.

VOLTAGE	L-L	CONNECT	L1	L2	L3	
60 HZ	2400	T1-T6				
		T2-T4	E1	E2	E3	
50 HZ	1905	T3-T5				

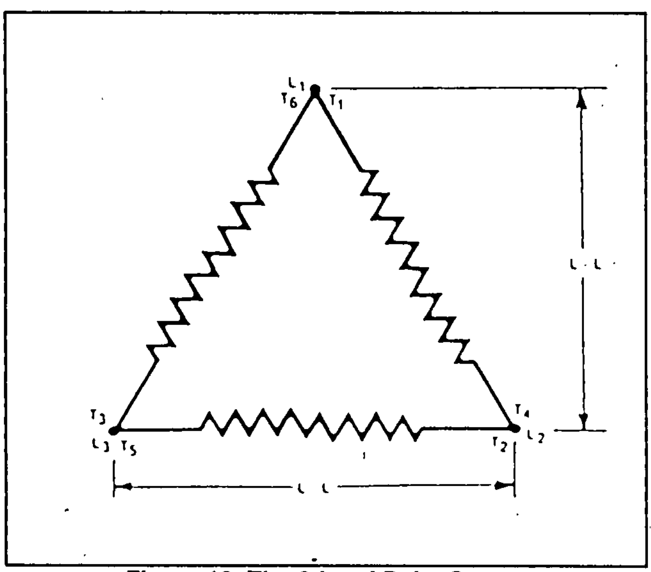


Figure 18. The 6-Lead Delta System

4-LEAD WYE CONNECTED SYSTEM:

This stator has 3 windings, with one end of each winding connected together. There are 4, 8 or 16 cables coming out of the stator. Wiring connections are indicated in the CHART that follows, and illustrated in Figure 19.

VOLTAGE	L-L	L-N		L1	L2	L3	NEUTRAL
60 HZ	380	219					
	416	240					
	440	254					
	460	266					
	480	277		E1	E2	E3	T0
50 HZ	380	219					
	400	231					
	416	240					
	480	277					

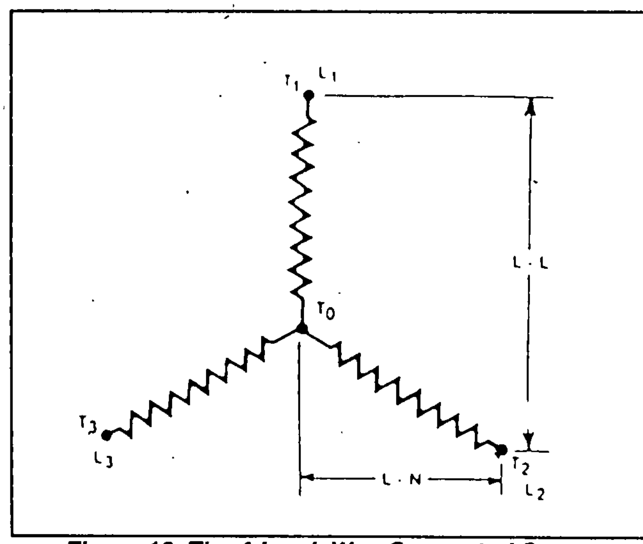


Figure 19. The 4-Lead, Wye Connected System

THE 3-LEAD DELTA CONNECTED SYSTEM:

This stator has 3 windings with one end of each winding connected into a Delta system internally. There are 3, 6 or 12 cables (or 3 bus bars) coming out of the stator. See Figure 20.

VOLTAGE	L-L	L1	L2	L3	
60 HZ	480	E1	E2	E3	

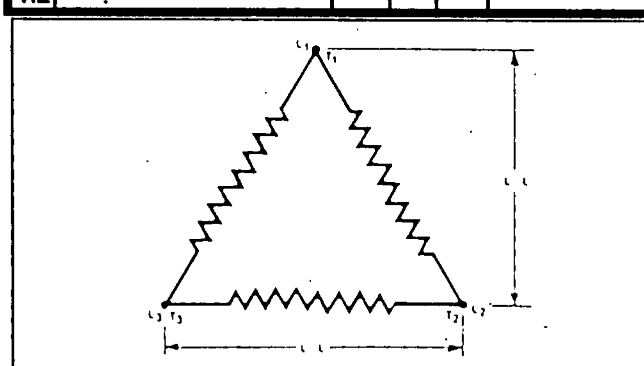


Figure 20. The 3-Lead Delta Connected System

Chapter 11. TRANSFER SWITCHES

Introduction

A transfer switch is required by code, as part of an engine-generator power system, to isolate the different power sources from each other. The NORMAL (Utility) and STANDBY (Generator) power supplies both connect to the transfer switch, which must function to perform the following tasks:

- ☐ The transfer switch must positively prevent the two power supplies from feeding the LOAD circuits simultaneously.
- ☐ The switch must positively isolate the LOAD circuits from the NORMAL power supply while the engine-generator is supplying those circuits.
- ☐ The transfer switch must provide for the transfer of critical electrical loads to a STANDBY (Emergency) source (such as the engine-generator) when the NORMAL (Utility) power supply has failed or has dropped below an acceptable level.

NOTE: You may wish to review the information in Chapter 1, "ENGINE-GENERATOR POWER SYSTEMS", on Pages 3 through 5.

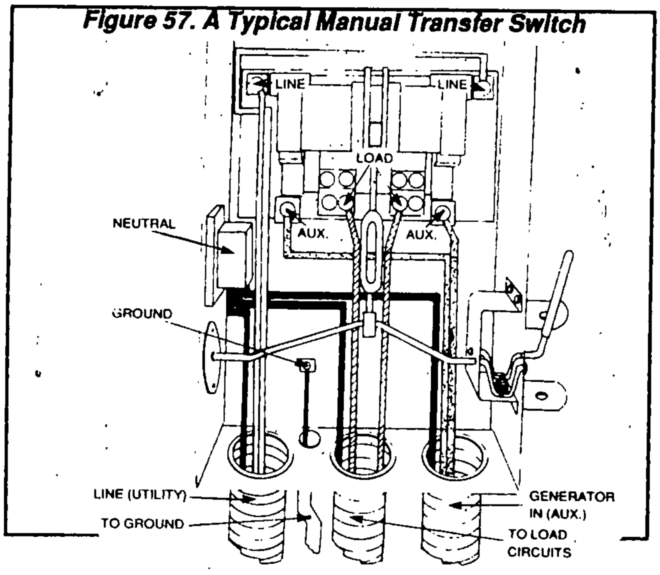
Manually Actuated Transfer Switches

Some advantages of manually operated transfer switches are (a) simplicity, (b) relatively low initial cost, and (c) reduced maintenance costs.

Figure 57 (below) shows an example of one typical manual transfer switch. When this type of switch is used, the operator must crank and start the engine-generator. He must then actuate the transfer switch contacts to supply the LOAD circuits from the STANDBY power source side. When the NORMAL power supply has been restored, he must actuate the transfer switch contacts back to the source and then shut the engine-generator down.

If a manual transfer switch is to be installed, the installer must ensure that the switch is capable of carrying full load currents, as well as the thermal affects of short circuit currents.

Figure 57. A Typical Manual Transfer Switch



Automatic Transfer Switches

TRANSFER SWITCH APPLICATIONS:

Automatic transfer switches may be provided as open devices, for use in switchboards and motor control centers. They may also be mounted in their own enclosure or cabinet. The installer can select a NEMA 1 enclosure for general indoor applications; a NEMA 3R enclosure for weather-tight outdoor protection; or a NEMA 12 enclosure for severe industrial conditions.

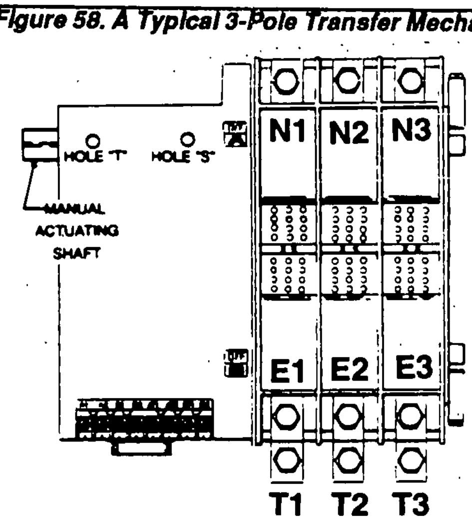
An automatic transfer switch is equipped with solid state circuits which constantly monitor the NORMAL (Utility) power source voltage. Should that power source voltage drop below a preset level, the transfer switch will (a) signal the engine-generator to crank and start, and (b) transfer LOAD circuits to the STANDBY (Generator) power supply. Following transfer to STANDBY, the transfer switch continues to monitor the NORMAL (Utility) power supply voltage. On restoration of that power source above a preset voltage, LOAD circuits will be retransferred back to the NORMAL source and the engine-generator will be shut down automatically.

A TYPICAL TRANSFER MECHANISM:

Figure 58 shows one typical transfer mechanism which houses the main load-carrying contacts. The "Wn" type is shown. The silver alloy main contacts are electrically actuated and mechanically held. The mechanism shown is a "3-pole" type. Transfer mechanisms equipped with 2 and 4 poles are also available.

NOTE: At the time this was written, "Wn" type automatic transfer switches (rated 600 volts) were not available with 2-pole transfer mechanisms. The "Y" type switches, rated up to 250 volts, are available with 2, 3 or 4 poles. When ordering a transfer switch, the purchaser must specify (a) rated voltage, (b) rated phase, (c) rated current. Some switches that are rated single phase will be equipped with a 3-pole transfer mechanism. However, since the unit is rated for 1-phase, factory wiring to the third pole (N3, E3, T3) is omitted and a 1-phase utility voltage sensing interface is installed.

Figure 58. A Typical 3-Pole Transfer Mechanism

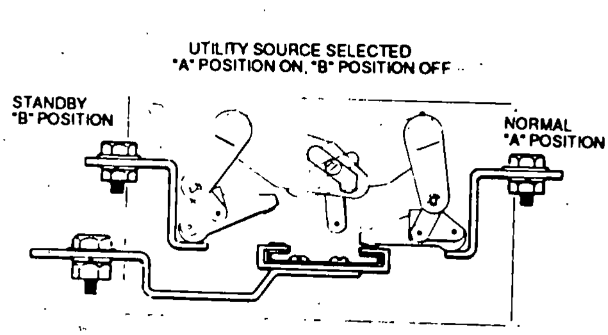


Automatic Transfer Switches (Continued)

HOW LOADS ARE RECONNECTED:

Load Connected to the NORMAL Power Supply: See Figure 59. LOAD terminals are connected to the NORMAL power source side and disconnected from the STANDBY source side.

Figure 59. LOAD Connected to NORMAL Side

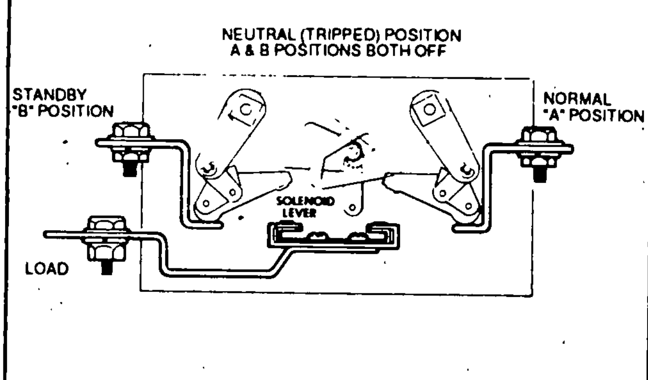


NOTE: Figures 59, 60 and 61 represent a "Wn" type transfer mechanism. For "Y" type switch positions, see Page 46.

"Neutral" or "Tripped" Position: Figure 60 shows the LOAD contacts disconnected from both the NORMAL and STANDBY power source sides.

NOTE: Some automatic transfer switches may be equipped with a "Time Delay at Neutral" feature. By allowing the LOAD to be disconnected from both power supplies for a preset time, residual voltages generated by heavy inductive loads can decay to a safe level before the LOAD is reconnected to a power source. This feature offers some protection against nuisance tripping of circuit breakers or blowing of fuses that can occur during rapid transfer of heavy inductive loads.

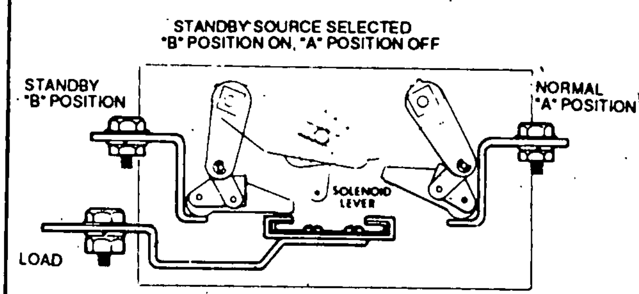
Figure 60. "Neutral" or "Tripped" Position



Load Connected to STANDBY Source Side: See Figure 61. The STANDBY main contacts are connected to the LOAD contacts. The engine-generator is supplying the LOAD.

DANGER: DIFFERENCES MAY EXIST BETWEEN TRANSFER SWITCHES. BE SURE TO READ ALL INSTRUCTIONS FOR THE SPECIFIC TRANSFER SWITCH BEING INSTALLED. FAILURE TO COMPLY WITH ALL INSTRUCTIONS CAN RESULT IN PERSONAL INJURY, AS WELL AS DAMAGE TO EQUIPMENT AND/OR PROPERTY.

Figure 61. Load Connected to STANDBY Side



Transfer Switch Selection

GENERAL:

Transfer switches are an integral part of a unified, coordinated electrical distribution system. For that reason, certain factors should be considered when selecting the transfer switch to be used. These factors are:

- ☐ Distribution system parameters.
- ☐ Functional circuit demands.
- ☐ System coordination.
- ☐ Environmental or unusual operating conditions.
- ☐ Safety.

DISTRIBUTION SYSTEM PARAMETERS:

The "Transfer Switch Selection Chart" on next page is a simplified guide for selecting a transfer switch. The Chart includes a list of operating system parameters, switch ratings, available enclosuyres and required options.

FUNCTIONAL CIRCUIT DEMANDS:

An automatic transfer switch that can monitor all phases of the NORMAL (Utility) power supply is said to offer complete protection. Other transfer switches are said to offer partial protection.

SYSTEM COORDINATION:

The transfer switch must be properly coordinated with the rest of the electrical distribution system. That is, the switch must be carefully selected on the basis of the distribution

Transfer Switch Selection (Continued)

system's voltage, continuous current, AC frequency, short circuit capabilities, etc.

The continuous current rating of the transfer switch should be determined based on both the NORMAL and STANDBY loads being supplied. Two factors are especially important when coordinating the transfer switch with the rest of the system:

- ☐ The switch must be capable of carrying full load currents and must also be able to withstand the thermal and electro-magnetic effects of short circuit currents.
- ☐ Transfer equipment and associated wiring must be provided with suitable protective devices (circuit breakers or fuses). These devices must be able to clear a fault without extensive damage.

Under abnormal operating conditions where a fault exists between the transfer switch and the LOAD, the switch may be subjected to (a) withstand, (b) closing, and (c) interrupting conditions as follows:

- ☐ With the switch main contacts closed to the NORMAL power source side, it must be able to WITHSTAND the energy let-through of the NORMAL service protective device while that device interrupts the fault.
- ☐ When the STANDBY power supply is available, the transfer switch could transfer the LOAD before the NORMAL system's protective device clears the fault. This requires that the transfer switch be capable of INTERRUPTING the protective device's let-through current.
- ☐ The transfer switch might have to "close in" on a fault and, for that reason, a CLOSING rating is required.

NOTE: Special circuitry may be required to make sure the transfer switch operates safely under interrupting, closing and withstand conditions. Publications that outline the safe use of transfer switches are (a) the National Electric Code and (b) UL 1008, "Standard for Safety, Automatic Transfer Switches".

Installation Requirements

In most cases, Generac transfer switches will be housed in a sturdy, steel, lockable enclosure. Installation requirements include the following:

- ☐ Mounting the enclosure.
- ☐ Connection of engine-generator start/stop wires.
- ☐ Connection of power source and load lines.
- ☐ Installation/connection of any options or accessories.
- ☐ Completing all required functional tests of the system, as well as system adjustments.

Mounting the Enclosure

Refer to the appropriate instruction manual for the transfer switch to be installed. Comply with mounting instructions in that manual. Some switch enclosures are designed for wall mounting and should be installed vertically onto a rigid supporting structure. Some enclosures, especially larger ones, are intended for floor mounting. Handle the transfer switch carefully and protect it against impact. Protect the switch from metal chips, construction grit, lint, filings, dust, etc. Never attempt to use a transfer switch that has become damaged.

Transfer Switch Selection Chart

1. SYSTEM DATA

	NORMAL	STANDBY
Voltage	______	______
Frequency	______	______
Phase	______	______
No. of Wires	______	______
Current Rating	______	______

Available short circuit current at point where the Transfer Switch is to be installed ______________

Interrupting rating of the upstream protective device ______________________

2. AUTOMATIC TRANSFER SWITCH RATINGS

Voltage	______
Continuous Current	______
Withsrand	______
Closing	______
Interrupting	______

3. TYPE OF ENCLOSURE (CHECK ONE)

( ) Open
( ) NEMA 1 General Purpose
( ) NEMA 3R Outdoors
( ) NEMA 12 Industrial
( ) Other (Specify)

4. OPTIONS OR SPECIAL EQUIPMENT

____
____
____
____
____

Connection of Start Circuit Wiring

Suitable, approved wiring must be properly connected to a 2-wire start terminal strip in the transfer switch enclosure and to an identically numbered terminal strip in the engine-generator's AC connection (lower) panel. Route these wires through their own conduit, separated from wires of any other power source. Recommended wire sizes depends on the length of the wiring run, as follows:

MAXIMUM WIRE LENGTH	RECOMMENDED WIRE SIZE
460 feet (140 meters)	No. 18 AWG
730 feet (223 meters)	No. 16 AWG
1160 feet (354 meters)	No. 14 AWG
1850 feet (565 meters)	No. 12 AWG

Power Source and Load Lines

Power source and load line conductors must be (a) properly supported, (b) of approved insulative qualities, and (c) of the correct wire gauge size.

When connecting power source and load lines, remove surface oxides from stripped ends of wires with a wire brush. Apply joint compound to stripped ends of conductors. Tighten terminals to the specified torque value, as given in the instruction manual for the specific transfer switch.

Before connecting any 3-phase power supply to the transfer switch, make sure the switch is rated for 3-phase use. Similarly, connect a 1-phase power supply only to a switch that is rated for 1-phase use.

DANGER: ALWAYS TURN OFF ALL POWER SUPPLY VOLTAGES TO THE TRANSFER SWITCH BEFORE ATTEMPTING TO CONNECT ANY POWER SOURCE AND LOAD LINES. BOTH THE "NORMAL" AND "STANDBY" POWER SUPPLIES MUST BE POSITIVELY TURNED OFF. FAILURE TO TURN OFF ALL POWER VOLTAGE SUPPLIES TO THE SWITCH MAY RESULT IN DANGEROUS AND POSSIBLY LETHAL ELECTRICAL SHOCK.

CAUTION: Be sure to maintain proper electrical clearances between live electrical parts and grounded metal. Allow at least one-half inch of clearance for 100-400 amp circuits; allow one inch for circuits over 400 amps.

Multi-Voltage Transfer Switches

Multi-voltage transfer switches are available. These transfer switches allow greater flexibility of use since they permit several different voltage and phase selections by the installer.

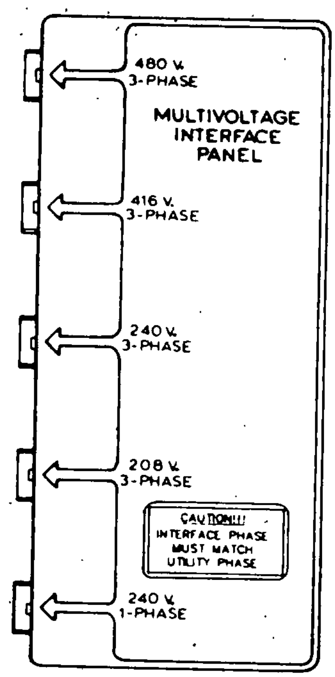
Multi-voltage transfer switches are equipped with a "multi-voltage interface panel" (Figure 62). The typical panel shown permits selection of any one of five voltage/phase ratings (480 volt, 3-phase; 416 volt, 3-phase; 240 volt, 3-phase; 208 volt, 3-phase; 240 volt, 1-phase). To select a specific voltage and phase rating, plug the panel connector plug into the interface panel receptacle indicated by the correct voltage and phase.

NOTE: On some automatic transfer switches, it may be necessary to position a Voltage Selector switch on a Utility Voltage Sensor circuit board to the correct voltage-phase setting. Refer to appropriate transfer switch instructions.

NOTE: The transfer switch's Utility Voltage Sensor circuit board should be calibrated to match the ACTUAL NORMAL power source voltage. Refer to appropriate instructions.

NOTE: A special procedure may be required when connecting a 1-phase power supply to a 3-pole multi-voltage transfer switch. Refer to the appropriate instruction manual.

Figure 62. A Typical Multi-Voltage Interface Panel



Chapter 12. ELECTRICAL CONNECTIONS

General

All wiring in the standby electric power system must be in strict compliance with applicable codes, standards and regulations. Such wiring must be properly supported, properly routed, and properly connected. In addition, wiring must be properly sized to carry the maximum load current to which it will be subjected.

Chapter 10 discusses and illustrates many of the stator AC connection systems used on engine-generators. When connecting an engine-generator into the electric system, be sure to refer to appropriate wiring diagrams and schematics for the specific model being installed.

A "Standby Electric System Interconnection Diagram" is included in Chapter 13 of this manual.

Engine-Generator Connections

Customer LOAD leads must be connected in the engine-generator's AC connection (lower) panel. In most cases, an opening must be provided in the panel for a conduit clamp and routing of AC leads into the lower panel interior. Before connecting AC cables, remove surface oxides with a wire brush. Apply joint compound to the stripped ends of conductors, then install the conductors and tighten terminal screws to their specified torque. After tightening, wipe away excess joint compound.

Some units mount a main line circuit breaker (MLCB) on the AC connection panel side. If this is the case, connect customer LOAD leads to the appropriate terminals on the circuit breaker. If the unit is not equipped with a main line breaker, an approved breaker must be provided.

Transfer Switch AC Interconnections

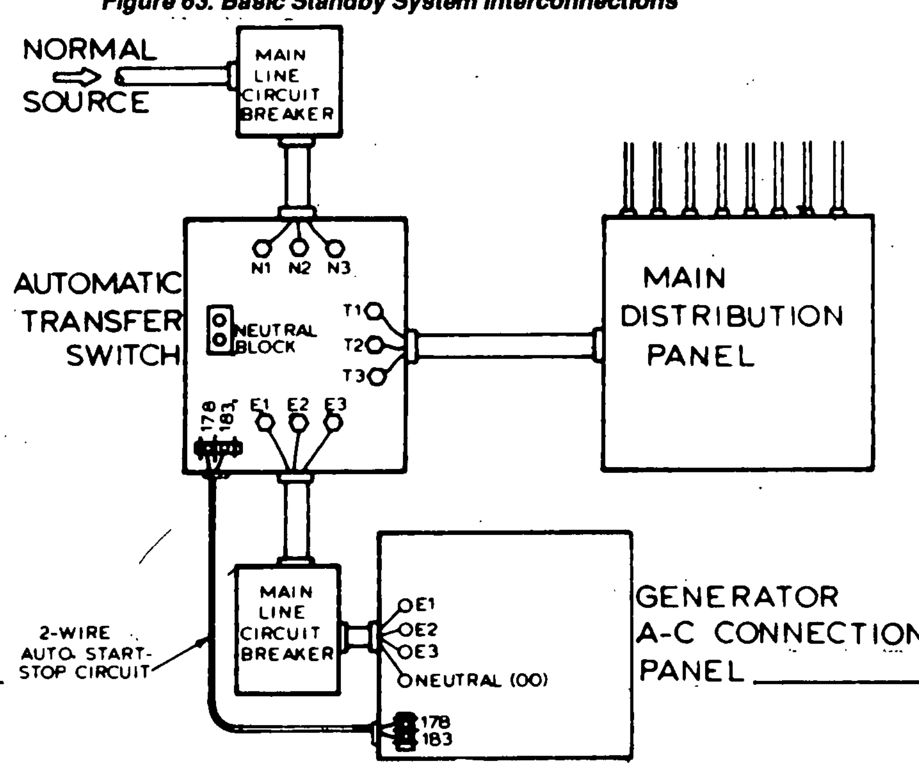
Chapter 11 outlines some basic information pertaining to transfer switches. Be sure to follow the instructions in the applicable transfer switch manual.

Automatic Start/Stop Connections

A start/stop terminal strip is provided in the engine-generator's AC connection (lower) panel. Terminals 178 and 183 are identified on the terminal strip. Connect appropriate wiring to the engine-generator terminal strip and to identically numbered terminals in the automatic transfer switch enclosure.

NOTE: Also see "Connection of Start Circuit Wiring" on Page 39.

Figure 63. Basic Standby System Interconnections



Chapter 13. SPECIFICATIONS AND CHARTS

Identification of Engine-Generators

DATA PLATE:

A Data Plate is prominently affixed to the standby generator set. The Data Plate provides the following information:

- Serial number
- Rated voltage
- Rated maximum continuous current of the generator
- Rated maximum continuous power output in watts or kW
- Rated phase of generator (1 or 3-phase)
- Rated AC frequency in Hertz
- Rated RPM of the revolving field (rotor)
- Power factor of unit (usually1.0 for 1-phase units, and 0.8 for 3-phase units)

DATA CARD:

A "Data Card" is shipped with each standby generator set. This card provides valuable information about the unit When requesting information, asking for service, ordering parts, etc., you may be asked to provide information from this card. A typical Data Card is shown at right. The Data Card provides the following information:

GENERAC CORP.

MODEL NO. 97A 01256 S — DATE 9/15/97
SG045-A164.3G18CDYNY

GROUP	DESCRIPTION	ASSEMBLY NUMBERS
A	Generator	00000 00000
B	Control Panel	00000 00000 00000
C	Mounting Base	00000 00000 00000
D	Engine & Accy.	00000 00000
E	Fuel Systems	00000
G	Wiring Diagrams	00000 00000 00000

- Generator Model Number
- Date of Manufacture
- Generator Identification Code (see below)
- Generator Assembly Groups and drawing numbers

Generator Identification Code

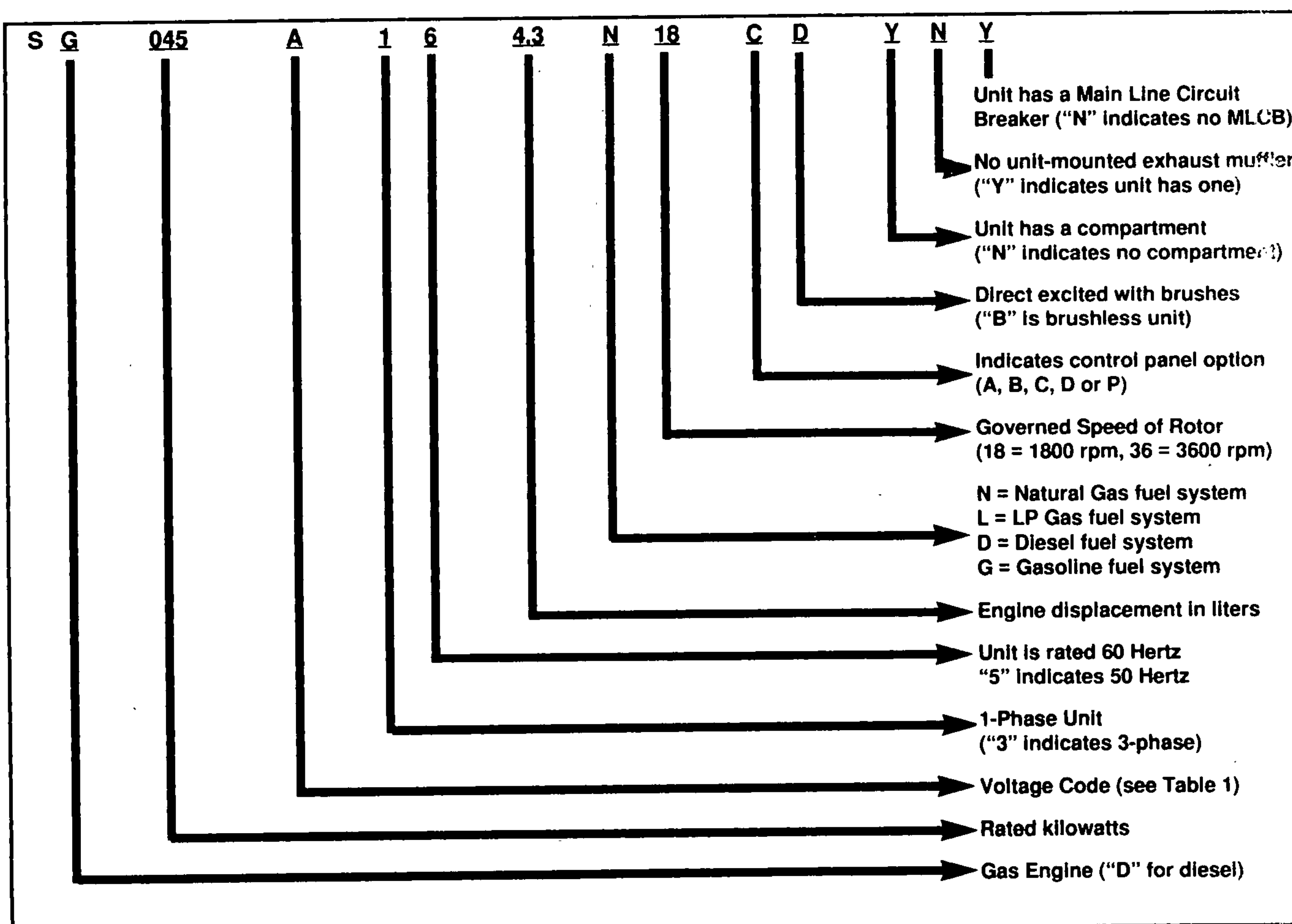


Table 1. Voltage Codes

VOLTAGE CODE	RATED VOLTS	PHASE	HERTZ	NO. OF WINDINGS	NO. OF LEADS	TYPE OF STATOR CONNECTION SYSTEM
A	120/240	1	60	2	4	Dual voltage, 3-wire, 1-phase
B*	120/208	3	60	6	12	Low (Parallel) Wye
C*	240/416	3	60	6	12	High (Series) Wye
D**	120/240	1 & 3	60	6	12	Delta
G	120/208	3	60	6	12	Low (Parallel) Wye
H	240/416	3	60	6	12	High (Series) Wye
J	120/240	3	60	6	12	Delta
K	277/480	3	60	6	12	High (Series) Wye
L	600	3	60	6	4	Wye Connected
M	110/220	1	50	2	4	Dual voltage, 3-wire, 1-phase
N	115/200	3	50	6	12	Low (Parallel) Wye
P	100/200	3	50	6	12	Delta
R	231/400	3	50	6	12	High (Series) Wye
S	480	3	50	6	4	Wye Connected

* Voltage codes "B" and "C" are obsolete, but were used prior to 1988.

** Units with Voltage Code "D" can supply 1-phase output at up to full rated capacity of the generator, but cannot be reconnected to 277/480 volts (High Wye).

Table 2. General Specifications for Gas Fueled Generators

MODEL	FREQUENCY (HERTZ)	POWER RATING (NOTE 1)	PHASE	ENG. SIZE IN LITERS (NOTE 2)	ENGINE RPM	GENERATOR RPM	EXCITATION (NOTE 3)
SG008*	60	8.0 kW	1,3	480cc	3600	3600	Direct
	50	8.0 kVA	1,3	480cc	3000	3000	Direct
SG010	60	12.0 kW	1,3	1.6	1800	1800	Direct
	50	12.0 kVA	1,3	1.6	1500	1500	Direct
SG015	60	15.0 kW	1,3	3.0	1800	1800	D or B
	50	15.0 kVA	1,3	3.0	1500	1500	D or B
SG015	60	15.0 kW	1,3	1.6	1800	1800	Direct
	50	15.0 kVA	1,3	1.6	1500	1500	Direct
SG020	60	20.0 kW	1,3	1.6	3600	3600	Direct
	50	20.0 kVA	1,3	1.6	3000	3000	Direct
SG020	60	20.0 kW	1,3	3.0	1800	1800	D or B
	50	20.0 kVA	1,3	3.0	1500	1500	D or B
SG025	60	25.0 kW	1,3	3.0	1800	1800	D or B
	50	25.0 kVA	1,3	3.0	1500	1500	D or B
SG035	60	35.0 kW	1,3	4.3	1800	1800	D or B
	50	35.0 kVA	1,3	4.3	1500	1500	D or B
SG045	60	45.0 kW	1,3	4.3	1800	1800	D or B
	50	45.0 kVA	1,3	4.3	1500	1500	D or B
SG050	60	50.0 kW	1,3	5.7	1800	1800	Brushless
	50	50.0 kVA	1,3	5.7	1500	1500	Brushless
SG070	60	70.0 kW	1,3	7.4	1800	1800	Brushless
	50	70.0 kVA	1,3	7.4	1500	1500	Brushless
SG085	60	85.0 kW	3	5.7 (GD)	3000	1800	Brushless
	50	85.0 kVA	3	5.7 (GD)	2500	1500	Brushless
SG100	60	100 kW	3	7.4 (GD)	3000	1800	Brushless
	50	100 kVA	3	7.4 (GD)	2500	1500	Brushless
SG125	60	125.0 kW	1,3	13.3	1800	1800	Brushless
	50	125.0 kVA	1,3	13.3	1500	1500	Brushless
SG150	60	150.0 kW	1,3	13.3	1800	1800	Brushless
	50	150.0 kVA	1,3	13.3	1500	1500	Brushless
SG175	60	175.0 kW	1,3	13.3	1800	1800	Brushless
	50	175.0 kVA	1,3	13.3	1500	1500	Brushless
SG200	60	200.0 kW	1,3	13.3	1800	1800	Brushless
	50	200.0 kVA	1,3	13.3	1500	1500	Brushless

NOTE 1: All 50 Hertz models are 0.8 Power Factor, including 1-phase units. All 60 Hertz, 1-phase units are 1.0 (Unity) Power Factor.
NOTE 2: "T" indicates "Turbocharged"; "GD" indicates "Gearbox Driven."
NOTE 3: "D" indicates "direct excited"; "B" indicates "brushless" units.

Table 3. General Specifications for Diesel Engine Driven Generators

MODEL	FREQUENCY (HERTZ)	POWER RATING (NOTE 1)	PHASE	ENG. SIZE IN LITERS (NOTE 2)	ENGINE RPM	GENERATOR RPM	EXCITATION (NOTE 3)
SD008	60	8.0 kW	1,3	1.0	1800	1800	Direct
	50	8.0 kVA	1,3	1.0	1500	1500	Direct
SG010	60	10.0 kW	1,3	2.4	1800	1800	D or B
	50	10.0 kVA	1,3	2.4	1500	1500	D or B
SD015	60	15.0 kW	1,3	2.4	1800	1800	D or B
	50	15.0 kVA	1,3	2.4	1500	1500	D or B
SD020	60	20.0 kW	1,3	2.4	1800	1800	D or B
	50	20.0 kVA	1,3	2.4	1500	1500	D or B
SD025	60	25.0 kW	1,3	3.0	1800	1800	D or B
	50	25.0 kVA	1,3	3.0	1500	1500	D or B
SD030	60	30.0 kW	1,3	3.0 (T)	1800	1800	D or B
	50	30.0 kVA	1,3	3.0 (T)	1500	1500	D or B
SD035	60	35.0 kW	1,3	3.0 (T)	1800	1800	D or B
	50	35.0 kVA	1,3	3.0 (T)	1500	1500	D or B
SD040	60	40.0 kW	1,3	4.0	1800	1800	Brushless
	50	40.0 kVA	1,3	4.0	1500	1500	Brushless
SD050	60	50.0 kW	1,3	4.0 (T)	1800	1800	Brushless
	50	50.0 kVA	1,3	4.0 (T)	1500	1500	Brushless
SD060	60	60.0 kW	1,3	4.0 (T)	1800	1800	Brushless
	50	60.0 kVA	1,3	4.0 (T)	1500	1500	Brushless
SD075	60	75.0 kW	1,3	4.0 (T/A)	1800	1800	Brushless
	50	75.0 kVA	1,3	4.0 (T/A)	1500	1500	Brushless
SD080	60	80.0 kW	1,3	6.4 (T)	1800	1800	Brushless
	50	80.0 kVA	1,3	6.4 (T)	1500	1500	Brushless
SD100	60	100.0 kW	3	6.4 (T/A)	1800	1800	Brushless
	50	100.0 kVA	3	6.4 (T/A)	1500	1500	Brushless
SD125	60	125.0 kW	3	6.4 (T/A)	1800	1800	Brushless
	50	125.0 kVA	3	6.4 (T/A)	1500	1500	Brushless
SD125	60	125.0 kW	3	7.5 (T)	1800	1800	Brushless
	50	125.0 kVA	3	7.5 (T)	1500	1500	Brushless
SD150	60	150.0 kW	3	7.5 (T/A)	1800	1800	Brushless
	50	150.0 kVA	3	7.5 (T/A)	1500	1500	Brushless
SD180	60	175.0 kW	3	7.5 (T/A/GD)	2300	1800	Brushless
	50	175.0 kVA	3	7.5 (T/A/GD)	2300	1500	Brushless
SD200	60	200.0 kW	3	13.3 (T)	1800	1800	Brushless
	50	200.0 kVA	3	13.3 (T)	1500	1500	Brushless
SD230	60	230.0 kW	3	13.3 (T/A)	1800	1800	Brushless
	50	230.0 kVA	3	13.3 (T/A)	1500	1500	Brushless
SD250	60	250.0 kW	3	13.3 (T/A)	1800	1800	Brushless
	50	250.0 kVA	3	13.3 (T/A)	1500	1500	Brushless
SD275	60	275.0 kW	3	13.3 (T/A)	1800	1800	Brushless
	50	275.0 kVA	3	13.3 (T/A)	1500	1500	Brushless

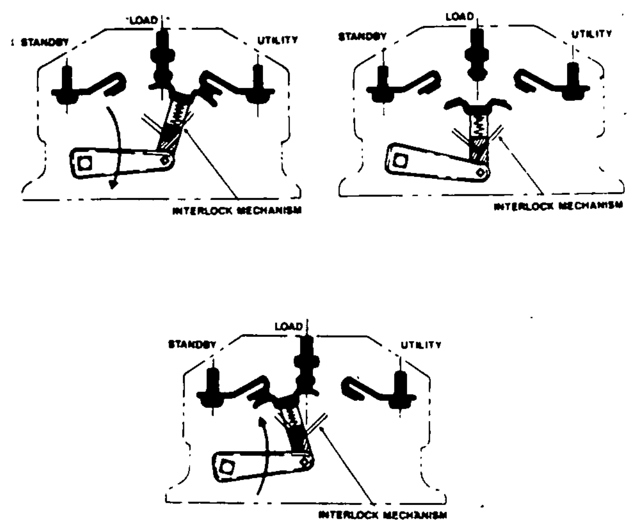
NOTE 1: All 50 Hertz models are 0.8 Power Factor, including 1-phase units. All 60 Hertz, 1-phase units are 1.0 (Unity) Power Factor.
NOTE 2: "T" indicates "turbocharged" engine; "A" indicates "aftercooled" engine; "GD" indicates "Gearbox Driven."
NOTE 3: "D" indicates "direct excited"; "B" indicates "brushless" units.

Table 4. Automatic Transfer Switches

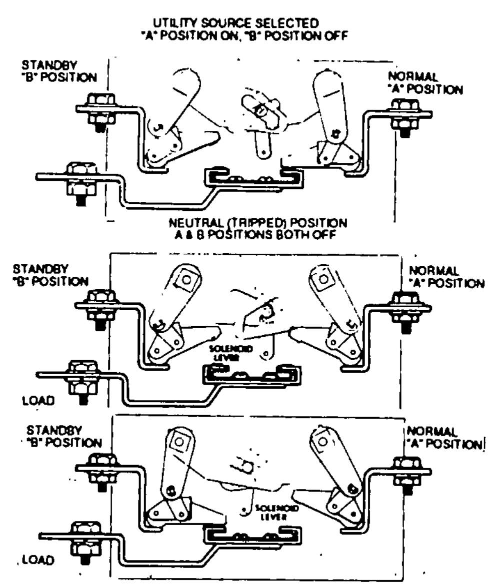
MODEL**	RATED AMPS	RATED VOLTS	NO. OF POLES
GTS010Y	105	250	2, 3 or 4
GTS015Y	150	250	2, 3 or 4
GTS020Y	200	250	2, 3 or 4
GTS030Y	300	250	2, 3 or 4
GTS042Y	420	250	2, 3 or 4
GTS010N	100	600	3 or 4
GTS015N	150	600	3 or 4
GTS020N	200	600	3 or 4
GTS030N	300	600	3 or 4
GTS040N	400	600	3 or 4
GTS060N	600	600	3 or 4
GTS080N	800	600	3 or 4
GTS100N	1000	600	3 or 4
GTS120N*	1200	600	3 or 4
GTS160N*	1600	600	3 or 4
GTS200N*	2000	600	3 or 4
GTS260N*	2600	600	3 or 4

*Cabinets on these models are free standing.
** "Y" type switches are rated 250 volts maximum and are available with 2, 3 or 4 poles. "N" type switches are rated 600 volts maximum and are available with 3 or 4 poles.

"Y" Type Main Contacts Positions



"N" Type Main Contacts Positions



TRANSFER SWITCH STANDARD FEATURES:

- ☐ Single coil design.
- ☐ Time delay at neutral.
- ☐ Silver plated or silver alloy main contacts.
- ☐ System controls include (a) utility voltage sensing, (b) automatic engine startup, (c) engine warmup before transfer, (d) engine minimum run timer, (e) engine cooldown timer, (f) weekly exerciser.
- ☐ Single pole double throw (SPDT) auxiliary contacts.
- ☐ Advisory lamps show main contacts position.
- ☐ A NEMA 1 enclosure with locking door.

TRANSFER SWITCH OPTIONAL ACCESSORIES:

- ☐ A programmed logic control system.
- ☐ NEMA 12 dustproof enclosure.
- ☐ NEMA 3R rainproof enclosure.
- ☐ Quick change multi-voltage capability.
- ☐ Exterior meter package (voltmeter, ammeter, frequency meter).
- ☐ Preferred source selector switch.
- ☐ Manual selector switch.
- ☐ Remote automatic control circuit switch.
- ☐ Signal before transfer contacts.
- ☐ Additional auxiliary contacts.

Table 5. Nominal Ampere Ratings of AC Generators

Always use KVA ratings When known — POWER FACTOR 80% KW	KVA	UNITY KW=KVA	SINGLE PHASE 120V. AMP	SINGLE PHASE 120/240V. AMP	THREE PHASE 120/208V. AMP	THREE PHASE 139/240V. 240V. 120/240V. AMP	THREE PHASE 220/380V. AMP	THREE PHASE 240/416V. AMP	THREE PHASE 240/480V. 277/480V. AMP
		0.5	4.2	2.1					
		0.75	6.25	3.2					
		1.00	8.30	4.2					
		1.25	10.4	5.2					
		1.50	12.5	6.2					
		2.00	16.7	8.3					
		2.50	20.8	10.4					
		3.00	25.0	12.5	8.3	7.2	4.6	4.2	
		3.50	29.2	14.6	9.7	8.4	5.3	4.9	
		4.50	38	19	13	11	7.2	6.3	5.4
4.0	5.0	5.00	42.0	21.0	14	12	8	7	6
		6.00	50	25	16	14	9	8	7.6
6.0	7.5	7.5	63	32	21	18	11	10.5	9
		9.0	75	38	25	22	14	12.5	11
		10.0	83	42	28	24	15	14.0	12
10.0	12.5	12.5	104	52	35	30	19	17.5	15
12.5	15.6	15.6	130	65	43	38	23	21.5	19
		15.0	125	63	42	36	23	21.0	18
15.0	18.75	18.75	156	78	53	45	29	26.5	23
		17.50	146	73	49	42	27	24.5	21
17.5	21.87	21.87	182	91	61	53	33	30.5	26
		20.0	167	84	56	48	30	28.0	24
20.0	25.0	25.0	208	104	70	60	38	35.0	30
25.0	31.25		260	130	87	75	48	43.5	38
				125	83	72	46	41.5	36
30.0	37.5			156	104	90	57	52.0	45
35.0	43.75			182	122	105	67	61.0	53
40.0	50.0			208	139	120	76	69.5	60
45.0	56.25			234	156	135	86	78.0	68
50.0	62.5			250	174	151	95	87.0	75
55.0	68			286	191	166	105	95.5	83
60.0	75.0			313	209	181	114	104.5	90
65.0	81.25			339	226	196	124	113.0	98
70.0	87.5			365	244	210	133	122.0	105
75.0	93.75			390	261	226	143	130.5	113
80.0	100.0			417	278	240	152	139	120
85.0	106.25			443	295	256	162	147.5	128
90.0	112.5			468	312	271	171	156.0	135
100.0	125			520	348	300	190	174.0	150
110.0	137.5			573	382	332	210	191.0	166
115.0	143.75			595	400	346	218	200.0	173
125.0	156.25			651	435	376	238	217.5	188
140.0	175.0			729	486	421	266	243.0	241
150.0	187.5				521	452	285	260.5	226
155.0	193.75				538	468	295	269.0	234
165.0	206.25				575	498	314	287.5	248
170.0	212.5				591	513	324	295.5	256
175.0	218.75				609	527	333	304.5	263
190.0	237.5				660	573	361	330.0	286
200.0	250.0				696	602	380	348.0	300
230.0	287.5				799	693	438	399.5	346
250.0	312.5				867	751	475	433.5	376
300.0	375				1042	903	570	521.0	452
350.0	437.5				1215	1054	666	607.5	527
400.0	500				1390	1204	761	695	602
450.0	562.5				1560	1354	855	780	676
500.0	625.0				1734	1500	950	867	751

Table 6. Allowable Ampacities of Insulated Conductors Rated 0-2000 Volts, 60° to 90° C. (140° to 194° F.) Not More Than Three Conductors in Raceway or Cable or Earth (Directly Buried), Based on Ambient Temperature of 30° C. (86° F.)

SIZE	TEMPERATURE RATING OF CONDUCTOR (See Table 7)						SIZE
	60° C. (140° F.)	75° C. (167° F.)	90° C. (194° F.)	60° C. (140° F.)	75° C. (167° F.)	90° C. (194° F.)	
AWG kcmil	TYPES TW†, UF†	TYPES FEPW† RH†, RHW† THHW† THW† THWN† XHHW† USE†, ZW†	TYPES TA, TBS, SA SIS, FEP† FEPB† RHH†, RHW2 THHN†,THHW† THW2, THWN2 USE2, XHH XHHW† XHHW2, ZW2	TYPES TW† UF†	TYPES RH†, RHW† THHW† THW† THWN† XHHW† USE†	TYPES TA, TBS, SA, SIS, THHN† THHW† THW2, THWN2 RHH†, RHW2 USE2 XHH, XHHW XHHW2, ZW2	AWG
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18	.....	.....	14	.....	.....	.....	.....
16	.....	.....	18	.....	.....	.....	.....
14	20†	20†	25†	.....	.....	.....	.....
12	25†	25†	30†	20†	20†	25†	12
10	30	35†	40†	25	30†	35†	10
8	40	50	55	30	40	45	8
6	55	65	75	40	50	60	6
4	70	85	95	55	65	75	4
3	85	100	110	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	150	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	190	230	255	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	355	420	475	285	340	385	600
700	385	460	520	310	375	420	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	450	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	520	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	560	665	750	470	560	630	2000

† Unless otherwise specifically permitted in the NEC, the overcurrent protection for conductor types marked with an obelisk (†) shall not exceed 15 amperes for No. 14; 20 amperes for No. 12, and 30 amperes for No. 10 copper; or 15 amperes for No. 12 and 25 amperes for No. 10 aluminum and copper-clad aluminum after any correction factors for ambient temperature and number of conductors have been applied.

Table 6. Allowable Ampacities of Insulated Conductors (Continued)

CORRECTION FACTORS:

Ambient Temp °C.	For ambient temperatures other than 30° C. (86° F.), multiply the allowable ampacities shown in Table 6 matching columns by the appropriate factor shown below						Ambient Temp. ° F.
21-25	1.08	1.05	1.04	1.08	1.05	1.04	70-77
26-30	1.00	1.00	1.00	1.00	1.00	1.00	78-86
31-35	0.91	0.94	0.96	0.91	0.94	0.96	87-95
36-40	0.82	0.88	0.91	0.82	0.88	0.91	96-104
41-45	0.71	0.82	0.87	0.71	0.82	0.87	105-113
46-50	0.58	0.75	0.82	0.58	0.75	0.82	114-122
51-55	0.41	0.67	0.76	0.41	0.67	0.76	123-131
56-60	.....	0.58	0.71	.....	0.58	0.71	132-140
61-70	.....	0.33	0.58	.....	0.33	0.58	141-158
71-80	.....	.....	0.41	.....	.....	0.41	159-176

Table 7. Conductor Application and Insulations

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions	Insulation	AWG or kcmil	Thickness of Insulation	Outer Mils	Covering*
Fluorinated Ethylene Propylene	FEP or FEPB	90° C. 194° F. 200° C.	Dry and damp locations Dry locations and for special applications†	Same as Trade Name Same as Trade Name	14-10 8-2 14-8 6-2		20 30 14 14	None Glass braid Asbestos
Mineral Insulation (Metal Sheathed)	MI	90° F. 194° F. 250° C. 482° F.	Dry and wet locations Special applications†	Magnesium Oxide	18-16 16-10 9-4 3-500		23 36 50 55	Copper or Alloy Steel
Moisture, Heat & Oil Resistant Thermo-plastic	MTW††	60° c.	Machine tool wiring in wet locations as permitted in NFPA 79	Flame retardant, moisture heat & oil resistant thermo-plastic	 22-12 10 8 6 4-2 1-4/0 213-500 501-1000	A 30 30 45 60 60 80 95 110	B 15 20 30 30 40 50 60 70	A= None B= Nylon Jacket or equivalent
Paper		85° C.	For underground service conductors or by special permission	Paper				Lead Sheath
Perfluoro-alkoxy	PFA	90° C. 194° F. 200° C.	Dry & damp locations Dry locations	Perfluoro-alkoxy	14-10 8-2 1-4/0		20 30 45	None
Perfluoro-alkoxy	PFAH	250° C. 482° F.	Dry areas only. See NOTE 1.	Perfluoro-alkoxy	14-10 8-2 1-4/0		20 30 45	None
Heat Resistant or Cross-Linked Synthetic Polymer	RH RHH	75° C. 167° F. 90° C. 194° F.	Dry and damp Dry and damp		10 8-2 14-12 1-4/0 213-500 501-1000 1001-2000		45 60 20 80 95 110 125	NOTE 2

Table 7. Conductor Applications and Insulations (Continued)

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions	Insulation	AWG or kcmil	Thickness of Insulation	Outer Mils	Covering
Moisture & Heat Resistant or Cross Link Synthetic Polymer	RHW	75° C. 167° F.	Dry and wet areas Where over 2000 volts insulation, shall be ozone resistant	Same as Trade Name	14-10 8-2 1-4/0 213-500 501-1000 1001-2000		45 60 80 95 110 125	Moisture Resistant flame retardant non-metal covering
Moisture & Heat Resistant or Cross Link Synthetic Polymer	RHW-2	90° C. 194° F.	Dry and wet areas	Same as Trade Name	14-10 8-2 1-4/0 213-500 501-1000 1001-2000		45 60 80 95 110 125	Moisture resistant flame retardant non-metal covering
Silicone Asbestos	SA	90° C. 194° F.	Dry and damp areas	Silicone Rubber	14-10 8-2 1-4/0 213-500 501-1000 1001-2000		45 60 80 95 110 125	Asbestos, glass or other suitable braid material
Synthetic Heat Resistant	SIS	90° C. 194° F.	Switchboard wiring only	Heat Resist. Cross Link Synthetic Polymer	14-10 8 6-2 1-4/0		30 45 60 80	None
Thermo-plastic & Asbestos	TA	90° C. 194° F.	Switchboard wiring only	Same as Trade Name	14-8 6-2 1-4/0	Th'pl 20 30 40	Asb 20 25 30	Flame retardant non-metal covering
Thermo-plastic & Fibrous Outer Braid	TBS	90° C. 194° F.	Switchboard wiring only	Thermo-plastic	14-10 8 6-2 1-4/0		30 45 60 80	Flame retardant non-metal covering
Extended Polytetra-fluoro-ethylene	TFE	250° C. 482° F.	Dry areas only Only for leads in apparatus or in raceways conn-ected to appa-ratus (Nickel or nickel coated copper only)	Extruded Polytetra-fluoro-ethylene	14-10 8-2 1-4/0		20 30 45	None
Heat Resistant Thermo-plastic	THHN	90° C. 194° F.	Dry and damp locations	Flame Retard. Heat Resistant Thermo-plastic	14-12 10 8-6 4-2 1-4/0 250-500 501-1000		15 20 30 40 50 60 70	Nylon Jacket or equivalent
Moisture & Heat Resistant Thermo-plastic	THW	75° C. 167° F. 90° C. 194° F.	Dry & wet area Special application	Same as Trade Name	14-10 8-2 1-4/0 213-500 501-1000 1001-2000		45 60 80 95 110 125	None
Moisture & Heat Resistant Thermo-plastic	THHW	75° C. 167° F. 90° C. 194° F.	Wet location Dry location		14-10 8-2 1-4/0 213-500 501-1000		45 60 80 95 110	None

Table 7. Conductor Applications and Insulations (Continued)

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions	Insulation	AWG or kcmil	Thickness of Insulation Mils	Outer Covering
Moisture & Heat Resistant Thermo-plastic	THWN	75° C. 167° F.	Dry & wet areas	See Trade Name	14-12 10 8-6 4-2 1-4/0 250-500 501-1000	15 20 30 40 50 60 70	Nylon jacket or equivalent
Moisture Resistant Thermo-plastic	TW	60° C. 140° F.	Dry & wet areas	See Trade Name	14-10 8 6-2 1-4/0 213-500 501-1000 1001-2000	30 45 60 80 95 110 125	None
Heat Resistant Cross-Linked Synthetic Polymer	XHH	90° C. 194° F.	Dry & damp areas	See Trade Name	14-10 8-2 1-4/0 213-500 501-1000 1001-2000	30 45 55 65 80 95	None
Moisture & Heat Resist. Cross Linked Synthetic Polymer	XHHW	90° C. 194° F. 75° C. 167° F.	Dry & damp areas Wet locations	See Trade Name	14-10 8-2 1-4/0 213-500 501-1000 1001-2000	30 45 55 65 80 95	None
Moisture & Heat Resistant Cross Linked Synthetic Polymer	XHHW-2	90° C. 194° F.	Dry & wet areas	See Trade Name	14-10 8-2 1-4/0 213-500 501-1000 1001-2000	30 45 55 65 80 95	None
Modified Ethylene Tetra-fluoro-ethylene	Z	90° C. 194° F. 150° C 302° F.	Dry & damp areas Dry locations	See Trade Name	14-12 10 8-4 3-1 1/0-4/0	15 20 25 35 45	None
Modified Ethylene Tetra-fluoro-ethylene	ZW	75° C. 167° F. 90° C. 194° F. 150° C. 302° F.	Wet locations Dry and damp areas Dry locations	See Trade Name	14-10 8-2	30 45	None

* Some insulations do not require an outer covering.

NOTE 1: Type PFAH is only for leads within apparatus or within raceways connected to apparatus (Nickel or nickel-coated copper).

NOTE 2: Type RH and RHH requires a moisture resistant, flame retardant, non-metallic covering.

Table 8. Electrical Formulas

VALUE	1-PHASE	3-PHASE
WATTS	I x E x PF	1 x E x 1.73 x PF
KILOWATTS	E x I x PF 1000	E x I x 1.73 x PF 1000
AMPERES	kW x 1000 E x PF	kW x 1000 E x 1.73 x PF
KILOVOLT AMPERES (KVA)	I x E 1000	I x EX 1.73 1000
FREQUENCY (HERTZ)	Rotor Poles x RPM 120	Rotor Poles x RPM 120
RPM	Hertz x 120 Rotor Poles	Hertz x 120 Rotor Poles
NUMBER OF ROTOR POLES	Hertz x 120 RPM	Hertz x 120 RPM
POWER FACTOR	Actual Watts I x E	Actual Watts I x 1.73 x E
HORSEPOWER	I x E x PF 746 x Efficiency	I x E x 1.73 x PF 746 x Efficiency
AMPERES (when kilowatts is know)	kW x 1000 E x PF	kW x 1000 E x 1.73 x PF
AMPERES (when kilovolt-amperes [kVA] is known	kVA x 1000 E	kVA x 1000 E x 1.73

Table 9. Cooling Requirements — Gas Engine Generators

TYPE	ENGINE	COOLING SYSTEM CAPACITY (Gallons)	COOLANT FLOW (gallons per hour)		HEAT REJECTION TO COOLANT BTU/Hour	AIR FLOW Cubic feet per minute	
			60 Hz	50 Hz		60 Hz	50 Hz
SG010	1.6 liter	2.12	8.00	6.75	45,000	3000	2750
SG015	3.0 liter	2.00	22.3	18.6	41,000	2160	1800
SG015	1.6 liter	2.12	8.00	39.75	78,000	3500	3150
SG020	3.0 liter	2.00	22.3	18.6	54,000	2160	1800
SG020	1.6 liter	2.00	15.8	13.2	80,000	1590	1325
SG025	1.6 liter	2.37	15.75	14.25	133,000	4000	3750
SG025	3.0 liter	2.00	22.3	18.6	68,000	2160	1800
SG035	4.3 liter	5.00	23.75	19.75	180,000	7500	6250
SG045	4.3 liter	5.00	23.75	19.75	235,000	7500	6250
SG050	5.7 liter	5.00	23.75	19.75	235,000	7500	6250
SG070	7.4 liter	5.25	23.75	19.75	330,000	8800	7330
SG085	5.7 liter	5.00	50	41.75	400,000	8800	7330
SG100	7.4 liter	5.25	50	41.75	475,000	8800	7330
SG125	13.3 liter	7.66	45	37.5	514,000	8086	6744
SG150	13.3 liter	7.66	45	37.5	440,000	17,400	14,500
SG175	13.3 liter	7.66	45	37.5	440,000	17,400	14,500
SG200	13.3 liter	7.66	45	37.5	467,000	17,400	14,500

Table 10. Cooling Requirements — Diesel Engine Generators

TYPE	ENGINE	COOLING SYSTEM CAPACITY (Gallons)	COOLANT FLOW (gallons per hour)		HEAT REJECTION TO COOLANT BTU/Hour	AIR FLOW Cubic feet per minute	
			60 Hz	50 Hz		60 Hz	50 Hz
SD008	1.0 liter	1.75	8	6.75	35,000	1540	1285
SD010	2.4 liter	2.00	14	12	45,500	1335	1112
SD015	2.4 liter	2.00	14	12	52,000	1335	1112
SD025	3.0 liter	2.80	23.75	19.75	95,054	4330	3608
SD030	3.0 liter†	2.80	23.75	19.75	107,452	4330	3608
SD035	3.0 liter†	2.80	23.75	19.75	136,382	4330	3608
SD040	4.0 liter	4.00	18.75	15.50	150,000	4500	3800
SD050	4.0 liter†	4.00	18.75	15.50	186,000	4500	3800
SD060	4.0 liter†	4.00	18.75	15.50	220,000	4500	3800
SD060	5.0 liter†	4.00	49	40	167,000	5600	4300
SD075	4.0 liter*	4.00	18.75	15.50	250,000	4500	3800
SD080	5.0 liter†	4.00	49	40	223,000	5600	4300
SD080	6.4 liter†	5.29	26.50	22.00	250,000	4950	4123
SD100	5.0 liter*	4.0	49	40	303,000	4950	4123
SD100	6.4 liter*	5.29	37	32.00	303,000	4950	4123
SD125	5.0 liter*	4.0	49	49	375,000	4950	4123
SD125	6.4 liter*	5.29	37	32.00	375,000	4950	4123
SD125	7.5 liter†	4.6	48.8	40	375,000	4950	4123
SD150	7.5 liter*	4.6	48.8	40	380,000	4950	4123
SD150	13.3 liter†	7.66	45	37.5	560,000	6700	5580
SD175	13.3 liter†	7.66	45	37.5	600,000	6700	5580
SD180	7.5 liter*	4.6	48.8	40	380,000	4950	4123
SD200	13.3 liter†	7.66	45.00	37.50	710,000	8086	6744
SD230	13.3 liter*	15.3	59.40	49.50	710,000	17,400	14,500
SD250	13.3 liter*	15.3	59.40	49.50	758,000	17,400	14,500
SD275	13.3 liter*	15.3	59.40	49.50	830,000	17,400	14,500
SD400	14.6 liter*	22.40	132	114	776,340	19,067	15,890
SD500	18.5 liter*	29.00	172	153	1,104,600	25,423	19,067
SD600	24.5 liter*	35.00	211	177	1,346,000	25,423	20,550
SD800	33.0 liter*	48.60	291	264	1,852,680	48,728	40,253

† Engine is turbocharged

* Engine is turbocharged and aftercooled

Table 11. Fuel Consumption for Gas Engine Generators

TYPE	RATED FREQUENCY	ENGINE	FUEL SYSTEM	CONSUMPTION AT PERCENT OF RATED LOAD* 25%	50%	75%	100%
SG010	60 Hz	1.6 liter	LP Gas	35	54	64	77
	50 Hz	1.6 liter	LP Gas	33	48	55	64
SG010	60 Hz	1.6 liter	Natural Gas	88	137	162	195
	50 Hz	1.6 liter	Natural Gas	82	121	145	162
SG015	60 Hz	3.0 liter	Gasoline	0.76	1.27	1.79	2.18
	50 Hz	3.0 liter	Gasoline	0.63	1.02	1.40	1.79
SG015	60 Hz	3.0 liter	LP Gas	39	64.4	90.5	110
	50 Hz	3.0 liter	LP Gas	31.8	51.4	70.9	90.5
SG015	60 Hz	3.0 liter	Natural Gas	96	162	228	277
	50 Hz	3.0 liter	Natural Gas	80	129	178	228
SG015	60 Hz	1.6 liter	LP Gas	41	67	92	118
	50 Hz	1.6 liter	LP Gas	41	61	80	99
SG015	60 Hz	1.6 liter	Natural Gas	171	197	232	260
	50 Hz	1.6 liter	Natural Gas	104	153	201	249
SG020	60 Hz	1.6 liter	LP Gas	47	79	111	143
	50 Hz	1.6 liter	LP Gas	41	66	86	112
SG020	60 Hz	1.6 liter	Natural Gas	120	200	281	361
	50 Hz	1.6 liter	Natural Gas	104	168	217	281
SG020	60 Hz	3.0 liter	Gasoline	0.95	1.58	2.21	2.84
	50 Hz	3.0 liter	Gasoline	0.82	1.32	1.83	2.33
SG020	60 Hz	3.0 liter	LP Gas	48	80	112	144
	50 Hz	3.0 liter	LP Gas	41	67	92	118
SG020	60 Hz	3.0 liter	Natural Gas	121	185	249	329
	50 Hz	3.0 liter	Natural Gas	102	169	233	281
SG025	60 Hz	1.6 liter	LP Gas	57	97	136	175
	50 Hz	1.6 liter	LP Gas	52	88	124	159
SG025	60 Hz	1.6 liter	Natural Gas	145	245	343	441
	50 Hz	1.6 liter	Natural Gas	118	200	279	359
SG025	60 Hz	3.0 liter	Gasoline	1.2	2.21	3.21	4.10
	50 Hz	3.0 liter	Gasoline	1.07	1.83	2.58	3.34
SG025	60 Hz	3.0 liter	LP Gas	61	112	163	207
	50 Hz	3.0 liter	LP Gas	54	92	131	169
SG025	60 Hz	3.0 liter	Natural Gas	169	281	410	522
	50 Hz	3.0 liter	Natural Gas	137	233	329	426
SG035	60 Hz	4.3 liter	LP Gas	73	127	188	239
	50 Hz	4.3 liter	LP Gas	61	105	150	195
SG035	60 Hz	4.3 liter	Natural Gas	185	320	474	603
	50 Hz	4.3 liter	Natural Gas	153	265	378	490
SG045	60 Hz	4.3 liter	LP Gas	86	156	226	310
	50 Hz	4.3 liter	LP Gas	73	131	188	261
SG045	60 Hz	4.3 liter	Natural Gas	201	362	522	735
	50 Hz	4.3 liter	Natural Gas	169	297	426	648
SG060	60 Hz	4.3 liter	LP Gas	110	207	305	403
	50 Hz	4.3 liter	LP Gas	91	175	253	338
SG060	60 Hz	4.3 liter	Natural Gas	277	523	769	1050
	50 Hz	4.3 liter	Natural Gas	228	424	621	818
SG075	60 Hz	4.3 liter	LP Gas	137	253	403	500
	50 Hz	4.3 liter	LP Gas	110	207	325	403
SG075	60 Hz	4.3 liter	Natural Gas	277	523	769	1015
	50 Hz	4.3 liter	Natural Gas	227	424	621	818
SG070	60 Hz	7.4 liter	LP Gas	118	220	328	431
	50 Hz	7.4 liter	LP Gas	99	182	265	348
SG070	60 Hz	7.4 liter	Natural Gas	281	522	763	1005
	50 Hz	7.4 liter	Natural Gas	233	426	619	812
SG085	60 Hz	7.4 liter	LP Gas	144	271	400	526
	50 Hz	7.4 liter	LP Gas	120	225	332	440
SG085	60 Hz	7.4 liter	Natural Gas	360	683	1005	1320
	50 Hz	7.4 liter	Natural Gas	300	570	840	1100

* Gasoline consumption in GALLONS PER HOUR. LP Gas and Natural Gas consumption in CUBIC FEET PER HOUR.

Table 11. Fuel Consumption for Gas Engine Generators

TYPE	RATED FREQUENCY	ENGINE	FUEL SYSTEM	CONSUMPTION AT PERCENT OF RATED LOAD*			
				25%	50%	75%	100%
SG100	60 Hz	7.4 liter	LP Gas	175	335	494	654
	50 Hz	7.4 liter	LP Gas	144	271	399	526
SG100	60 Hz	7.4 liter	Natural Gas	442	844	1245	1647
	50 Hz	7.4 liter	Natural Gas	362	683	1005	1326
SG125	60 Hz	13.3 liter	LP Gas	220.9	416.6	624.9	827
	50 Hz	13.3 liter	LP Gas	175.2	338.1	507.7	664.1
SG125	60 Hz	13.3 liter	Natural Gas	556	1048	1572	2081
	50 Hz	13.3 liter	Natural Gas	441	851	1277	1671
SG150	60 Hz	13.3 liter	Natural Gas				1850
	50 Hz	13.3 liter	Natural Gas				1400
SG175	60 Hz	13.3 liter	Natural Gas				2200
	50 Hz	13.3 liter	Natural Gas				1675
SG200	60 Hz	13.3 liter	Natural Gas				2550
	50 Hz	13.3 liter	Natural Gas				1935

Table 12. Fuel Consumption for Diesel Engine Generators

TYPE	RATED FREQUENCY	ENGINE	FUEL SYSTEM	CONSUMPTION AT PERCENT OF RATED LOAD*			
				25%	50%	75%	100%
SD008	60 Hz	1.0 Liter	Diesel	0.35	0.52	0.63	0.84
SD008	50 Hz	1.0 Liter	Diesel	0.31	0.47	0.56	0.68
SD010	60 Hz	2.4 Liter	Diesel	0.42	0.60	0.90	1.10
SD010	50 Hz	2.4 Liter	Diesel	0.34	0.50	0.72	0.84
SD015	60 Hz	2.4 Liter	Diesel	0.50	0.90	1.20	1.50
SD015	50 Hz	2.4 Liter	Diesel	0.40	0.70	0.90	1.20
SD020	60 Hz	2.2 Liter	Diesel	0.60	1.00	1.40	1.80
SD020	50 Hz	2.2 Liter	Diesel	0.50	0.80	1.00	1.30
SD025	60 Hz	3.0 Liter	Diesel	0.7	1.2	1.7	2.2
SD025	50 Hz	3.0 Liter	Diesel	0.6	1.0	1.4	1.8
SD030	60 Hz	3.0 Liter	Diesel Turbo	0.8	1.4	2.0	2.6
SD030	50 Hz	3.0 Liter	Diesel Turbo	0.7	1.2	1.7	2.1
SD035	60 Hz	3.0 Liter	Diesel Turbo	0.9	1.6	2.3	3.0
SD035	50 Hz	3.0 Liter	Diesel Turbo	0.8	1.3	1.9	2.5
SD040	60 Hz	4.0 Liter	Diesel	1.0	1.8	2.6	3.4
SD040	50 Hz	4.0 Liter	Diesel	0.8	1.5	2.1	2.8
SD050	60 Hz	4.0 Liter	Diesel Turbo	1.2	2.2	3.2	4.2
SD050	50 Hz	4.0 Liter	Diesel Turbo	1.0	1.8	2.6	3.4
SD060	60 Hz	4.0 Liter	Diesel Turbo	1.4	2.6	3.8	5.0
SD060	50 Hz	4.0 Liter	Diesel Turbo	1.2	2.1	3.1	4.0
SD075	60 Hz	4.0 Liter	Diesel Turbo†	1.6	3.1	4.6	6.2
SD075	50 Hz	4.0 Liter	Diesel Turbo†	1.4	12.6	3.8	5.1
SD060	60 Hz	5.0 Liter (T)	Diesel	2.0	2.8	3.6	4.7
SD060	50 Hz	5.0 Liter (T)	Diesel	1.27	2.36	3.44	4.52
SD080	60 Hz	5.0 Liter (T)	Diesel	2.3	3.2	4.3	6.0
SD080	50 Hz	5.0 Liter (T)	Diesel	2.1	3.0	4.0	5.5
SD100	60 Hz	5.0 Liter (T/A)	Diesel	2.2	4.2	6.2	8.9
SD100	50 Hz	5.0 Liter (T/A)	Diesel	1.8	3.5	5.2	6.7
SD125	60 Hz	5.0 Liter (T/A)	Diesel	2.9	5.6	8.4	11.02
SD125	50 Hz	5.0 Liter (T/A)	Diesel	2.8	5.3	7.9	10.60
SD080	60 Hz	6.4 Liter	Diesel Turbo	1.8	3.4	5.0	6.6
SD080	50 Hz	6.4 Liter	Diesel Turbo	1.5	2.8	4.2	5.5
SD100	60 Hz	6.4 Liter	Diesel Turbo†	2.2	4.2	6.2	8.2
SD100	50 Hz	6.4 Liter	Diesel Turbo†	1.8	3.5	5.2	6.8
SD125	60 Hz	6.4 Liter	Diesel Turbo†	2.7	5.2	7.7	10.2
SD125	50 Hz	6.4 Liter	Diesel Turbo†	2.2	4.2	6.2	8.2

* Consumption given in GALLONS PER HOUR.

† Units are AFTER-COOLED and turbocharged.

Table 12. Fuel Consumption — Diesel Engine Generators

TYPE	RATED FREQUENCY	ENGINE	FUEL SYSTEM	CONSUMPTION AT PERCENT OF RATED LOAD*			
				25%	50%	75%	100%
SD125	60 Hz	7.5T Liter	Diesel	2.70	5.20	7.70	10.02
SD125	50 Hz	7.5T Liter	Diesel	2.20	4.20	6.20	8.20
SD150	60 Hz	7.5TA Liter	Diesel	3.40	6.70	9.80	13.90
SD150	50 Hz	7.5TA Liter	Diesel	2.80	5.40	7.90	10.50
SD180	60 Hz	7.5TA Liter	Diesel	4.00	7.99	11.90	15.79
SD180	50 Hz	7.5TA Liter	Diesel	3.10	6.43	9.52	12.57
SD175	60 Hz	13.3 Liter	Diesel Turbo	3.8	7.5	11.3	15
SD175	50 Hz	13.3 Liter	Diesel Turbo	3.2	6.2	9.4	12.5
SD200	60 Hz	13.3 Liter	Diesel Turbo	4.3	8.5	12.5	16.5
SD200	50 Hz	13.3 Liter	Diesel Turbo	3.6	7.1	10.4	13.7
SD230	60 Hz	13.3 Liter	Diesel Turbo†	4.3	7.4	10.8	15
SD230	50 Hz	13.3 Liter	Diesel Turbo†	3.2	6.5	8.7	13.2
SD250	60 Hz	13.3 Liter	Diesel Turbo†	4.8	7.6	11.2	16.4
SD250	50 Hz	13.3 Liter	Diesel Turbo†	4.2	6.4	10.1	13.3
SD275	60 Hz	13.3 Liter	Diesel Turbo†	5.3	8.2	11.9	18.2
SD275	50 Hz	13.3 Liter	Diesel Turbo†	4.7	6.8	10.9	16.3
SD400	60 Hz	14.6 Liter	Diesel	6.85	13.70	20.55	27.40
SD400	50 Hz	14.6 Liter	Diesel	5.76	11.53	17.29	23.05
SD500	60 Hz	18.5 Liter	Diesel	8.39	16.78	25.17	33.57
SD500	50 Hz	18.5 Liter	Diesel	6.95	13.91	20.86	27.81
SD625	60 Hz	24.5 Liter	Diesel	9.89	19.78	29.67	39.56
SD625	50 Hz	24.5 Liter	Diesel	8.64	17.27	25.91	34.54
SD800	60 Hz	33.9 Liter	Diesel	13.79	27.58	41.38	55.17
SD800	50 Hz	33.9 Liter	Diesel	11.91	23.82	35.73	47.63

* Consumption given in GALLONS PER HOUR.
† Units are AFTER-COOLED and turbocharged.

Table 13. Fuel Comparison Chart

PHYSICAL PROPERTIES	BUTANE	PROPANE	NATURAL GAS	GASOLINE
Normal Atmospheric State	Gas	Gas	Gas	Liquid
Boiling Point (in ° F.) Initial End	 +32 +32	 -44 -44	 -259 -259	 +97 +420
Heating Value BTU per Gallon (Net LHV*) BTU per Gallon (Gross**) Cubic Feet (Gas)	 94,670 102,032 3264	 83,340 91,547 2516	 63,310 1000	 116,400 124,600 6390
Density***	31.26	36.39	57.75	19.50
Weight†	4.81	4.24	2.65	6.16
Octane Number Research Motor	 94 90	 110+ 97	 110+ 	 82-100 75-90

* LHV (Low Heat Value) is the more realistic rating.
** Gross Heat Value does not consider heat lost in the form of water during combustion.
*** Density is given in "Cubic Feet of Gas per Gallon of Liquid".
† Weight is given in "Pounds per Gallon of Liquid".

Table 14. Pipe Size-Gas Flow Chart

This table is based on a specific gravity of 1.00 (specific gravity of air). For that reason, a correction is required when the fuel used has a different specific gravity. The fuel's specific gravity can be obtained from the fuel supplier. The table is also based on a pressure drop of 0.3, which allows for a nominal amount of restrictions from bends, fittings, etc. An example of how to calculate pipe size follows the table.

LENGTH OF PIPE (In Feet)	IRON PIPE SIZE (IPS INCHES)										
	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"	6"	8"
15	76	172	345	750	1220	2480	3850	6500	13880	38700	79000
30	52	120	241	535	850	1780	2750	4700	9700	27370	55850
45	43	99	199	435	700	1475	2300	3900	7900	23350	45600
60	38	86	173	380	610	1290	2000	3450	6800	19330	39500
75		77	155	345	545	1120	1750	3000	6000	17310	35300
90		70	141	310	490	1000	1560	2700	5500	15800	32250
105		65	131	285	450	920	1430	2450	5100	14620	29850
120			120	270	420	860	1340	2300	4800	13680	27920
150			109	242	380	780	1220	2090	4350	12240	25000
180			100	225	350	720	1120	1950	4000	11160	22800
210			92	205	320	660	1030	1780	3700	10330	21100
240				190	300	620	970	1680	3490	9600	19740
270				178	285	580	910	1580	3250	9000	18610
300				170	270	545	860	1490	3000	8500	17660
450				140	226	450	710	1230	2500	7000	14420
600				119	192	390	600	1030	2130	6000	12480

CORRECTION FACTORS:

SPECIFIC GRAVITY	MULTIPLIER	SPECIFIC GRAVITY	MULTIPLIER	PRESSURE DROP	MULTIPLIER
0.50	1.10	1.0	0.775	0.1	0.577
0.55 (Sewage Gas)	1.04	1.2	0.707	0.2	0.815
0.60	1.00	1.4	0.655	0.3	1.000
0.65 (Nat. Gas)	0.962	1.5 (Propane)	0.633	0.5	1.29
0.70	0.926	1.7	0.594	1.0	1.83
0.80	0.867	1.9	0.565	2.0	2.58
0.90	0.817	2.1 (Butane)	0.535	5.0	4.08

Table 14. Pipe Size-Gas Flow Chart (Continued)

EXAMPLE:

From Table 11, it is determined that a generator set running at 100% of rated load on natural gas requires 545 cubic feet of gas per hour. The unit is located 75 feet from the supply tank and will use gas having a specific gravity of 0.65 (multiplier is 0.962). From Table 14, it is apparent that a 1-1/2 inch pipe will deliver this amount of gas. However, when the correction factor is applied (545 x 0.962), it becomes evident that a 1-1/2 inch pipe will deliver 524.29 cubic feet of gas per hour. The next larger pipe (2 inch) will deliver 1120 cubic feet per hour and, when the correction factor is applied, will actually deliver 1077.4 cubic feet per hour. the 2 inch pipe is required at the given distance of 75 feet. Pressure drop does not have to be considered unless an unusual number of fittings, bends or other restrictions are used. In such unusual cases, the fuel supplier will usually specify which multiplier is applicable.

Table 15. Line Sizing Chart for Liquid Propane

LIQUID GAS FLOW (CFH)	GAS FLOW GPH	PIPE LENGTH IN FEET															
		1/4" SCHEDULE		3/8" SCHEDULE		1/2" SCHEDULE		3/4" SCHEDULE		1" SCHEDULE		1-1/4" SCHEDULE		1-1/2" SCHEDULE		2" SCHEDULE	
		40	80	40	80	40	80	40	80	40	80	40	80	40	80	40	
360	10	729	416														
540	15	324	185														
720	20	182	104	825	521												
1440	40	46	26	205	129	745	504										
2160	60	20	11	92	58	331	224										
2880	80	11	6	51	32	187	127	735	537								
3600	100	7	4	33	21	119	81	470	343								

HOW TO USE TABLE 15:

1. From Table 11, find the required flow of liquid propane (LP Gas) and locate this flow in the left hand column. If the flow falls between two numbers, use the larger number.
2. Determine the total length of piping from source to point of use.
3. Read across chart from left (Required Flow) to right, to find the total length which is equal to or exceeds the distance from source to point of use.
4. From this point, read up to find the correct pipe size.

Table 16. Size of Propane Tank (In Gallons) Required at Various Temperatures when Kept at Least Half Full (Vapor Withdrawal Systems)

WITHDRAWAL RATE	LOWEST AVERAGE WINTER TEMPERATURE						
	32° F.	20° F.	10° F.	0° F.	-10° F.	-30° F.	-40° F.
500 CFH (125,000 BTU/Hour)	115	115	115	250	250	400	600
100 CFH (250,000 BTU/Hour)	250	250	250	400	500	1000	1500
150 CFH (375,000 BTU/Hour)	300	400	500	500	1000	1500	2500
200 CFH (500,000 BTU/Hour)	400	500	750	1000	1200	2000	3500
300 CFH (750,000 BTU/Hour)	750	1000	1500	2000	2500	4000	5000

Table 17. Number of 20-Gallon Propane Cylinders Required at Various Indicated Temperatures When Kept at Least Half Full (Vapor Withdrawal Systems)

	LOWEST AVERAGE WINTER TEMPERATURE					
WITHDRAWAL RATE	32° F.	20° F.	10° F.	0° F.	-10° F.	-20° F.
10 CFH (25,000 BTU/Hour)	1	1	1	1	1	2
25 CFH (62,500 BTU/Hour)	1	1	1	2	2	3
50 CFH (125,000 BTU/Hour)	2	2	3	3	4	5
100 CFH (250,000 BTU/Hour)	4	4	5	6	7	10

Table 18. Exhaust Piping Diameters

OUTLET DIAMETER OF ENGINE EXHAUST (INCHES)	RECOMMENDED EXHAUST PIPING DIAMETER (IN INCHES) BASED ON LENGTH OF PIPE (IN FEET)			
	0-10 Feet	10-20 Feet	20-30 Feet	30-80 Feet
1"	1"	1-1/4"	1-1/2"	2"
1-1/4"	1-1/4"	1-1/2"	2"	2-1/2"
1-1/2"	1-1/2"	2"	2-1/2"	3"
2"	2"	2-1/2"	3"	3-1/2"
2-1/2"	2-1/2"	3"	3-1/2"	4"
3"	3"	3-1/2"	4"	5"
3-1/2"	3-1/2"	4"	5"	6"
4"	4"	5"	6"	7"
5"	5"	6"	6"	7"

Table 19. Length Equivalents

UNIT	cm	inch	feet	yard	meter	kilometer	mile
cm	1	0.3937	0.03281	0.01094	0.01	0.00001	—
inch	2.54	1	0.0833	0.02778	0.0254	0.00003	—
feet	30.48	12	1	0.33333	0.3048	0.00030	—
yard	91.44	36	3	1	0.9144	0.00091	—
meter	100	39.3701	3.28084	1.09361	1	0.001	0.00062
kilometer	100,000	39370.1	3280.84	1093.61	1000	1	0.62137
mile	160,934	63,360	5280	1760	1609.34	1.60934	1

Table 20. Conversion Table- Units of Power

UNIT	HORSEPOWER	FT.-LB./MIN	WATT	KILOWATT	METRIC HP	BTU/MIN
HORSEPOWER	1	33,000	745.70	0.74570	1.014	42.456
FT.-LB./MINUTE	...	1	0.0226	.....	.....	0.00128
WATT	0.00134	44.25	1	0.001	0.00136	0.05687
KILOWATT	1.34102	44, 250	1000	1	1.35962	56.8690
METRIC HP	0.98632	32,550	735.498	0.73549	1	41.8271
BTU/MIN	0.02358	778.2	17.5843	0.01758	0.02391	1

Table 21. Units of Pressure and Head

UNIT	mm Hg mm of mercury	in. Hg inches of mercury	in. H2O inches of water	ft. H2O feet of water
mm Hg	1	0.03937	0.52525	0.0446
in. Hg	25.4	1	13.5954	1.13296
in. H2O	1.86827	0.07355	1	0.08333
ft. H2O	22.4193	0.88265	12	1
psi (pounds per square inch)	51.7151	2.03603	27.6807	2.30673
kg/cm2 (kilograms per square centimeter)	735.561	28.9591	393.712	32.8094
bar	750.064	29.5301	401.474	33.4562
atmosphere	760	29.9213	406.794	33.8995
kPa	7.50064	0.29530	4.01474	0.33456

Engine Room Ventilation

GENERAL:

Approximately 6 to 8 percent of the fuel consumed by an average internal combustion engine is dissipated to the surrounding air by radiation. Removal of this heat is important and is usually accomplished by the use of induced draft or ventilating fans.

Air should be removed from around the engine in a manner that will ensure an upward flow of air. The room ventilating system should also provide sufficient air distribution and removal to prevent excessive temperatures in any part of the engine room.

When engine noise must be contained within the engine-generator room, ventilating air should be delivered to and removed from the room through sound insulated air ducts. The inlet and outlet air ducts must be properly located to provide a minimum transmission of noise. Use of louvered openings in the wall of the room, for ventilating air inlets and outlets, is generally not satisfactory when noise must be contained.

SIZING OF VENTILATING FANS:

To correctly size the ventilating fan or fans in a room housing a generator, the following formula may be used:

$$CFM = \frac{400 \times HP}{T}$$

Where "CFM" = Required cubic feet per minute of air flow
"HP"=maximum engine horsepower
"T" = Room temperature rise above ambient

NOTE: Increase air flow 10% for every 2500 feet (760m) above sea level.

During cold weather, the desired temperature rise in the engine room may be as high as 80° F. (27° C.), instead of the usual 10° or 20° F. (5.519 or 11° C.) rise that is encountered, for example, at -10° F. (-23° C.). In such a case (theoretically), only 1/8 of the ventilating air is required and it is good practice to use a number of smaller fans rather than one large fan. This also permits correct ventilation at reduced engine-generator output.

Combustion Air

A diesel engine requires approximately 2.5 cfm or 0.09 cubic meters per minute per kilowatt produced.

A supply of cool, clean air is just as essential for good engine performance as an adequate fuel supply. The colder the air the higher the potential output.

Because cooler air boosts engine performance, it may be desireable to extend the air intake piping from the engine air cleaner(s) to a suitable outside point. Such an air intake must be properly located to avoid contaminants such as exhaust fumes, process fumes, dust, etc.

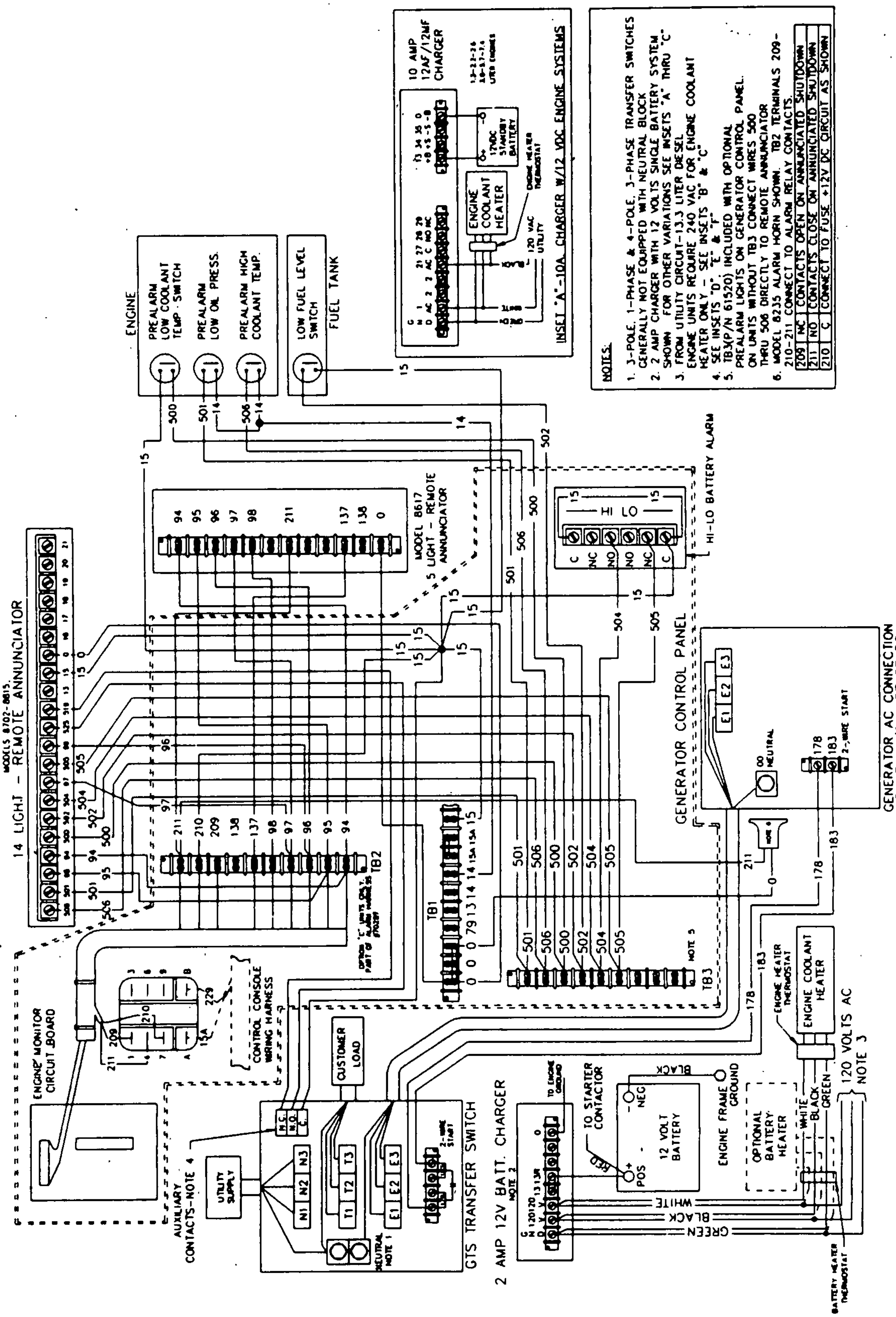
NOTE: When the engine room is well ventilated, use of air intake piping to provide cooler air to the air cleaner is usually unnecessary.

If air intake piping to the engine air cleaner is to be provided, the following rules apply:

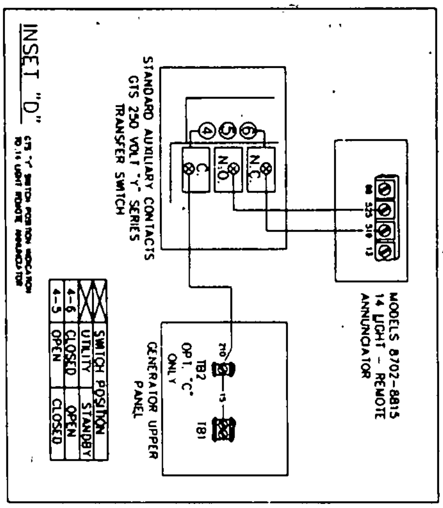
- ☐ The air cleaner should remain attached to the engine, where servicing is convenient.
- ☐ With the engine running at its rated output, restrictions in the air intake piping should not exceed 3 inches of water.

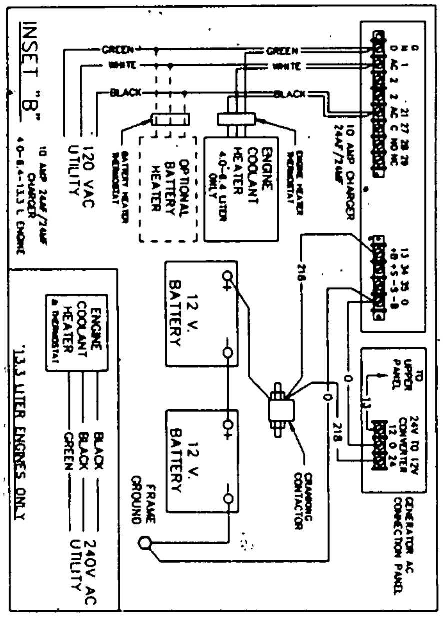
NOTE: As a general rule of thumb, required combustion air for gas engines can be calculated by multiplying fuel consumption (in cubic feet per minute) by 10.

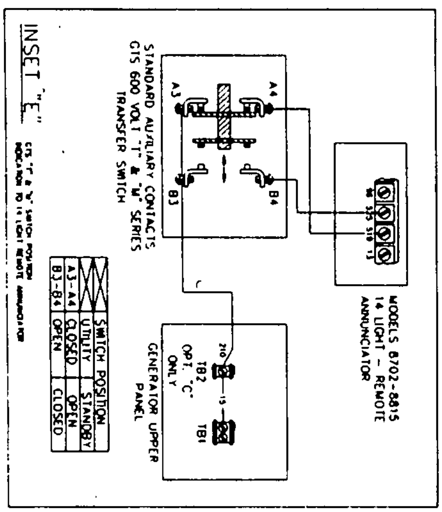
Standby Electric System Interconnection Diagram

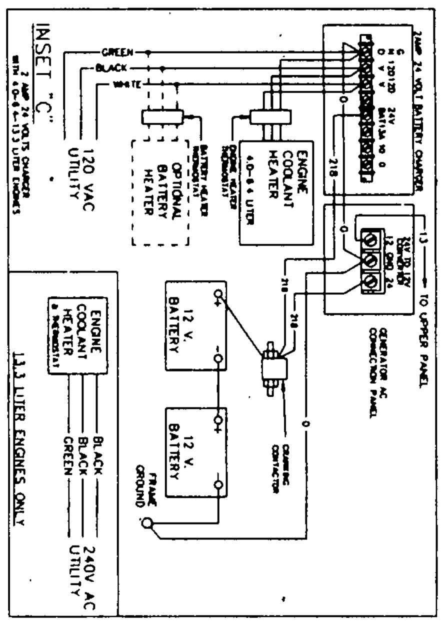


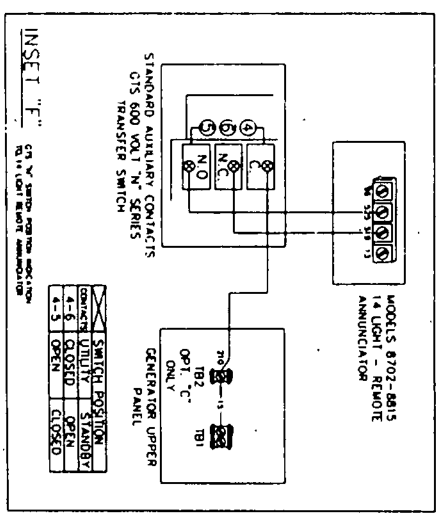
Standby Electric System Interconnection Diagram











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