TAYLOR ®

POWER SYSTEMS

GS25 STANDBY GENERATOR OPERATORS MANUAL FOR 20KW RATED & 25KW RATED GAS UNITS

TAYLOR POWER SYSTEMS / 461 Highway 49 South / Richland, Mississippi 39218

CALIFORNIA

PROPOSITION 65 WARNING

Diesel engine exhaust and some of its Constituents are known to the State of California to cause cancer, birth defects, And other reproductive harm.

INDEX

WELCOME

YOU HAVE PURCHASED ONE OF THE FINEST COMMERCIAL GENERATOR SETS AVAILABLE ON THE MARKET TODAY, A

TAYLOR POWER SYSTEMS GENERATOR SET.

READ THIS MANUAL CAREFULLY AND KEEP IT CLOSE TO THE UNIT SO THAT IT CAN BE USED WHEN NEEDED. PLEASE BEGIN YOUR OWNERSHIP PROPERLY BY REVIEWING THE SAFETY SECTION WHICH IS DIRECTLY AFTER THIS INTRODUCTION.

SAFETY!

PLEASE REVIEW THE FOLLOWING BEFORE PROCEEDING WITH INSTALLATION OR OPERATION OF YOUR TAYLOR POWER SYSTEMS GENERATOR SET.

Think Safety first at all times and when in doubt call Taylor Power Systems and get additional information before performing installation, operation, service or testing of the generator set. Each section of this manual will have **caution!** and **warning!** information which should be regarded with the utmost care. Repairs should only be done by properly trained personnel and under no circumstances should anyone proceed with a repair when they are not sure of proper procedure. This manual is not intended to be all that is required to properly operate this unit but is merely an aid to performing basic service to keep the unit in proper operating condition. Included with the unit should be an engine operator's guide and a generator operator's guide to assist a generator technician in maintaining the unit.

Installation of the unit should be done in compliance with the installation section of this manual. Proper installation in accordance with the National Electric Code, Occupational Safety and Health Administration(OSHA) and local safety codes must be strictly complied with. Proper grounding is essential in preventing possible electrical shock are even death. Remember, safety begins with the owner/operator of the unit. Make sure to keep fingers, hair, jewelry and clothing away from the revolving parts of the generator set such as belts, fan blade and generator rotor fan.

Operation of the unit should be first done by Taylor Power Systems authorized start up personnel so that they make sure the unit was properly installed and is functioning properly with the load system being applied to the unit. The start up personnel will instruct the owner on basic procedures and will answer any questions the owner may have on general operation and maintenance.

Before performing routine maintenance, disconnect the unit from the load and disable the control system as discussed in the maintenance section, **Disabling the System.** Proper maintenance is the primary method of assuring the unit will operate when it is needed.

Review each of the sections before proceeding with installation or operation of the TAYLOR POWER SYSTEMS generator set. The following page lists some of the safety do's and don'ts that everyone should remember.

SAFETY DO'S AND DON'TS

DO PRACTICE SAFETY, The life you save may be your own.

Do -

- Do perform your tasks carefully, without undue haste
- Do provide fire extinguishers(rated ABC)
- Do provide a First Aid kit(for burns and abrasions). Obtain medical attention.
- Do use the correct tools for the job you are doing
- Do make sure that all fasteners are secure.
- Do use extreme care while making adjustments on the generator set while it is running.
- Do keep your hands away from moving parts.
- Do remember - Horseplay is for horses! It has no place around machinery.
- Do disconnet batteries before starting work on generator set.
- Do use screwdrivers, pliers, diagonal pliers,etc. with insulated handles.
- Do remember to keep one hand in your pocket if it is necessary to work on "live circuits. To do so will prevent passage of electricity into one hand and out the other which passes current across the heart.

Don't -

- Don't allow inexperienced personnel to work on the generator or electrical equipment
- Don't remove plastic guards or protective devices.
- Don't wear loose clothing or jewelry in the vicinity of moving parts. These can get in machinery, with disastrous results. Don't wear jewelry while working on electrical equipment. If your hair is long, wear a head covering. Hair caught in a drill press, fan belt, or other moving parts can cause serious injury.
- Don't stand on a wet floor while working on electrical equipment. Use rubber insulated mats placed on dry wood platforms.
- Don't lunge after a dropped tool. To do so may place you in a position of extreme danger.
- Don't commence any operation until you have taken all the necessary steps to ensure that you are in complete safety.

Low Voltage

Control circuits utilized by the generator set are D.C. voltage. This voltage potential is not considered dangerous, but the large amount of current available (over 300 amps) can cause severe burns if shorted to ground.

1. Disconnect the negative terminal of the battery if possible when working on the generator set. Disconnect the cable end that is away from the battery.
2. Do not wear jewelry, watches, or rings. These items can short out and cause severe burns to the wearer.

General Safety Precautions

1. Use extreme caution if holes are drilled into the generator set. Holes drilled into an electrical wire can cause fire, explosion, or shock hazard.
2. Be sure all mounting screws are light and are the correct length.
3. Keep tools and equipment clean and in good working condition. Accidents occur when you attempt procedures without the proper tools.

Safety Precautions

Rotating Hazards

1. Keep your hands, clothing and tools clear of the fan and water pump belt when the generator set is running.
2. If it is necessary to run the generator with the end cover removed, by very careful with tools or meters being used in that area to avoid contacting the rotor.

Battery Hazards

Few people realize just how dangerous a battery can be.

The electrolyte in a lead acid battery is dilute sulphuric acid(H_2SO_4). During charge or discharge functions of a battery, a chemical change takes place within the individual cells that causes the bubbling we see through the filler hole. This gas bubbling is hydrogen and oxygen, and it is EXPLOSIVE. If, during this gassing action, a means of ignition is present, an explosion could occur. A defective battery may suddenly explode even while standing idle. Added to this danger, consider a fall-out of highly corrosive sulphuric acid caused by the explosion. A rubber blanket or other cover can be used to reduce the risk from possible explosion.

Precautions

1. Always wear eye protection when servicing batteries. If electrolyte is splashed on the skin or in the eyes, flush immediately under running water. Obtain medical help as soon as possible.
2. When charging batteries, do not remove the vent caps.
3. When disconnecting or reconnecting the generator set battery, make sure the on-off switch is in the off position to prevent an arc which could cause the battery to explode. Disconnect the ground cable first, preferably at a point away from the battery.

Reconnect

the ground cable last, again away from the battery.

Electrical Hazards

High Voltage

When servicing or repairing a generator set, the possibility of serious or even fatal injury from electrical shock exists. Extreme care must be used when working with an operating generator. Lethal voltage potentials can exist on connections that are in the exciter control box.

Precautions

1. When working on high voltage circuits on the genrator set, do not make anyu rapid moves. If a tool drops, do not grab for it. People do not contact high voltage wire on purpose. It occurs from anunplanned movement.
2. Make sure of your footing. If you slip, you will instinctively grab for support. This can be lethal around a generator set. Work on rubber mats or dry wood if possible.
3. Use tools with insulated handles that are in good condition. Never hold metal tools in your hand if exposed, energized conductors are within reach.
4. Treat all wires and connections as high voltage until a meter and wiring diagram show otherwise.

IMMEDIATE action must be initiated after a person has received an electric shock.

Obtain expert medical assistance if available.

The source of shock must be immediately removed by either shutting down the generator power or removing the victim from the source. If it is not possible to shut off the generator set, the wire should be cut with either an insulated instrument(e.g. a wooden handled axe or cable cutters with heavy insulated handles) or a rescuer wearing insulated gloves. Whichever method is used, do not look at the wire while it is being cut. The ensuing flash can cause blindness. Remember that insulated gloves manufactured for protection from liquids. If the victim has to be removed from live circuitry, pull him off. **DO NOT TOUCH HIM**, you could receive a shock from current flowing through his body. After separating the victim and power source, check immediately for respiration and presence of pulse. If a pulse is present, respiration can be restored by mouth-to-mouth resucitation.

MOUNTING

The foundation, floor or roof must be able to support the weight of the generator set and its accessories (such as a sub-base fuel tank), resist dynamic loads and not transmit objectionable noise and vibration. See the generator set Specification Sheet or outline drawing for the weight of the generator set and its mounting points.

Vibration Isolators

Figure 19 illustrates a steel spring vibration isolator of the type required for mounting the larger **TAYLOR POWER SYSTEMS generator sets** , even those models which have rubber vibration isolators between the skid and the engine-generator assembly. Steel spring isolators of this type can provide up to 98 percent reduction in the force of the vibration transmitted. Locate the isolators as shown on the generator set outline drawing referenced on the Specification Sheet. The outline drawing may show configurations involving 4-, 6-, 8- or 12-point mounting. Also, when the generator set is mounted on top of a sub-base fuel tank, the vibration isolators must be installed *between the generator set and the fuel tank.*

Bolting these generator sets directly to the floor or foundation will result in excessive noise and vibration and possible damage to the set, the floor and other equipment.

Smaller **TAYLOR POWER SYSTEMS generator sets** have rubber vibration isolators located between the skid and the engine-generator assembly. They may be bolted directly to the foundation, floor or sub-structure.

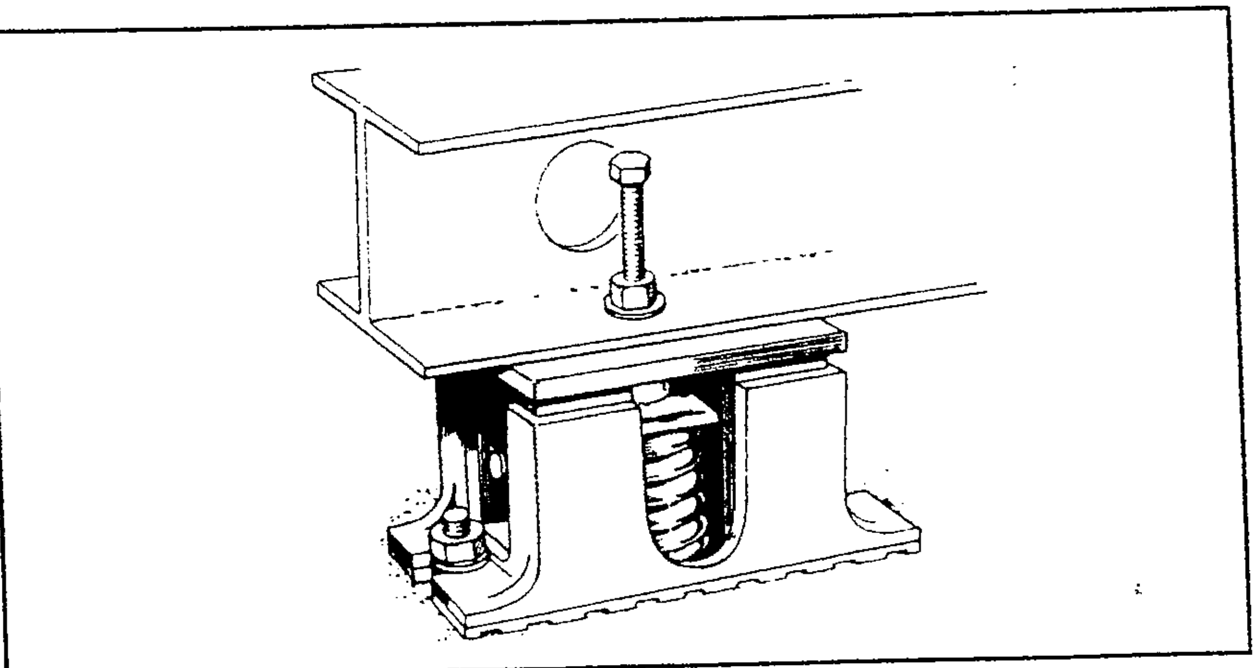


FIGURE 19. TYPICAL STEEL SPRING VIBRATION ISOLATOR

Mounting on a Slab Floor

When a generator set is mounted on a concrete slab floor, a concrete pad should be poured on top of the floor. The pad should be reinforced concrete with a 28 day compressive strength of at least 2500 psi (173 kPa). It should be at least 6 inches (150 mm) deep and extend at least 6 inches (150 mm) beyond the skid on all sides. Type J or L bolts should be used to anchor the skid or vibration isolators to the pad.

Mounting on a Sub-Base Fuel Tank

When a generator set is mounted on a sub-base fuel tank, the vibration isolators must be installed between the generator set and the fuel tank. The fuel tank must be able to support the weight of the set and resist the dynamic loads. It is recommended that the tank be mounted such that an air space is included between the bottom of the tank and the floor underneath to reduce corrosion and permit visual inspections for leaks.

Mounting on a Vibration Isolating Foundation

When a generator set is mounted on a foundation to reduce the transmission of vibrations to the building, the weight (W) of the foundation should be at least 2 times the weight of the set itself to resist dynamic loading. (The weight of fuel in a sub-base fuel tank should not be considered as contributing to the weight required of a vibration isolating foundation.) Figure 20 illustrates a typical vibration isolating foundation. Consider the following:

- The foundation should extend at least 6 inches (150 mm) beyond the skid on all sides. This determines the length (l) and width (w) of the foundation.
- Calculate the height (h) of the foundation necessary to obtain the required weight (W) by using the following formula:

  $$h = \frac{W}{d \times l \times w}$$

  where d is the density of concrete, typically 145 lbs / ft^3 (2322 kg / m^3).
- The foundation should extend at least 6 inches (150 mm) above the floor to make service and maintenance of the generator set easier.
- The foundation must extend below the frost line to prevent heaving.
- The foundation should be reinforced concrete with a 28 day compressive strength of at least 2500 psi (173 kPa).
- The total weight (TW) of the generator set, fuel and foundation usually results in a soil bearing load (SBL) of less than 2000 lbs / ft^2 (96 kPa). Although this is within the load bearing capacity of most soils, always find out the allowable soil bearing load by checking the local code and the soil analysis report for the building. Calculate the soil bearing load by using the following formula:

  $$SBL = \frac{TW}{l \times w}$$

  where l and w are the length and width of the foundation.

- Type J or L bolts should be used to anchor the skid or vibration isolators to the foundation.

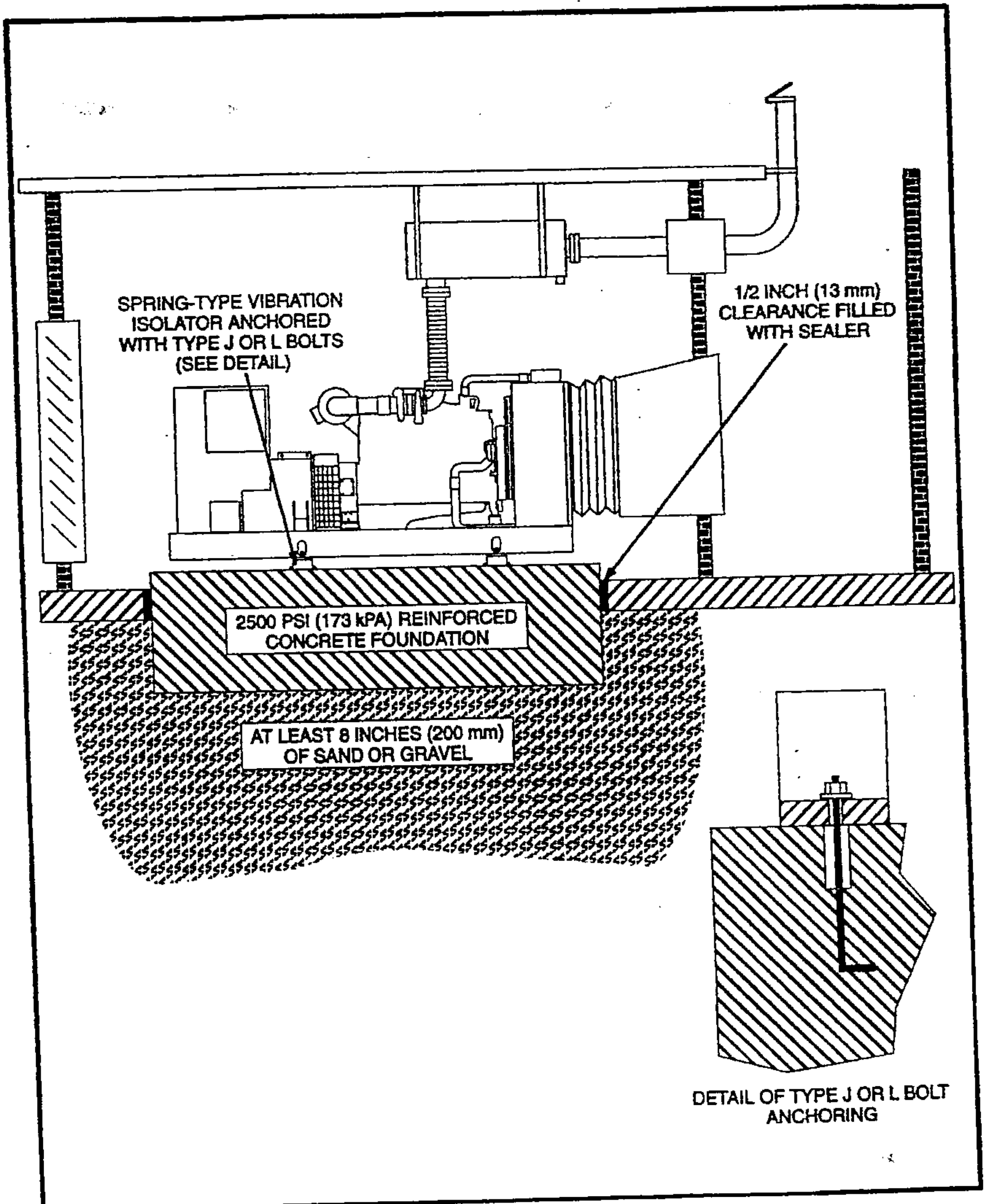


FIGURE 20. TYPICAL VIBRATION ISOLATING FOUNDATION

EXHAUST SYSTEM

The function of the exhaust system is to convey engine exhaust safely to the out-of-doors and to disperse the exhaust fumes, soot and noise away from people and buildings. See Figure 21. Consider the following (also review Location and Noise under *Application*):

- Flexible, corrugated stainless steel exhaust tubing at least 24 inches (610 mm) long must be connected to the engine exhaust outlet(s) to take up thermal expansion and generator set movement and vibration whenever the set is mounted on steel spring isolators of the type shown in Figure 19. Smaller sets that are bolted directly to the floor must be connected by corrugated stainless steel exhaust tubing at least18 inches (457 mm) long. Flexible tubing must not be used to form bends or to compensate for misaligned piping.
- To reduce corrosion due to condensate, a muffler should be installed as close as practical to the engine so that it heats up quickly.
- Mufflers and piping must be supported by non-combustible hangers or supports—not by the engine exhaust outlet. Weight on the engine exhaust outlet can cause damage to the engine exhaust manifold or reduce the life of a turbocharger.
- Schedule 40 black iron pipe is recommended for exhaust piping.

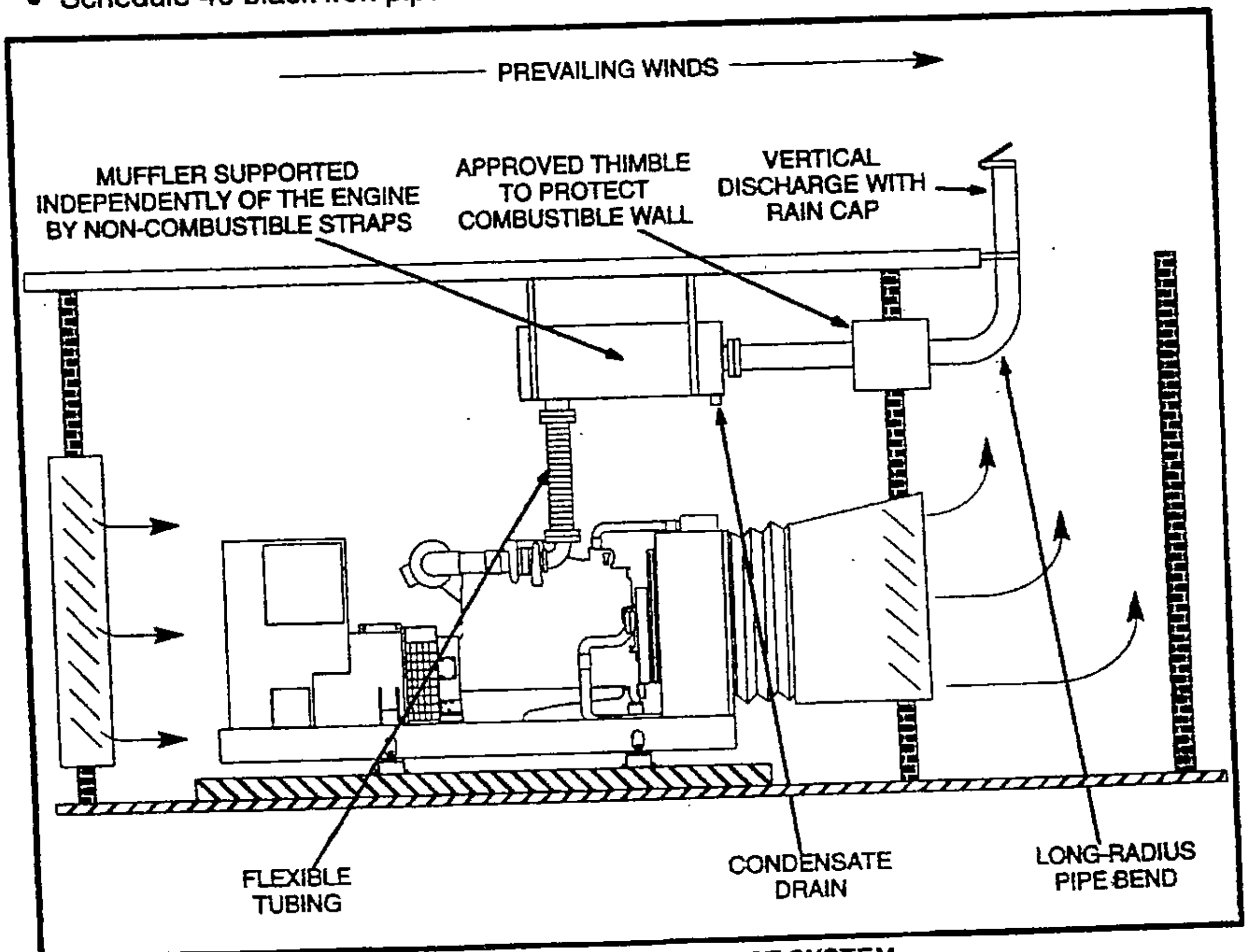


FIGURE 21. TYPICAL EXHAUST SYSTEM

- Pipe bend radii should be as long as practical.
- It is recommended that, as far as is possible and consistent with the exhaust back pressure limitations of the engine, exhaust tubing and piping of the same nominal diameter as the engine exhaust outlet be used throughout the exhaust system. **Piping of smaller diameter than the exhaust outlet must never be used.** Piping that is larger than necessary is more subject to corrosion due to condensate than smaller pipe and reduces the exhaust gas velocity available for dispersing the exhaust gases up and into the outdoor wind stream. Also, as a rule, the fewer pipe diameter changes in the exhaust system, the less friction loss.
- It is recommended that all exhaust piping and mufflers be thermally insulated to prevent burns from accidental contact, prevent activation of fire detection devices and sprinklers, reduce corrosion due to condensate and reduce the amount of heat radiated to the generator room. **Engine exhaust manifolds and turbocharger housings, unless water cooled, must never be insulated.** Doing so can result in material temperatures that can destroy the manifold and turbocharger.
- Exhaust piping must be routed at least 9 inches (229 mm) from combustible construction. Use approved thimbles where exhaust piping must pass through combustible walls or ceilings.
- Exhaust pipe (steel) expands approximately 0.0076 inches per foot of pipe for every 100° F rise in exhaust gas temperature above room temperature (1.14 mm per meter per 100° C rise). It is recommended that flexible, corrugated stainless steel tubing be used to take up expansion in long, straight runs of pipe.
- Horizontal runs of exhaust piping should slope downwards, away from the engine, to the out-of-doors or to a condensate trap.
- A condensate drain trap and plug should be provided where piping turns to rise vertically.
- The exhaust system must terminate out-of-doors at a location where engine exhaust will disperse away from buildings and building air intakes and not blacken walls and windows with soot. It is highly recommended that the exhaust system be carried up as high as practical on the downwind side of buildings and that it discharge straight up to maximize dispersal.

  Some codes specify that the exhaust outlet terminate at least 10 feet from the property line, 3 feet from an exterior wall or roof, 10 feet from openings into the building and at least 10 feet above the adjoining grade.
- A rain cap should be provided if the exhaust outlet points up.
- A generator set should not be connected to an exhaust system serving other equipment, including other generator sets. Soot, corrosive condensate and high exhaust gas temperatures can damage idle equipment served by a common exhaust system.

- Exhaust back pressure must not exceed the allowable back pressure on the generator set Specification Sheet. Excessive exhaust back pressure reduces engine power and engine life and may lead to high exhaust temperatures and smoke. Engine exhaust back pressure should be estimated before the layout of the exhaust system is finalized and it should be measured at the exhaust outlet under full-load operation before the set is placed in service.

Example Calculation: The layout of an exhaust system similar to that shown in Figure 21 calls for a 5-inch diameter by 24-inch long flexible tube at the engine exhaust outlet, a critical grade muffler with a 6-inch diameter inlet, 20 feet of 6-inch diameter pipe and one 6-inch diameter long radius elbow. The generator set Specification Sheet indicates that the engine exhaust gas flow is 2,715 cfm (cubic feet per minute) and that the maximum allowable exhaust back pressure is 41 inches WC (Water Column).

This procedure involves determining the exhaust back pressure caused by each element (flexible tubes, mufflers, elbows and pipes) and then comparing the sum of the back pressures with the maximum allowable back pressure.

1. Determine the exhaust back pressure caused by the muffler. Figure 22 is a graph of exhaust back pressures for mufflers made available by TPS. If the muffler is from another source, it will be necessary to obtain equivalent data from the muffler manufacturer. To use Figure 22:

   A. Find the cross-sectional area of the muffler inlet using Table 7 (0.1963 ft^2 in this example).

   B. Find exhaust gas velocity in feet per minute (fpm) by dividing exhaust gas flow (cfm) by the area of the muffler inlet, as follows:

   $$\text{Gas Velocity} = \frac{2,715 \text{ cfm}}{0.1963 \text{ ft}^2} = 13,831 \text{ fpm}$$

   C. In this example, the dashed lines in Figure 22 show that the critical grade muffler will cause a back pressure of approximately 21.5 inches W.C.

TABLE 7.CROSS-SECTIONAL AREAS OF OPENINGS OF VARIOUS DIAMETER

DIAMETER OF MUFFLER INLET (INCHES)	AREA OF MUFFLER INLET (FT^2)	DIAMETER OF MUFFLER INLET (INCHES)	AREA OF MUFFLER INLET (FT^2)
2	0.0218	5	0.1363
2.5	0.0341	6	0.1963
3	0.0491	8	0.3491
3.5	0.0668	10	0.5454
4	0.0873	12	0.7854

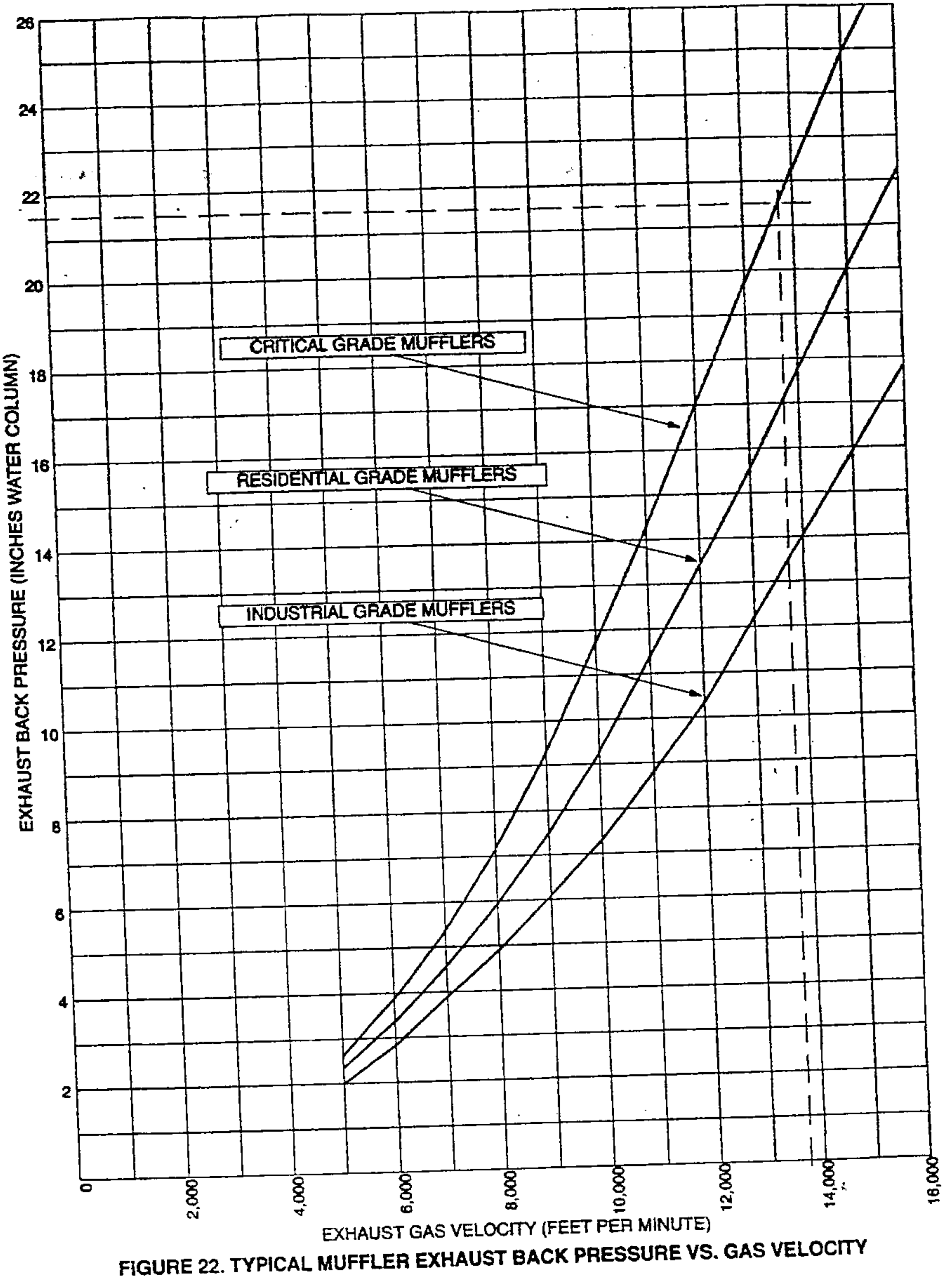


FIGURE 22. TYPICAL MUFFLER EXHAUST BACK PRESSURE VS. GAS VELOCITY

2. Find the equivalent lengths of all fittings and flexible tube sections by using Table 8.

TABLE 8. EQUIVALENT LENGTHS OF PIPE FITTINGS (FEET)

TYPE OF FITTING	NOMINAL DIAMETER (INCHES)									
	2	2.5	3	3.5	4	5	6	8	10	12
STANDARD ELBOW	5.3	6.4	8.1	9.6	11	14	16	21	26	32
MEDIUM RADIUS ELBOW	4.6	5.4	6.8	8	9	12	14	18	22	26
LONG RADIUS ELBOW	3.5	4.2	5.2	6	7	9	11	14	17	20
45° ELBOW	1.5	2	2.3	2.6	3	4	4.5	6	8	9
STANDARD TEE	13	14	17	19	22	27	34	44	56	67
18 INCH FLEXIBLE TUBE	3	3	3	3	3	3	3	3	3	3
24 INCH FLEXIBLE TUBE	4	4	4	4	4	4	4	4	4	4

3. Find the back pressure at the given exhaust flow per unit length of pipe for each nominal pipe diameter used in the system. In this example, 5 inch and 6 inch nominal pipe is used. Following the dashed lines in Figure 23, 5 inch pipe causes a back pressure of approximately **0.35** inches WC (Water Column) and 6 inch pipe approximately **0.145** inches WC.

4. Add the back pressures for all elements of the example, as follows:

Muffler	21.5
One 5 Inch Flexible Tube—0.35 x 4 ft	1.4
20 Feet of 6-Inch Pipe—0.145 x 20 ft	2.9
One 6-Inch, Long Radius Elbow—0.145 x 11 ft	1.6
TOTAL EXHAUST BACK PRESSURE (Inches WC)	**27.4**

5. The calculation indicates that the piping layout is adequate in terms of exhaust back pressure since the sum of the back pressures is less than the maximum allowable back pressure of 41 Inches WC.

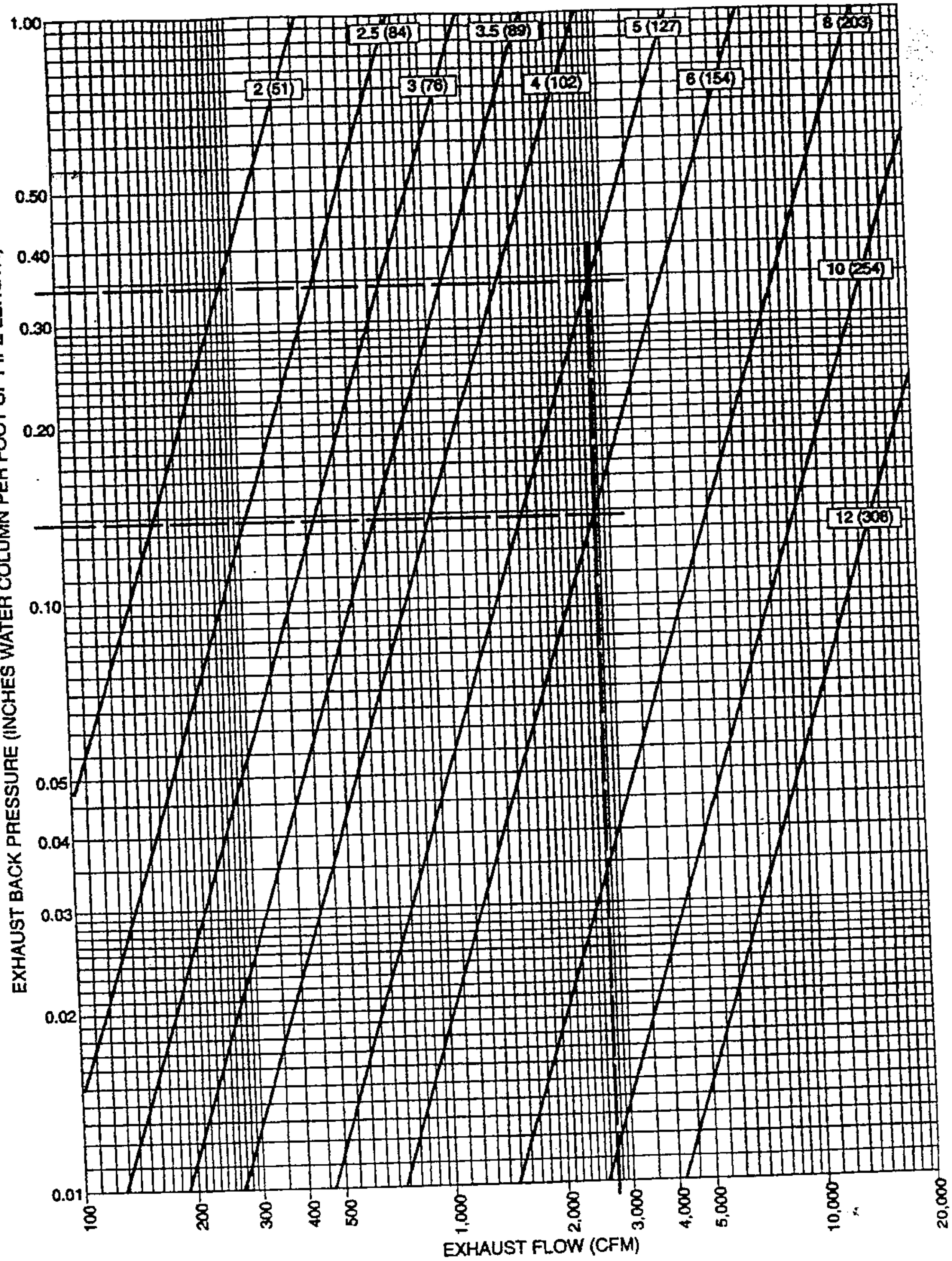


FIGURE 23. EXHAUST BACK PRESSURE IN NOMINAL INCH (mm) PIPE DIAMETERS

ENGINE COOLING

Liquid-cooled engines are cooled by pumping coolant (a mixture of water and anti-freeze) through passages in the engine cylinder block and head(s) by means of an engine-driven pump. The engine, pump and radiator or liquid-to-liquid heat exchanger form a closed, pressurized cooling system. The most common generator set configuration has a mounted radiator and engine-driven fan to cool the coolant and ventilate the generator room. Alternative methods for cooling the coolant include a mounted liquid-to-liquid heat exchanger, a remote radiator or a remote liquid-to-liquid heat exchanger.

Factory-Mounted Radiator

A generator set with a factory-mounted radiator (Figure 24) is an integral cooling and ventilating system. This is the recommended configuration involving the least amount of auxiliary equipment, piping, control wiring and coolant. A primary consideration for installations of this type is the necessity of moving large quantities of air through the generator room. See Ventilation in this section.

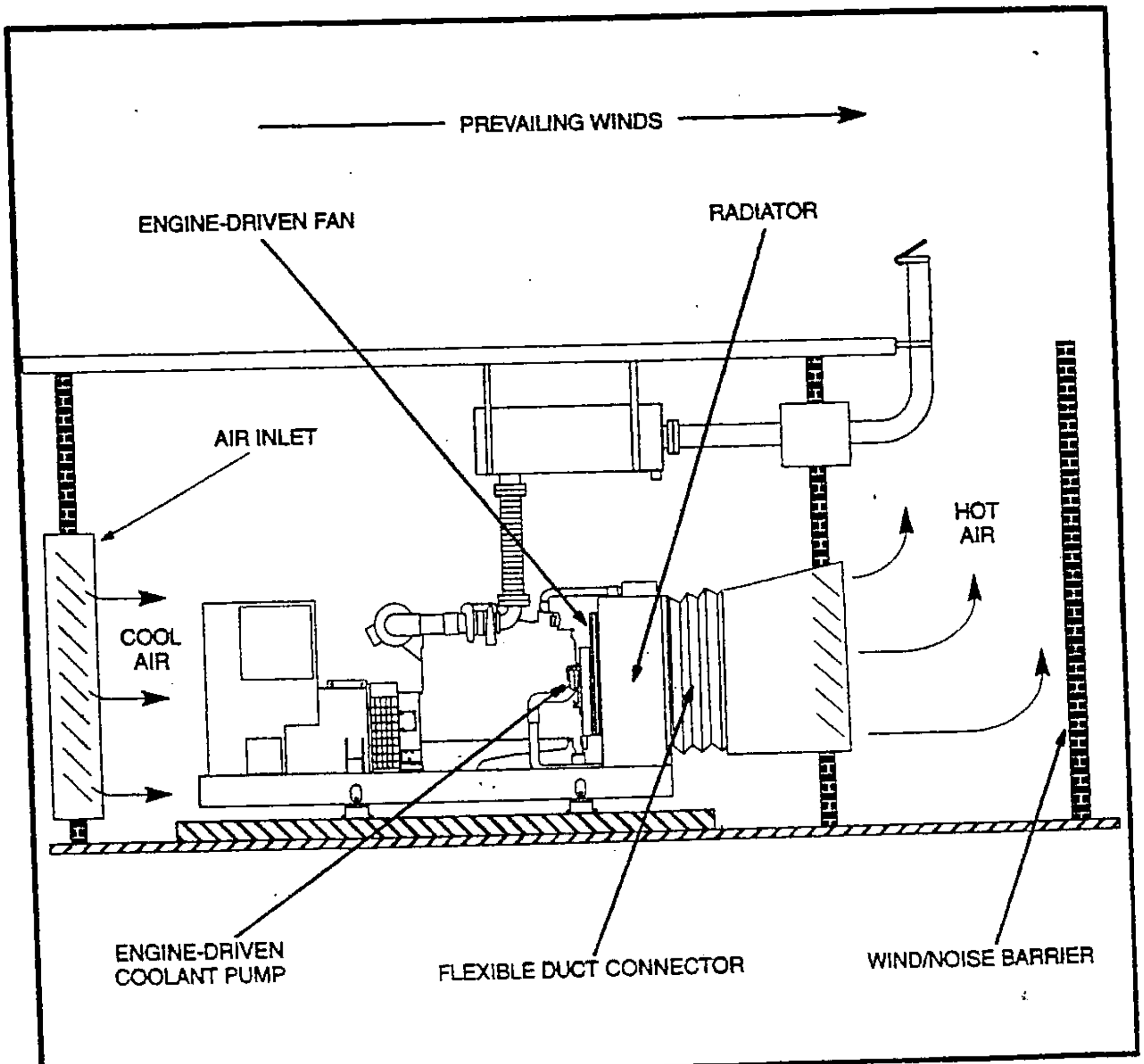


FIGURE 24. FACTORY-MOUNTED RADIATOR COOLING

Factory-Mounted Heat Exchanger

The engine, pump and liquid-to-liquid heat exchanger form a closed, pressurized cooling system. The engine coolant and raw cooling water do not mix. Consider the following:

- The installation will require a powered ventilating system. See Ventilation in this section.
- To obtain the **net power** available from the generator set, add the fan load indicated on the generator set Specification Sheet to the power rating of the set and subtract the power consumed by the remote radiator fan, ventilating fans, coolant pumps and other accessories required for the set to run.
- A pressure reducing valve must be provided if water source pressure exceeds the heat exchanger pressure rating on the generator set Specification Sheet.
- The heat exchanger and water piping must be protected from freezing if the ambient temperature can fall below 32° F (0° C).
- Recommended options include a thermostatic water valve (non-electrical) to modulate water flow in response to coolant temperature and a normally closed (NC) battery-powered shut off valve to shut off the water when the set is not running.
- There must be sufficient raw water flow to remove the **Heat Rejected To Coolant** indicated on the generator set Specification Sheet. Note that a gallon of water absorbs approximately 8 Btu each 1° F rise in temperature (specific heat). Also, it is recommended that the raw water leaving the heat exchanger not exceed 140° F (60° C). Therefore:

$$\text{Raw Water Required (gpm)} = \frac{\text{Heat Rejected}\left(\frac{\text{Btu}}{\text{min}}\right)}{\text{Temp Rise } (\Delta\ ^\circ\text{F}) \times \text{Specific Heat}\left(\frac{8\ \text{Btu}}{^\circ\text{F-Gallon}}\right)}$$

If a set rejects 19,200 Btu per minute and the raw water inlet temperature is 80° F, allowing a water temperature rise of 60° F:

$$\text{Raw Water Required} = \frac{19,200}{60 \times 8} = 40 \text{ gpm}$$

Remote Heat Exchanger

Remote heat exchanger systems can become very complex, taking a variety of configurations, especially if a secondary cooling system, such as a radiator, is used to cool the heat exchanger. Most of the considerations above and on the following pages discussing remote radiator systems apply. Careful design is required to ensure reliable, adequate cooling.

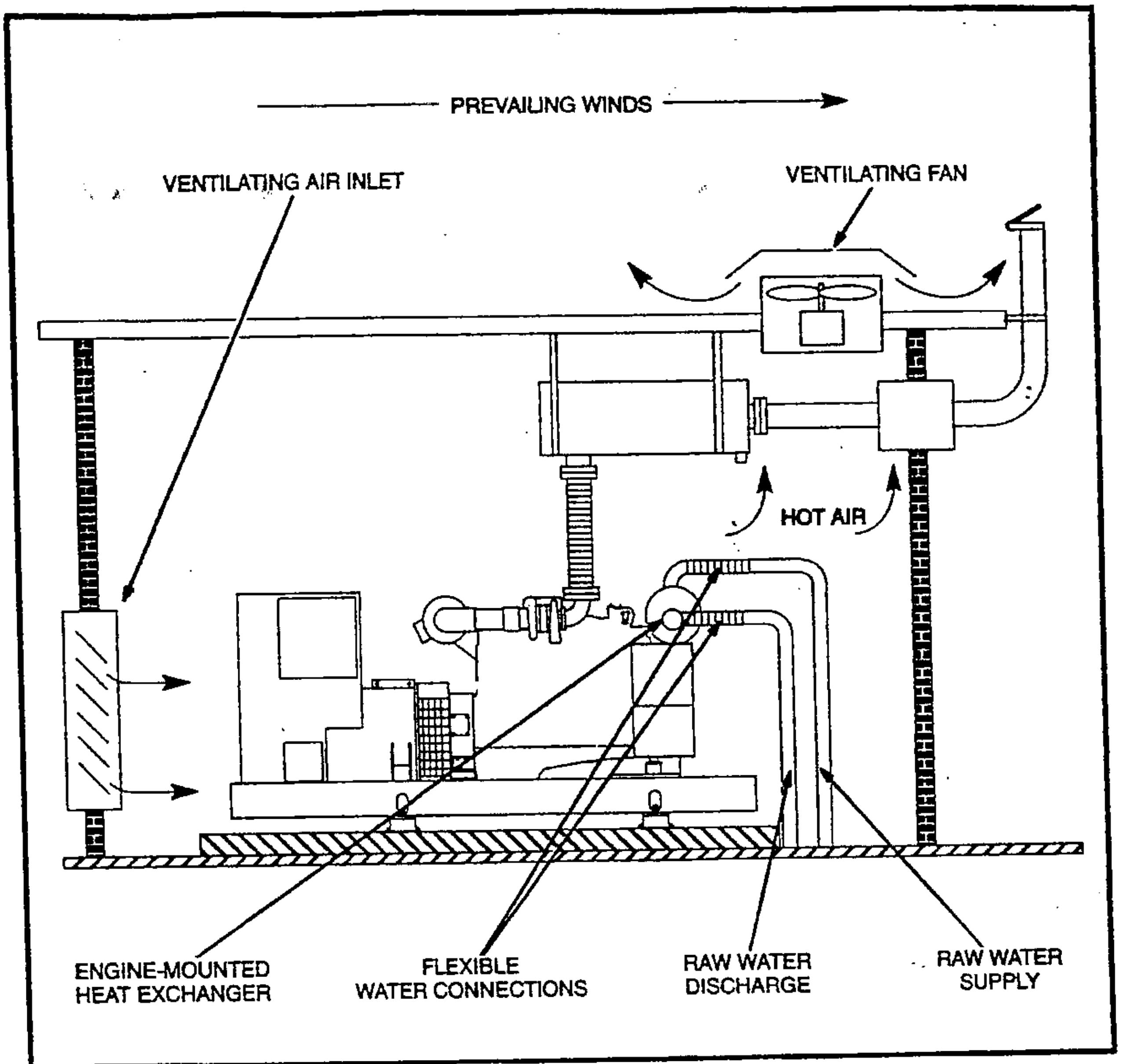


FIGURE 25. FACTORY-MOUNTED HEAT EXCHANGER COOLING

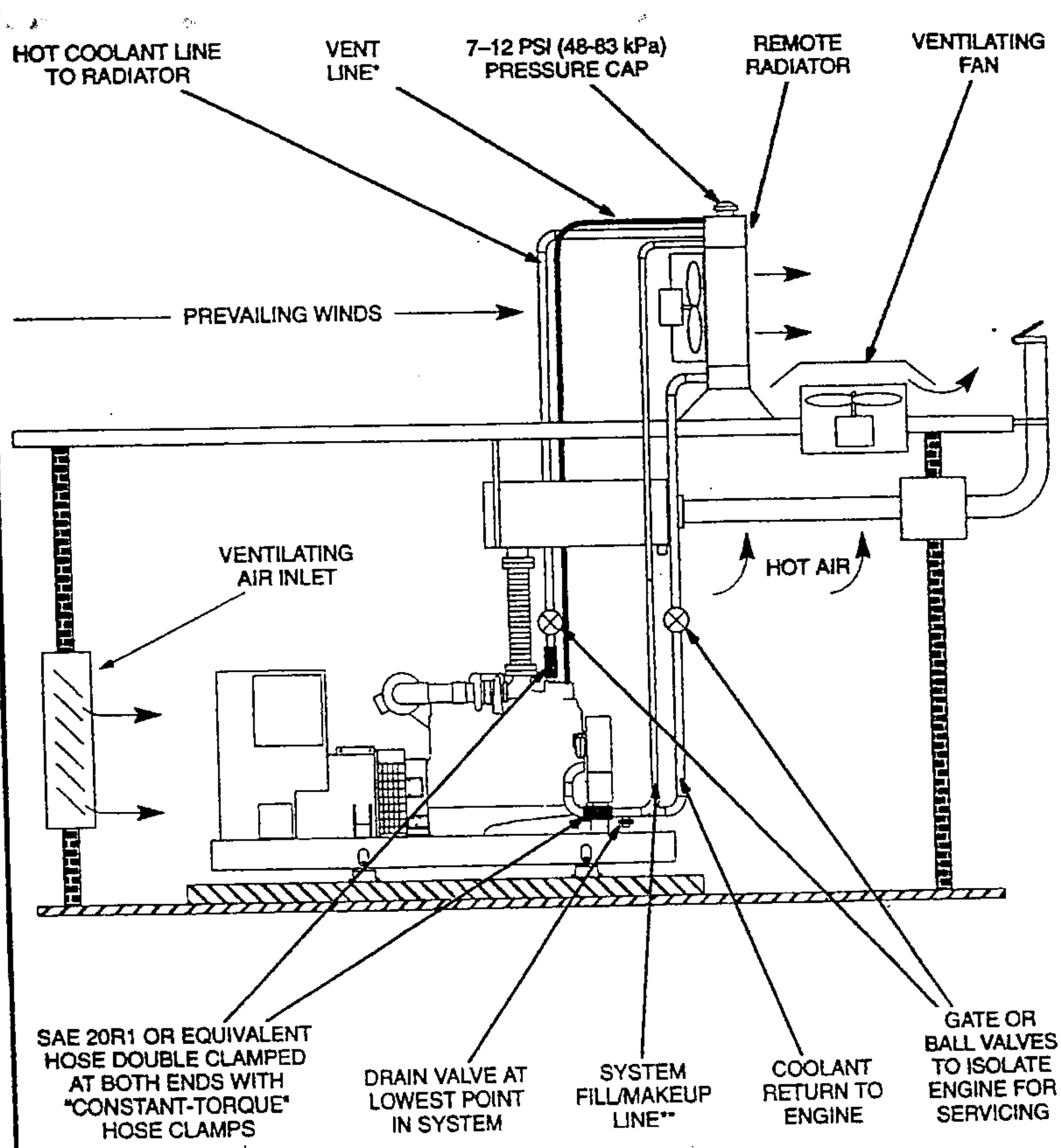
Remote Radiator

Application of a remote radiator to cool the engine requires careful design. Figures 26, 28 and 29 illustrate typical applications. Consider the following:

- It is recommended that the radiator and fan be sized on the basis of a maximum radiator top tank temperature of 200° F (93° C) and a 115 percent cooling capacity to allow for fouling. The generator set Specification Sheet indicates the **Heat Rejected To Coolant** and **Coolant Flow Rate** necessary for radiator sizing according to the radiator manufacturer's instructions.
- The capacity of the radiator top tank or auxiliary tank must be equivalent to at least 15 percent of the total volume of coolant in the system to provide a coolant "drawdown capacity" (10 percent) and space for thermal expansion (5 percent). Drawdown capacity is the volume of coolant that can be lost by slow, undetected leaks and the normal relieving of the pressure cap before air is drawn into the coolant pump. Space for thermal expansion is created by the fill neck when a cold system is being filled. See Figure 27.
- To reduce radiator fin fouling, radiators having a more open fin spacing (nine fins or less per inch) should be considered for dirty environments.
- Coolant friction head external to the engine (pressure loss due to pipe, fitting and radiator friction) and coolant static head (height of liquid column measured from crankshaft centerline) must not exceed the maximum allowable values on the generator set Specification Sheet. See the example calculation below for a method of calculating coolant friction head.

  Excessive coolant static head (pressure) can cause the coolant pump shaft seal to leak. Excessive coolant friction head (pressure loss) will result in insufficient engine cooling.

- Radiator hose 6 to 18 inches (152 to 457mm) long, complying with SAE 20R1, or equivalent standards, should be used to connect coolant piping to the engine to take up generator set movement and vibration.
- It is highly recommended that the radiator hoses be clamped with two premium grade "constant-torque" hose clamps at each end to reduce the risk of sudden loss of engine coolant due to a hose (which is under pressure) slipping off. **Major damage can occur to an engine if it is run without coolant in the block just a few seconds.**
- A drain valve should be located at the lowest part of the system
- Depending on the amount of coolant in the system, ball or gate valves (globe valves are too restrictive) are recommended to isolate the engine so that the entire system does not have to be drained before servicing the engine.
- To obtain the **net power** available from the generator set, add the fan load indicated on the generator set Specification Sheet to the power rating of the set and subtract the power consumed by the remote radiator fan, ventilating fans, coolant pumps and other accessories required for the set to run.



* – THE VENT LINE MUST NOT HAVE ANY DIPS OR TRAPS THAT WILL COLLECT COOLANT AND PREVENT AIR FROM VENTING WHEN THE SYSTEM IS BEING FILLED WITH COOLANT.

** – THE FILL/MAKEUP LINE MUST BE ROUTED DIRECTLY TO THE LOWEST POINT IN THE PIPING SYSTEM SO THAT THE SYSTEM CAN BE FILLED FROM THE BOTTOM UP AND NOT TRAP AIR.

FIGURE 26. REMOTE RADIATOR COOLING (DEAERATION TYPE SYSTEM, SEE FIGURE 27)

Deaeration Type Remote Radiator System: A deaeration type of radiator top tank (also known as a sealed top tank) or auxiliary tank must be provided for 150 kW and larger generator sets. In this system, a portion of the coolant flow (approximately 5 percent) is routed to the radiator top tank, above the baffle plate, where air in the coolant can separate from the coolant before the coolant returns to the system. Consider the following:

- Engine and radiator vent lines must rise without any dips or traps that will collect coolant and prevent air from venting when the system is being filled. Rigid steel or high density polystyrene tubing is recommended for long runs, especially if they are horizontal, to prevent sagging between supports.

- The fill/makeup line should also rise without any dips from the lowest point in the piping system to the connection at the radiator top tank or auxiliary tank. No other piping should be connected to it. This arrangement allows the system to be filled from bottom up without trapping air and giving a false indication that the system is full. With proper vent and fill line connections, it should be possible to fill the system at a rate of at least 5 gpm (19 L/Min) (approximately the flow rate of a garden hose).

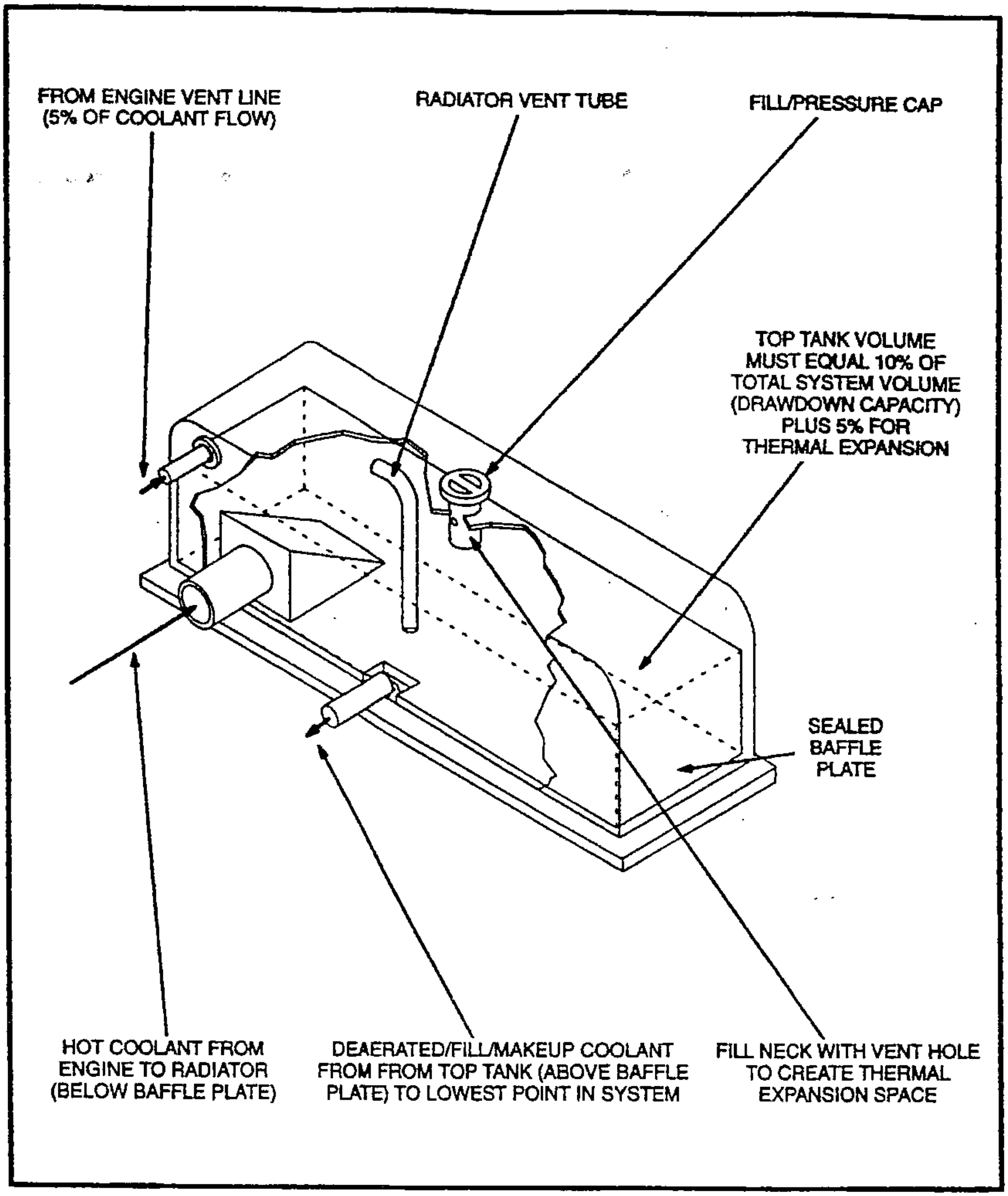


FIGURE 27. DEAERATION TYPE OF RADIATOR TOP TANK

Remote Radiator with Auxiliary Coolant Pump: A remote radiator with an auxiliary coolant pump (Figure 28) can be used if coolant friction exceeds the allowable value on the generator set Specification Sheet. In addition to the considerations under Remote Radiators, consider the following:

- An auxiliary pump and motor must be sized for the coolant flow indicated on the generator set Specification Sheet and develop enough head (pressure) to overcome the excess coolant friction head calculated by the method shown in the example above.

  One foot of pump head (pump manufacturer's data) is equivalent to 0.43 PSI of coolant friction head (pressure loss) or one foot of coolant static head (height of liquid column).

- A bypass gate valve (globe valves are too restrictive) must be plumbed in parallel with the auxiliary pump, for the following reasons:

  - To allow adjustment of the head developed by the auxiliary pump (the valve is adjusted to a partially-open position to recirculate some of the flow back through the pump).

  - To allow operation of the generator set under partial load if the auxiliary pump fails (the valve is adjusted to a fully open position).

- Coolant pressure at the inlet to the engine coolant pump, measured while the engine is running at rated speed, must not exceed the maximum allowable static head shown on the generator set Specification Sheet. Also, for deaeration type cooling systems (150 kW and larger generator sets), auxiliary pump head must not force coolant through the make-up line into the radiator top tank or auxiliary tank. In either case, the pump bypass valve must be adjusted to reduce pump head to an acceptable level.

- To obtain the **net power** available from the generator set, add the fan load indicated on the generator set Specification Sheet to the power rating of the set and subtract the power consumed by the remote radiator fan, ventilating fans, coolant pumps and other accessories required for the set to run.

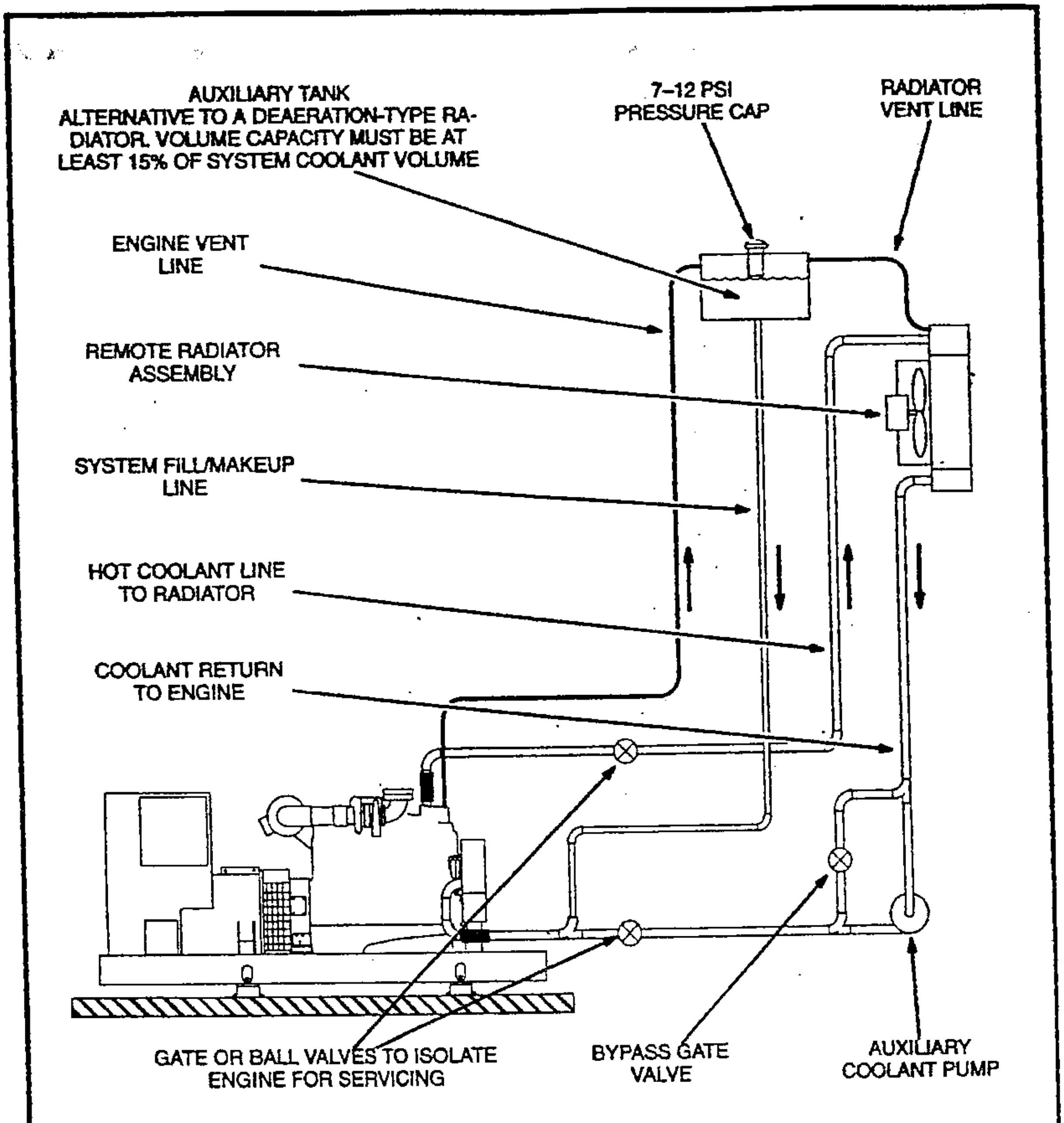


FIGURE 28. REMOTE RADIATOR WITH AUXILIARY COOLANT PUMP AND AUXILIARY TANK

Remote Radiator with Hot Well: A remote radiator with a hot well (Figure 29) can be used if the elevation of the radiator above the crankshaft centerline exceeds the allowable coolant static head on the generator set Specification Sheet. In a hot well system, the engine coolant pump circulates coolant between engine and hot well and an auxiliary pump circulates coolant between hot well and radiator. A hot well system requires careful design. In addition to the considerations under Remote Radiator, consider the following:

- The bottom of the hot well should be above the engine coolant outlet.
- Coolant flow through the hot well/radiator circuit should be approximately the same as coolant flow through the engine. The radiator and the auxiliary pump must be sized accordingly. Pump head must be sufficient to overcome the sum of the static and friction heads in the hot well/radiator circuit.

  One foot of pump head (pump manufacturer's data) is equivalent to 0.43 PSI of coolant friction head (pressure loss) or one foot of coolant static head (height of liquid column).

- The liquid holding capacity of the hot well should not be less than the sum of the following volumes:
  - 1/4 of the coolant volume pumped per minute through the engine (eg., 25 gallons if the flow is 100 gpm), plus
  - 1/4 of the coolant volume pumped per minute through the radiator (eg., 25 gallons if the flow is 100 gpm), plus

    Volume required to fill the radiator and piping, plus

    Five percent of total system volume for thermal expansion
- Careful design of the inlet and outlet connections and baffles is required to minimize coolant turbulence, allow free deareation and maximize blending of engine and radiator coolant flows.
- Coolant must be pumped to the bottom tank of the radiator and returned from the top tank, otherwise the pump will not be able to completely fill the radiator.
- The auxiliary pump must be lower than the low level of coolant in the hot well so that it will always be primed.
- The radiator should have a vacuum relief check valve to allow drain down to the hot well.
- The hot well should have a high volume breather cap to allow the coolant level to fall as the auxiliary pump fills the radiator and piping.
- To obtain the **net power** available from the generator set, add the fan load indicated on the generator set Specification Sheet to the power rating of the set and subtract the power consumed by the remote radiator fan, ventilating fans, coolant pumps and other accessories required for the set to run.

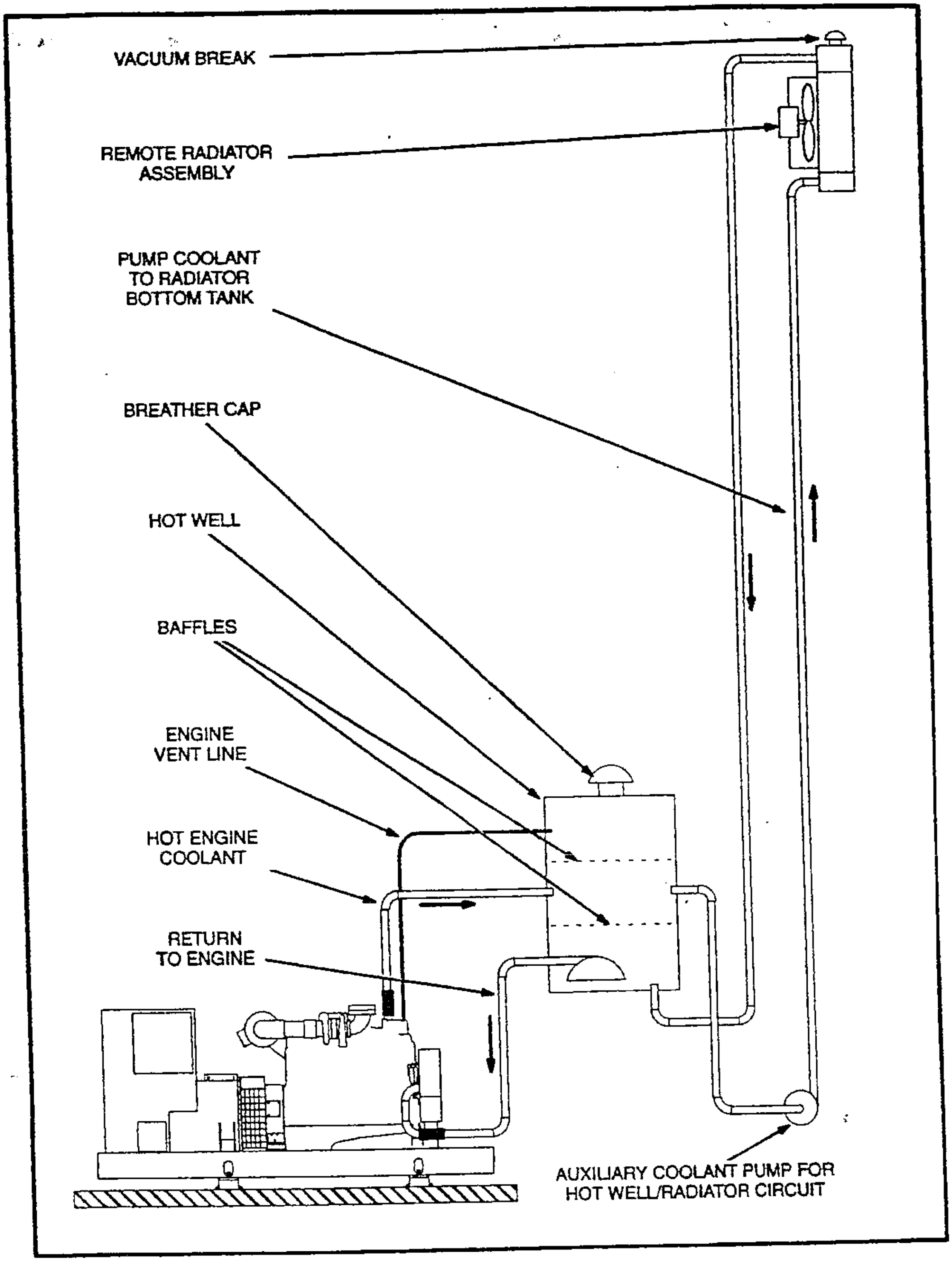


FIGURE 29. REMOTE RADIATOR WITH HOT WELL AND AUXILIARY COOLANT PUMP

Example Pipe Sizing Calculations for Remote Radiator/Heat Exchanger Systems: The preliminary layout of piping for a remote radiator cooling system similar to the one shown in Figure 26 calls for 60 feet of 3-inch diameter pipe, three long sweep elbows, two gate valves to isolate the radiator for engine servicing and a tee to connect the fill/makeup line. The generator set Specification Sheet indicates that coolant flow is 123 GPM and that the allowable friction head is 5 PSI.

This procedure involves determining the pressure loss (friction head) caused by each element and then comparing the sum of the pressure losses with the maximum allowable friction head.

1. Determine the pressure loss in the radiator by referring to the radiator manufacturer's data. For this example, assume the pressure loss is 1 psi at a flow of 123 gpm.

2. Find the equivalent lengths of all fittings and valves by using Table 9 and add to the total run of straight pipe.

Three Long Sweep Elbows—3 x 5.2	15.6
Two Gate Valves (Open)—2 x 1.7	3.4
Tee (Straight Run)	5.2
60 Feet Straight Pipe	<u>60.0</u>
EQUIVALENT LENGTH OF PIPE (FEET)	**84.2**

3. Find the back pressure at the given flow per unit length of pipe for the nominal pipe diameter used in the system. In this example, 3 inch nominal pipe is used. Following the dashed lines in Figure 30, 3 inch pipe causes a pressure loss of approximately **1.65 psi per 100 foot of pipe.**

4. Calculate the pressure loss in the piping as follows:

$$\text{Piping Loss} = 84.2 \text{ feet} \times \left(\frac{1.65 \text{ psi}}{100 \text{ feet}}\right) = 1.39 \text{ psi}$$

5. The total system loss is the sum of the piping and radiator losses:

   Total Pressure Loss = 1.39 psi (piping) + 1.00 psi (radiator) = 2.39 psi

6. The calculation for this example indicates that the layout of the remote radiator cooling system is adequate in terms of coolant friction head since it is not greater than the allowable friction head. If a calculation indicates excessive coolant friction head, repeat the calculation using the next larger pipe size. Compare the advantages and disadvantages of using larger pipe with that of using an auxiliary coolant pump.

TABLE 9. EQUIVALENT LENGTHS OF PIPE FITTINGS AND VALVES (FEET)

TYPE OF FITTING	NOMINAL DIAMETER (INCHES)						
	1.5	2	2.5	3	4	5	6
90° ELBOW	4.4	5.5	6.5	8	11	14	16
45° ELBOW	–	2.5	3	3.8	5	6.3	7.5
LONG SWEEP ELBOW	2.8	3.5	4.2	5.2	7	9	11
CLOSE RETURN BEND	–	13	15	18	24	31	37
TEE, STRAIGHT RUN	–	3.5	4.2	5.2	7	9	11
TEE, SIDE INLET OR OUTLET	9.3	12	14	17	22	27	33
GLOBE VALVE, FULLY OPEN	–	55	67	82	110	140	–
ANGLE VALVE, FULLY OPEN	–	27	33	41	53	70	–
GATE VALVE, FULLY OPEN	–	1.2	1.4	1.7	2.3	2.9	3.5
GLOBE VALVE, HALF OPEN	–	27	33	41	53	70	100

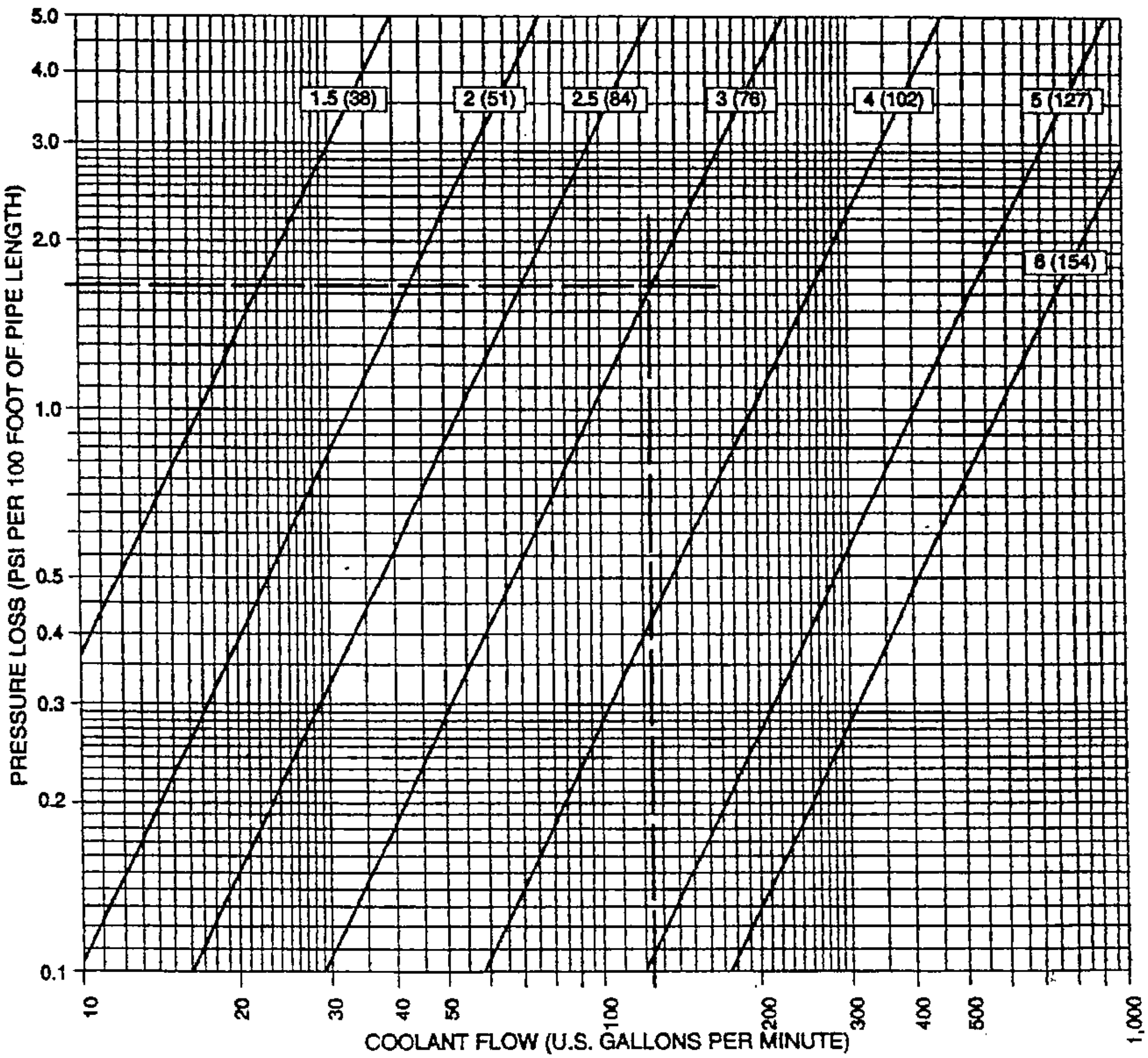


FIGURE 30. FRICTIONAL PRESSURE LOSSES FOR INCH (mm) DIAMETER PIPES

Coolant Treatment

Antifreeze (ethylene or propylene glycol base) and water are mixed to lower the freezing point of the cooling system and to raise the boiling point. Refer to Table 10 to determine the concentration of ethylene or propylene glycol necessary for protection against the coldest ambient expected. Antifreeze/water mixture percentages in the range of 30/70 to 60/40 are recommended for most applications.

Propylene glycol based antifreeze is less toxic than ethylene based antifreeze, offers superior liner protection and eliminates some fluid spillage and disposal reporting requirements.

Diesel generator sets may be equipped with replaceable coolant filtering and treating elements to minimize coolant system fouling and corrosion. They are compatible with most antifreeze formulations. For smaller sets, the antifreeze should contain a corrosion inhibitor.

TABLE 10. FREEZING AND BOILING POINTS VS. CONCENTRATION OF ANTIFREEZE

MIXTURE BASE		MIXTURE PERCENTAGES (ANTIFREEZE/WATER)					
		0/100	30/70	40/60	50/50	60/40	95/5
ETHYLENE GLYCOL	FREEZING POINT	32° F (0° C)	4° F (−16° C)	−10° F (−23° C)	−34° F (−36° C)	−65° F (−54° C)	8° F (−13° C)
	BOILING POINT	212° F (100° C)	220° F (104° C)	222° F (106° C)	226° F (108° C)	230° F (110° C)	345° F (174° C)
PROPYLENE GLYCOL	FREEZING POINT	32° F (0° C)	10° F (−12° C)	−6° F (−21° C)	−27° F (−33° C)	−56° F (−49° C)	−70° F (−57° C)
	BOILING POINT	212° F (100° C)	216° F (102° C)	219° F (104° C)	222° F (106° C)	225° F (107° C)	320° F (160° C)

Coolant Heaters

Thermostatically controlled engine coolant heaters are usually required for starting. For Level 1 emergency power systems, NFPA 110 requires that engine coolant be kept at a minimum of 90° F (32° C).

Engine coolant heaters must be connected to the normal power source.

VENTILATION

Ventilation of the generator room is necessary to remove the heat and fumes dissipated by the engine, generator and its accessories and to provide combustion air.

Factory-mounted Radiator Ventilation

In this configuration (Figure 31), the fan draws air over the set and pushes it through the radiator which has flanges for connecting a duct to the out-of-doors. Consider the following:

- See the generator set Specification Sheet for the design airflow through the radiator, allowable airflow restriction and minimum air inlet and outlet opening areas. **The allowable air flow restriction must not be exceeded.** The static pressure (air flow restriction) should be measured as shown in Figures 31 and 32 to confirm, before the set is placed in service, that the system is not too restrictive, especially when ventilating air is supplied and discharged through long ducts, restrictive grilles, screens and louvers.
- Refer to the ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) publications for recommendations on duct design if air ducts are required for the application. Note that the inlet duct must handle combustion air flow (see the Specification Sheet) as well as ventilating air flow and must be sized accordingly.

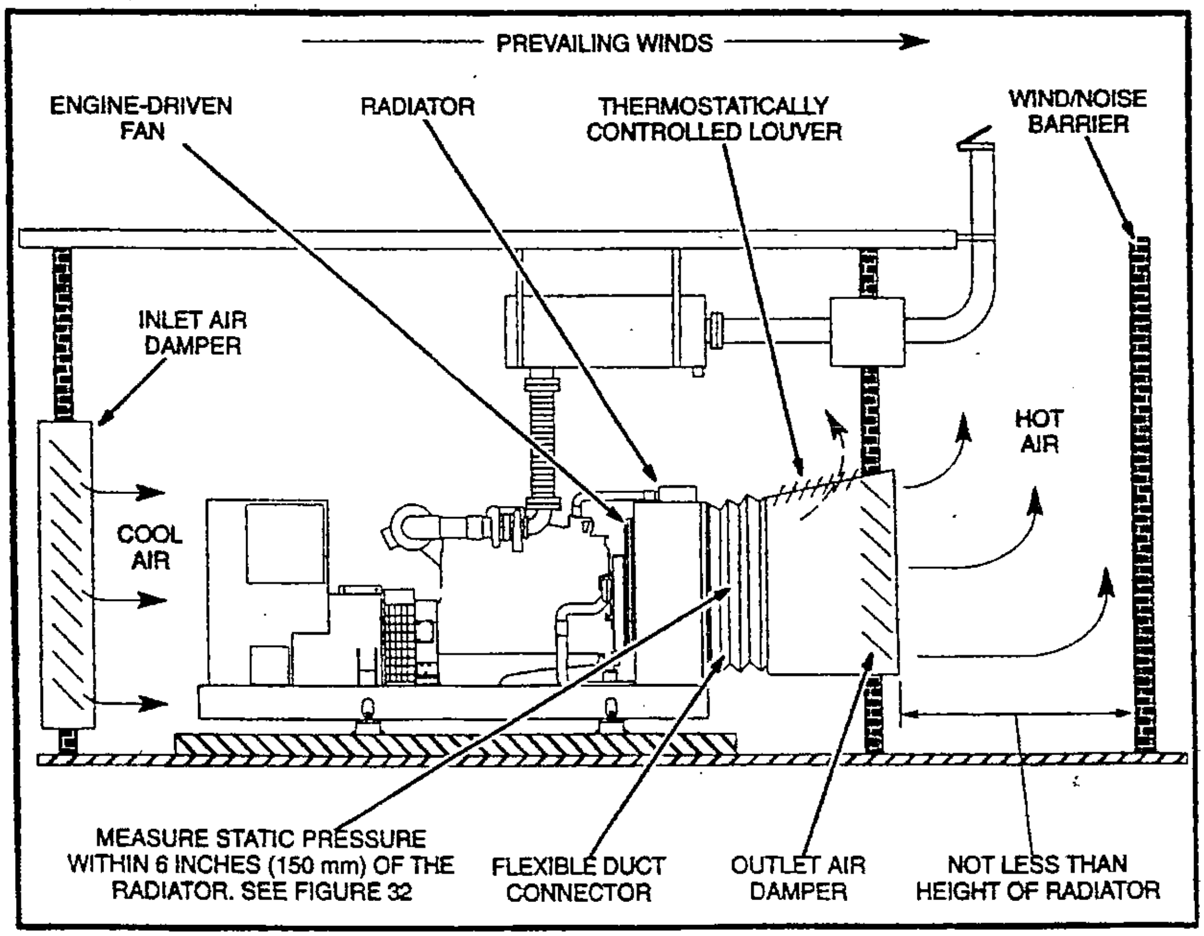


FIGURE 31. FACTORY-MOUNTED RADIATOR COOLING

- Louvers and screens over air inlet and outlet openings restrict air flow and vary widely in performance. A louver assembly with narrow vanes, for example, tends to be more restrictive than one with wide vanes. The effective open area specified by the louver or screen manufacturer should be used.
- The airflow through the radiator is usually sufficient for generator room ventilation. See the example calculation for a method of determining the air flow required to meet room air temperature rise specifications, if any.
- Because the radiator fan will cause a slight negative pressure in the generator room, it is highly recommended that combustion equipment such as the building heating boilers not be located in the same room as the generator set. If this is unavoidable, it will be necessary to determine whether there will be detrimental effects, such as backdraft, and to provide means (extra large room inlet openings and/or ducts, pressurizing fans, etc.) to reduce the negative pressure to acceptable levels.
- In colder climates, automatic dampers should be used to close off the inlet and outlet air openings to keep the generator room warm when the set is not running. And, a thermostatic damper should be used to recirculate a portion of the radiator discharge air to reduce the volume of cold air that is pulled through the room when the set is running. The inlet and outlet dampers must fully open when the set starts. The recirculating damper should close fully at 60°F (16°C).
- Other than recirculating radiator discharge air into the generator room in colder climates, all ventilating air must be discharged directly to the out-of-doors. It must not be used to heat any space other than the generator room.
- A flexible duct connector must be provided at the radiator to take up generator set movement and vibration and prevent transmission of noise.
- Ventilating air inlet and discharge openings should be located or shielded to minimize fan noise and the effects of wind on airflow.

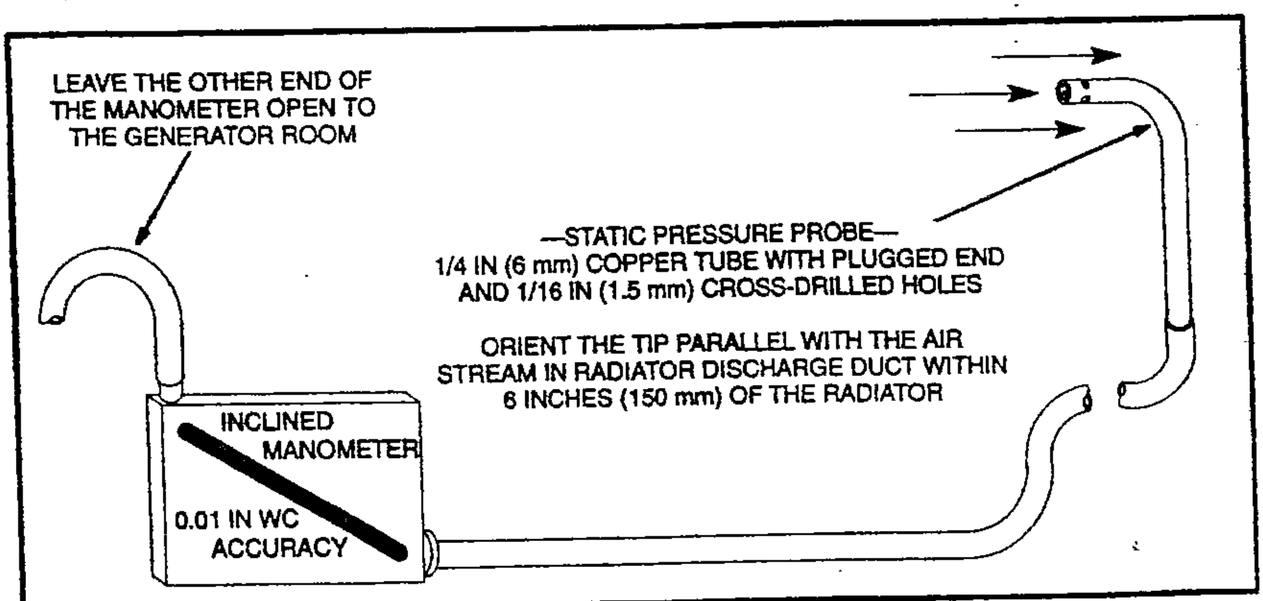


FIGURE 32. RECOMMENDED INSTRUMENTATION FOR MEASURING AIR FLOW RESTRICTION

Heat Exchanger Or Remote Radiator Ventilation

A heat exchanger or remote radiator cooling system might be selected because of noise considerations or because the air flow restriction through long ducts would be greater than that allowed for the engine-driven radiator fan. Consider the following:

- Ventilating fans must be provided for the generator room. The ventilating fans must have the capacity of moving the required flow of ventilating air against the air flow restriction. See the following example calculation for a method of determining the airflow required for ventilation.
- A remote radiator fan must be sized primarily to cool the radiator. Depending on its location, it might also be used to ventilate the generator room.
- The fan and air inlet locations must be such that the ventilating air is drawn forward over the set.
- To obtain the **net power** available from the generator set, add the fan load indicated on the generator set Specification Sheet to the power rating of the set and subtract the power consumed by the remote radiator fan, ventilating fans, coolant pumps and other accessories required for the set to run.

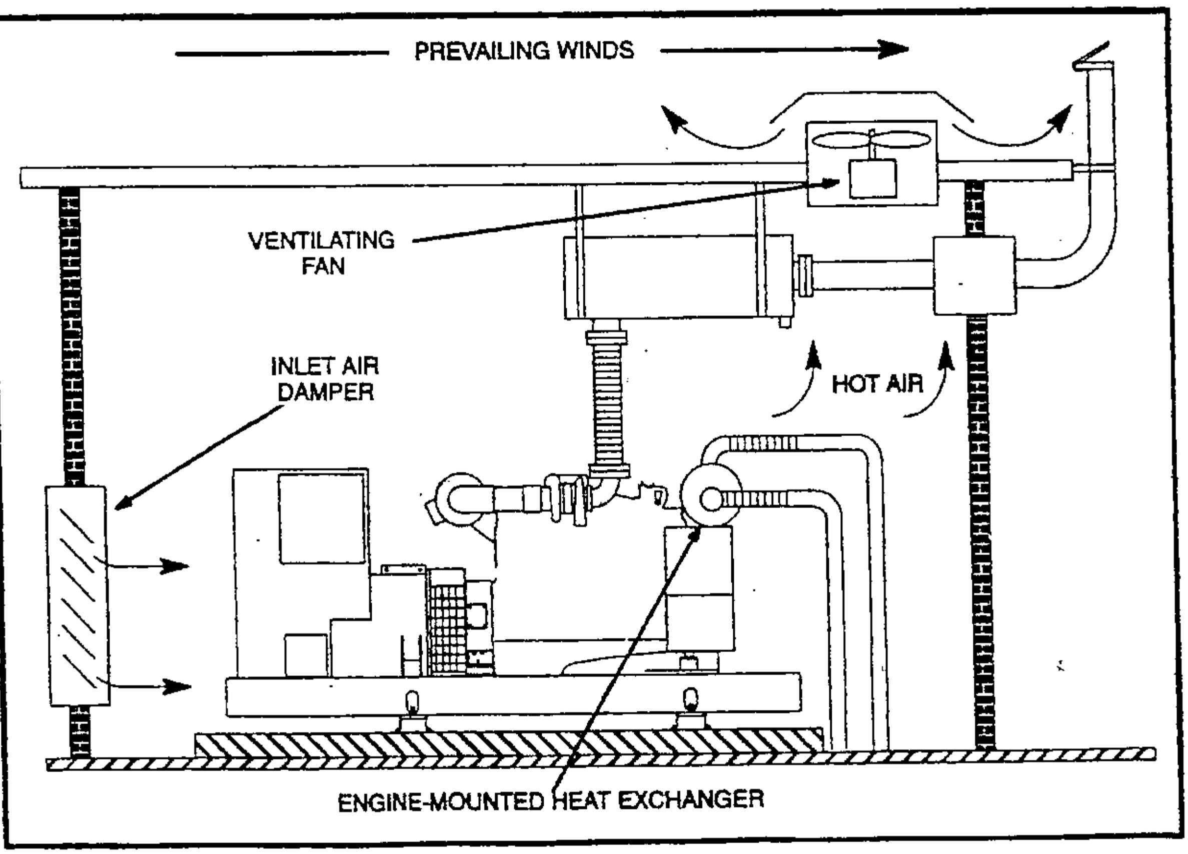


FIGURE 33. VENTILATION FOR A HEAT EXCHANGER COOLING SYSTEM

Example Ventilating Air Flow Calculation: The generator set Specification Sheet indicates that the heat radiated to the room from the generator set (engine and generator) is 4,100 BTU/min. The muffler and 10 feet of 5-inch diameter exhaust pipe are also located inside the generator room. Determine the air flow required to limit the air temperature rise to 30° F.

1. Add the heat inputs to the room from all sources. Table 11 indicates that the heat loss from 5-inch exhaust pipe is 132 BTU per min per foot of pipe and 2,500 BTU per min from the muffler. Add the heat inputs to the room as follows:

Heat from Generator Set	4,100
Heat from Exhaust Pipe—10 x 132	1,320
Heat from Muffler	2,500
TOTAL HEAT TO GENERATOR ROOM (Btu/Min)	**7,920**

2. The required air flow is proportional to the total heat input divided by the allowable room air temperature rise:

$$\text{Required Air Flow} = \frac{58 \times \text{Total Heat} \left(\frac{\text{Btu}}{\text{Min}}\right)}{\text{Temp Rise } (\Delta°\text{F})} = \frac{58 \times 7,920}{30} = 15,312 \text{ cfm}$$

TABLE 11. HEAT LOSSES FROM UNINSULATED EXHAUST PIPES AND MUFFLERS

PIPE DIAMETER INCHES (mm)	HEAT FROM PIPE BTU/MIN-FOOT (kJ/Min-Metre)	HEAT FROM MUFFLER BTU/MIN (kJ/Min)
1.5 (38)	47 (162)	297 (313)
2 (51)	57 (197)	490 (525)
2.5 (64)	70 (242)	785 (828)
3 (76)	84 (291)	1,100 (1,160)
3.5 (98)	96 (332)	1,408 (1,485)
4 (102)	108 (374)	1,767 (1,864)
5 (127)	132 (457)	2,500 (2,638)
6 (152)	156 (540)	3,550 (3,745)
8 (203)	200 (692)	5,467 (5,768)
10 (254)	249 (862)	8,500 (8,968)
12 (305)	293 (1,014)	10,083 (10,638)

FUEL SUPPLY

Diesel Fuel

The following should be considered when installing a diesel fuel supply system:

- Fuel supply tank construction, location, installation, venting, piping, testing and inspection must comply with applicable codes. See NFPA Standards No. 30 and No. 37.
- Fuel supply tanks must be adequately vented to prevent pressurization, have provisions for manually draining or pumping out water and sediment, and have at least a five percent expansion space to prevent fuel spillage when the fuel heats up and expands.
- The fuel lift pump, day tank transfer pump or float valve seat should be protected from fuel supply tank debris by a prefilter or sediment bowl with a 100 to 120 mesh element.
- The supply tank must hold enough fuel to run the set for the prescribed number of hours (NFPA No. 110 Class designation) without refueling. Tank sizing calculations can be based on the hourly fuel consumption rates on the generator set Specification Sheet. Other considerations for tank sizing include the duration of expected power outages vs. availability of fuel deliveries and the "shelf life" of the fuel. The shelf life for diesel fuel is 1-1/2 to 2 years.
- For emergency power systems, codes might not permit the fuel supply to be used for any other purpose, or may specify a draw-down level for other equipment that guarantees the fuel supply for emergency power use.
- The Cetane rating of No. 2 heating oil is not high enough for dependable starting of diesel engines in cold weather. Therefore, separate supply tanks for emergency power and building heating systems might have to be provided.
- Approved flexible fuel hose must be used for connections at the engine to take up generator set movement and vibration.
- Diesel fuel lines should be black iron pipe. Cast iron and aluminum pipe and fittings must not be used because they are porous and can leak fuel. Galvanized fuel lines, fittings and tanks should not be used because the galvanized coating is attacked by the sulfuric acid that forms when the sulfur in the fuel combines with tank condensate, resulting in debris that can clog fuel pumps and filters. Although copper has been used for diesel fuel lines for many years, black iron pipe is preferred. Diesel fuel polymerizes (thickens) in copper tubing during long periods of standby, with the result that fuel injectors can clog.

- The generator set Specification Sheet indicates the maximum fuel inlet and return restrictions, the maximum fuel flow and the fuel consumption. Table 12 indicates minimum hose and pipe sizes for connections to a supply tank or day tank that is relatively close to the set and at approximately the same elevation. Hose and pipe size should be based on the maximum fuel flow rather than on the fuel consumption. (The maximum fuel flow is approximately twice the full-load fuel consumption on TPS generators sets rated 200/175 kW and larger.) It is highly recommended that the fuel inlet and return restrictions be checked before the set is placed in service.

TABLE 12. MINIMUM FUEL SUPPLY/RETURN HOSE AND PIPE SIZES

MAXIMUM GPH	FUEL SUPPLY LINE				FUEL RETURN LINE			
	0-10 FEET (0-3 METRES)		10-50 FEET (3-15 METRES)		0-10 FEET (0-3 METRES)		10-50 FEET (3-15 METRES)	
	FLEX HOSE SIZE	PIPE I.D. INCHES (mm)	FLEX HOSE SIZE	PIPE I.D. INCHES (mm)	FLEX HOSE SIZE	PIPE I.D. INCHES (mm)	FLEX HOSE SIZE	PIPE I.D. INCHES (mm)
0-15	NO. 6	5/16 (7.9)	NO. 8	13/32 (10.3)	NO.4	3/16 (4.8)	NO. 6	5/16 (7.9)
15-20	NO. 8	13/32 (10.3)	NO. 10	1/2 (12.7)	NO.4	3/16 (4.8)	NO. 6	5/16 (7.9)
20-80	NO. 10	1/2 (12.7)	NO. 12	5/8 (15.9)	NO. 8	13/32 (10.3)	NO. 10	1/2 (12.7)
80-100	NO. 12	5/8 (15.9)	NO. 16	7/8 (22.3)	NO. 8	13/32 (10.3)	NO. 10	1/2 (12.7)
100-160	NO. 16	7/8 (22.3)	NO. 16	7/8 (22.3)	NO. 10	1/2 (12.7)	NO. 12	5/8 (15.9)
160>	NO. 16	7/8 (22.3)	NO. 16	7/8 (22.3)	NO. 12	5/8 (15.9)	NO.12	5/8 (15.9)
Based on four straight fittings, two 90° fittings and minimal fuel lift height.								

- Separate fuel return lines to the day tank or supply tank must be provided for each generator set in a multiple-set installation to prevent the return lines of idle sets from being pressurized. Also, a fuel return line must not include a shutoff device. Engine damage will occur if the engine is run when the line is shut off.

- A day tank is required whenever pipe friction and/or supply tank elevation, either below the fuel pump inlet or above the fuel injectors, would cause an excessive fuel inlet or return restriction. Some generator set models are available with an integral skid-mounted or sub-base day tank.

  For critical start applications, where generator sets are paralleled or must satisfy emergency start-time requirements, it is recommended that a fuel tank or reservoir be located such that the lowest possible fuel level is not less than 6 inches (150 mm) above the fuel pump inlet. This will prevent air from accumulating in the fuel line while the set is in standby, eliminating the period during startup when it has to be purged.

- Day tank fuel temperature might need to be considered in some high ambient applications when the warm fuel from the engine is returned to the day tank. Call the TPS distributor concerning inlet fuel temperature limits for specific generator set models. As fuel temperature increases, fuel density and lubricity decrease, reducing maximum power output and lubrication of fuel handling parts such as pumps and injectors. One solution might be to pipe the fuel back to the supply tank rather than to the day tank.
- The day tank fuel transfer pump capacity and supply piping should be sized on the basis of the maximum fuel flow indicated on the generator set Specification Sheet.

Gasoline Fuel

The following items should also be considered when installing a gasoline fuel supply system:

- Fuel supply tank construction, location, installation, venting, piping, testing and inspection must comply with applicable codes. See NFPA Standards No. 30 and No. 37.
- Fuel supply tanks must be adequately vented to prevent pressurization, have provisions for manually draining or pumping out water and sediment, and have at least a five percent expansion space to prevent fuel spillage when the fuel heats up and expands.
- The fuel lift pump, day tank transfer pump or float valve seat should be protected from fuel supply tank debris by a prefilter or sediment bowl with a 100 to 120 mesh element.
- Approved flexible fuel hose must be used for connections at the engine to take up generator set movement and vibration.
- Gasoline fuel lines may be black iron or galvanized steel pipe or Type-L copper or steel tubing. Cast iron and aluminum pipe and fittings must not be used because they are porous and can leak fuel.
- Most codes do not permit storage of gasoline inside buildings. If storage is permitted inside the building, the tank must be vented to the out-of-doors.
- Gasoline fuel storage life is only about six months. The size of the storage tank should therefore be carefully considered.
- See the generator set Specification Sheet for the maximum permissible fuel lift. Also, to prevent carburetor flooding or hydrostatic engine lock when the engine is not running, the maximum height of fuel in the day tank or supply tank should not exceed the height of the fuel pump on the engine.

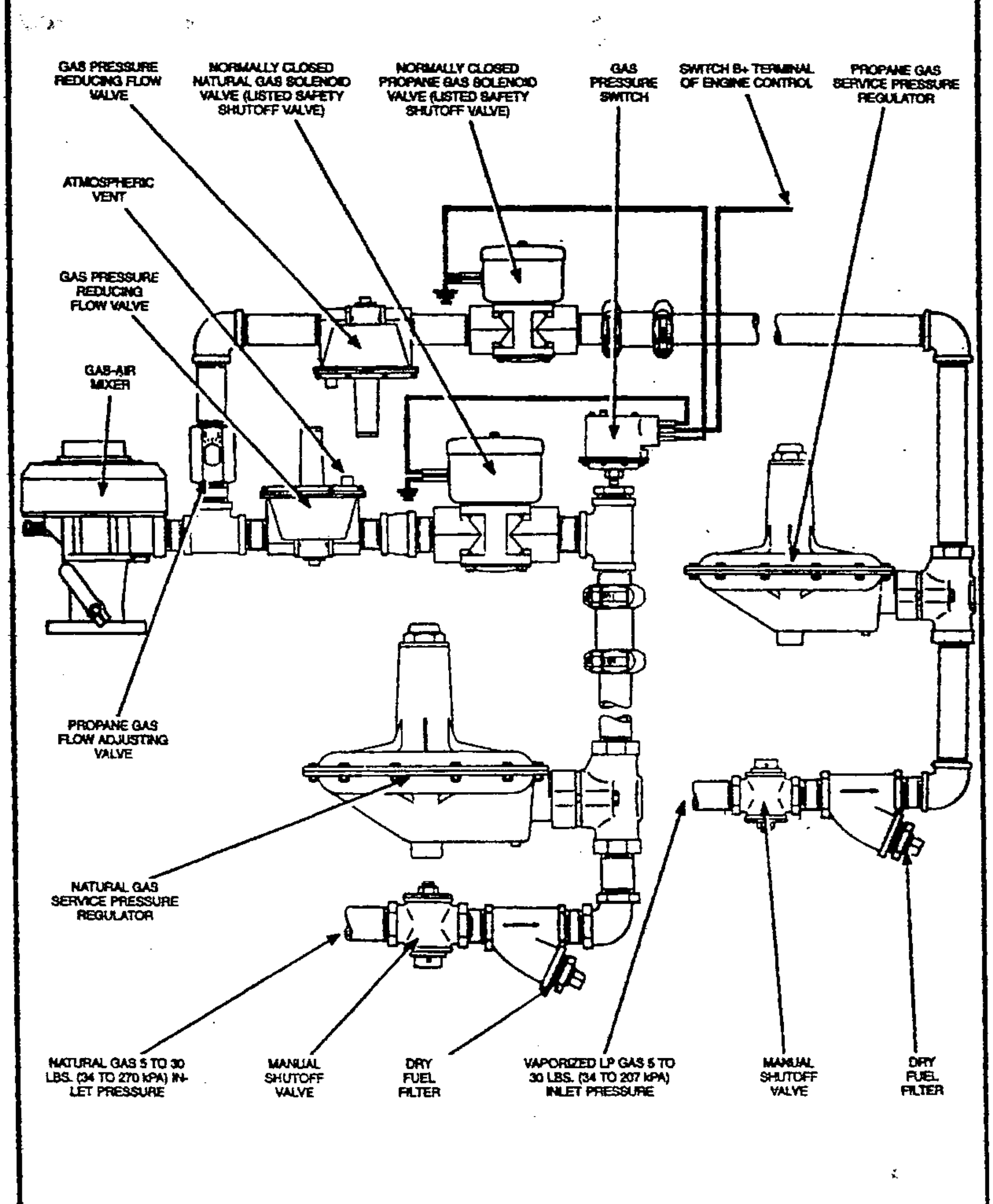
Gaseous Fuel

Figure 34 illustrates the typical gas line components in an automatic-transfer, dual-fuel system (natural gas and LPG). It is also representative of single fuel systems and the natural gas or LPG fuel components used when the alternate fuel is gasoline. When natural gas or LPG is used in combination with gasoline, the gas-air mixer is mounted on the air horn of the gasoline carburetor. Not shown is the LPG vaporizer supplied with TPS generator sets equipped for liquid withdrawal of LPG (engine-mounted on outdoor sets only). The service pressure regulator(s), dry gas filter(s) and manual shutoff valve(s) are typically provided by the installer.

Natural gas generator sets are tested and rated using natural gas having a heating value of approximately 1,000 Btu/ft^3 (37.24 MJ/m^3). With proper fuel mixture adjustments (see the generator set Service Manual), fuel gases of lower heating value can be used with good results but with less maximum power output. Depending on the fuel, deratings will be necessary.

The following should be considered when installing a natural gas and/or LPG fuel system:

- Gaseous-fuel supply system design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance must comply with the applicable codes. See NFPA Standards No. 30, No. 37, No. 54 and No. 58.
- The layout and sizing of the gas supply piping must be adequate for supplying the volume of gas required at full load as indicated on the generator set Specification Sheet while maintaining at least the minimum required supply pressure, **typically 10 inches (254 mm) WC** (water column). See the example pipe sizing calculation below and associated pipe sizing tables (Tables 14 and 15). Final determination of pipe sizes must, however, be based upon the method approved by the authority having jurisdiction (see NFPA No. 54).
- Most installations will require a service gas pressure regulator. Typically, gas supply pressure should not exceed **20 inches (508 mm) WC** at the inlet to the generator set. Depending on distribution gas pressure, more than one stage of pressure regulation may be required. **High pressure gas piping is not permitted inside buildings.** Gas pressure regulators must be vented to the out-of-doors according to code.
- Approved flexible fuel hose must be used for connections at the engine to take up generator set movement and vibration. Some TPS generator set models are equipped with flexible hoses that are connected to bulkhead fittings on the skid where solid pipe connections can be made by the installer.
- Most codes require both manual and electric (battery-powered) shutoff valves ahead of the flexible fuel hose(s). The manual valve should be of the indicating type.
- A dry fuel filter should be installed in each line as shown in Figure 34 to protect the sensitive pressure regulating components and orifices downstream from harmful foreign substances carried along in the gas stream (rust, scale, etc.).
- An LPG fuel supply system must be dedicated for the emergency power system if it is the required alternate fuel.



* THE GAS PRESSURE SWITCH CAUSES THE NATURAL GAS SOLENOID VALVE TO CLOSE AND THE PROPANE GAS SOLENOID VALVE TO OPEN UPON LOSS OF NATURAL GAS SUPPLY PRESSURE TO CONTINUE GENERATOR SET OPERATION WITHOUT INTERRUPTION. RETURN TO NATURAL GAS IS AUTOMATIC WHEN SUPPLY PRESSURE IS RESTORED.

FIGURE 34. TYPICAL GASEOUS FUEL SYSTEM

- An LPG vaporizer heated by engine coolant is factory installed on TPS generator sets equipped for a liquid-withdrawal of LPG. **Because high pressure gas piping (liquid or vapor) is not permitted inside buildings, generator sets equipped for liquid withdrawal of LPG must not be installed inside the building.** Weather protective housings for outdoor installation are available for most models.
- Ambient temperature affects the rate of vaporization in an LPG supply tank. In colder climates, a way to compensate for the reduced rate of vaporization is to install a larger supply tank. Table 13 can be used as a quick reference for sizing the propane tank to account for expected low ambient temperatures.
- The required rate of vaporization can also be obtained by means of a burner-type or engine coolant-type LPG vaporizer located just **outside** the building.

TABLE 13. MINIMUM PROPANE TANK SIZE IN GALLONS (LITERS) FOR REQUIRED VAPORIZATION

WITHDRAWAL RATE (Tank must be at least half full)	LOWEST AVERAGE WINTER TEMPERATURE					
	32°F (0°C)	20°F (-7°C)	10°F (-12°C)	0°F (-1°C)	-10°F (-23°C)	-20°F (-29°C)
100 cfh ($3 m^3/hr$)	100 (378)	150 (568)	200 (757)	250 (946)	400 (1514)	650 (2461)
200 cfh ($6 m^3/hr$)	250 (946)	300 (1136)	400 (1514)	600 (2271)	1000 (3785)	2000 (7571)
300 cfh ($9 m^3/hr$)	400 (1514)	600 (2271)	700 (2650)	1100 (4164)	1800 (6814)	3600 (13,627)
400 cfh ($11 m^3/hr$)	600 (2271)	900 (3407)	1200 (4542)	1700 (6435)	2700 (10,221)	4500 (17,034)
500 cfh ($14 m^3/hr$)	900 (3407)	1300 (4921)	1600 (6057)	2500 (9464)	3600 (13,627)	7500 (28,391)
600 cfh ($17 m^3/hr$)	1100 (4164)	1600 (6057)	2000 (7571)	3000 (11,356)	5000 (18,927)	10,000 (37,854)
700 cfh ($20 m^3/hr$)	1500 (5678)	2000 (7571)	2500 (9464)	4000 (20,820)	6000 (22,712)	13,000 (49,210)

Example Gas Pipe Sizing Calculations: An application calls for two natural gas generator sets. The sets could be run concurrently. The full-load fuel consumption indicated on the generator set Specification Sheet for the model selected is 890 cfh (cubic feet per hour). The two sets will be supplied by a service pressure regulator adjusted to maintain 14 inches (356 mm) WC (water column). The service pressure regulator will not serve any other load. Figure 35 illustrates the gas piping arrangement.

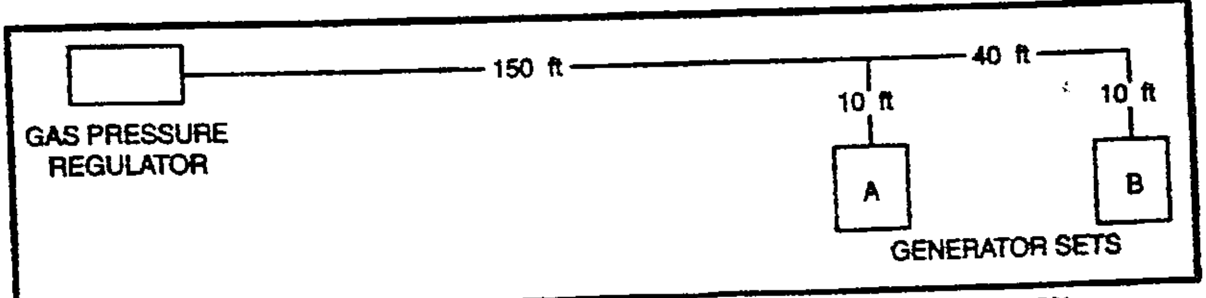


FIGURE 35. GAS PIPING LAYOUT FOR A TWO-GENERATOR INSTALLATION

Determine minimum pipe sizes as follows:

1. Add up the length of pipe to the generator set farthest from the source, which is generator set B.

   Total length of pipe for Set B = 150 ft + 40 ft + 10 ft = 200 ft
2. The length of pipe to the farthest set will be the only length used when referring to Tables 14 and 15. In this case, refer to the 200 ft column in Table 14 (natural gas).
3. The 50 foot length of pipe serving generator set B alone, supplies 890 cfh of gas. This section will therefore have to be 2-1/2 inch pipe.
4. The 10 foot length of pipe serving generator set A alone, supplies 890 cfh of gas. This section will also have to be 2-1/2 inch pipe.
5. The 150 foot length of pipe serving both generator sets supplies 1780 cfh of gas. This section will therefore have to be 3 inch pipe.
6. When piping is sized on this basis, the pressure loss should not be more than 0.5 inches (13 mm) WC.

This procedure can be used when other types of equipment, such as the building heating boilers, are also supplied by the service pressure regulator supplying the generator sets. Note that Tables 14 and 15 cover gas supply pressures not greater than 1/2 psig. See NFPA 54 for gas pipe capacity tables for higher gas supply pressures (1, 5, 10, 20 and 50 psig).

TABLE 14. NATURAL GAS PIPE CAPACITY—CUBIC FEET OF GAS PER HOUR

NOMINAL IRON PIPE SIZE (INCHES)	LENGTH OF PIPE IN FEET													
	10	20	30	40	50	60	70	80	90	100	125	150	175	200
3/4	360	250	200	170	151	138	125	118	110	103	93	84	77	72
1	680	465	375	320	285	260	240	220	205	195	175	160	145	135
1-1/4	1400	950	770	660	580	530	490	460	430	400	360	325	300	280
1-1/2	2100	1460	1180	990	900	810	750	690	650	620	550	500	460	430
2	3950	2750	2200	1900	1680	1520	1400	1300	1220	1150	1020	950	850	800
2-1/2	6300	4350	3520	3000	2650	2400	2250	2050	1950	1850	1650	1500	1370	1280
3	11000	7700	6250	5300	4750	4300	3900	3700	3450	3250	2950	2650	2450	2280

Based on 0.5 inch (13 mm) WC pressure drop, 0.60 specific gravity gas and nominal 1/2 psig (3.4 kPa) pressure

TABLE 15. LPG GAS PIPE CAPACITY—CUBIC FEET OF GAS PER HOUR

NOMINAL IRON PIPE SIZE (INCHES)	LENGTH OF PIPE IN FEET											
	10	20	30	40	50	60	70	80	90	100	125	150
3/4	227	157	126	107	95	87	78	74	69	65	58	53
1	428	293	236	201	179	164	151	138	129	123	110	101
1-1/4	882	598	485	416	365	333	308	289	207	252	230	204
1-1/2	1323	920	743	624	567	570	472	434	409	390	346	315
2	2488	1732	1386	1197	1058	958	882	819	768	724	642	598

Based on 0.5 inch (13 mm) WC pressure drop and nominal 11 inch (280 mm) WC pressure at inlet

ENGINE STARTING SYSTEMS

Battery Starting Systems

Battery starting systems for generator sets are usually 12 volt or 24 volt. Figure 36 illustrates typical battery-starter connections. Consider the following:

- Batteries must have enough capacity to provide the cranking motor current indicated on the generator set Specification Sheet. The batteries may be either lead-acid or nickel-cadmium. They must be designated for this use and may have to be approved by the authority having jurisdiction.
- A high output engine-driven alternator and automatic voltage regulator are provided to recharge the batteries during operation.
- For emergency power systems, a float-type battery charger, powered by the normal power source, must be provided to keep the batteries fully charged during standby.
- Codes usually specify a maximum battery charging time. The following rule-of-thumb can be used to size battery chargers:

$$\text{Required Battery Charging Amps} = \frac{1.2 \times \text{Battery Amp-Hours}}{\text{Charging Hours}}$$

- Local codes may require battery heaters to maintain a minimum battery temperature of 50° F (10° C) if the set is subject to freezing temperatures.
- Standard sets include skid mounted battery racks and battery cables.
- Battery cable resistance must not result in a voltage drop between the battery and the starter motor of more than 1 volt for 12 volt systems or more than 2 volts for 24 volt systems. See the following example calculation.

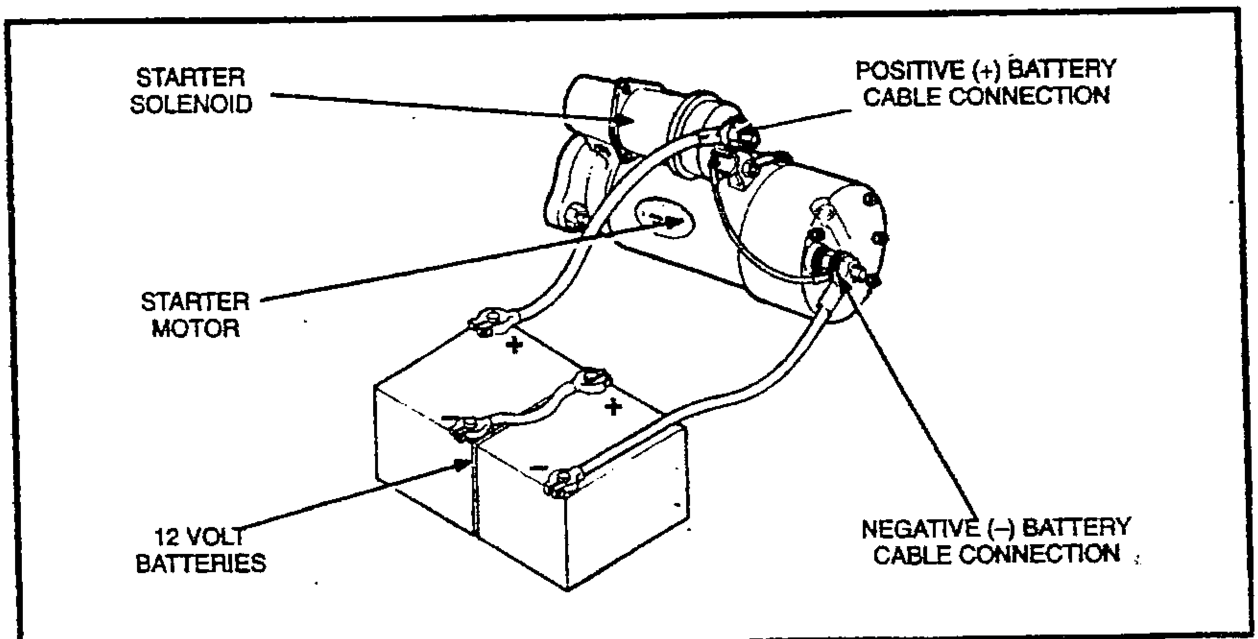


FIGURE 36. TYPICAL ELECTRIC STARTER MOTOR CONNECTIONS

Example Calculation: A generator set has a 24 VDC starting system to be powered by two 12 volt batteries connected in series (Figure 36). Total cable length is 375 inches, including the cable between the batteries. There are six cable connections. The generator set Specification Sheet indicates that cranking motor current is 565 amps. Calculate the required cable size as follows:

1. Assume a resistance of 0.0002 ohms for the starter solenoid contact.
2. Assume a resistance of 0.00001 ohms for each cable connection (six).
3. Based on the formula that:

$$R \text{ (ohms)} = \frac{E \text{ (volts)}}{I \text{ (amperes)}},$$

$$\text{Allowable Cable Resistance} = \left(\frac{\text{Allowable Voltage Drop}}{\text{Cranking Amps}}\right) - \text{Sum of Other Resistances}$$

$$= \left(\frac{2}{565}\right) - (0.0002 + (6 \times 0.00001)) = 0.00328 \text{ ohms}$$

4. Refer to Figure 37 for AWG (American Wire Gauge) cable resistances. In this example, as shown by the dashed lines, #0 AWG is the smallest cable size that can be used.

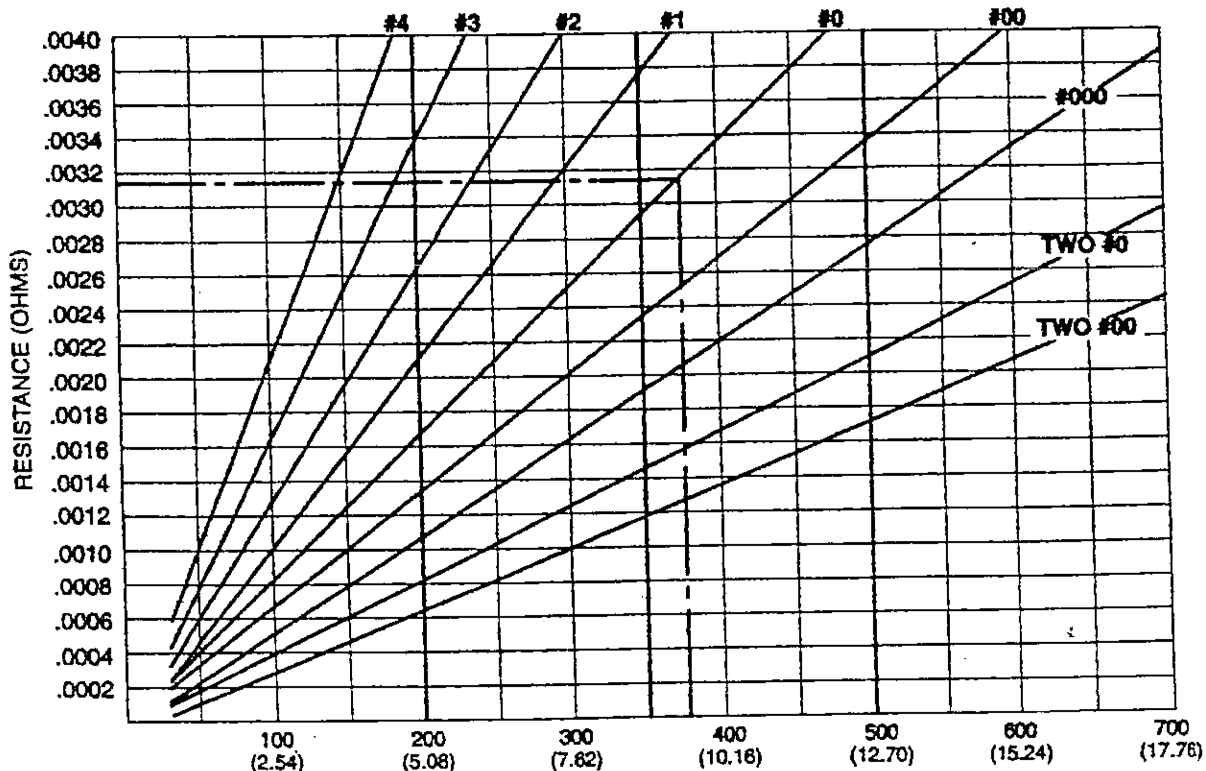


FIGURE 37. RESISTANCE VS. LENGTH FOR VARIOUS AWG CABLE SIZES

Air Starting Systems

Figure 38 shows a piping arrangement for a typical air starter. The following items should be considered when installing an air starter system:

- The engine manufacturer should be consulted for recommendations regarding air hose size and the minimum tank volume required for each second of cranking. Tank size will depend on the minimum cranking time required. All of the starters available from TPS have a maximum pressure rating of 150 psig (1035 kPa).
- Air tanks (receivers) should be fitted with a drain valve of the screw-out, tapered-seat type (other types are unreliable and a common source of air leaks). Moisture can damage starter components.
- All valves and accessories in the system should be designed for diesel air starting service.
- Pipe fittings should be of the dry seal type and should be made up with thread sealant. Teflon tape is not recommended as it does not prevent thread loosening and can be a source of debris that can clog valves.

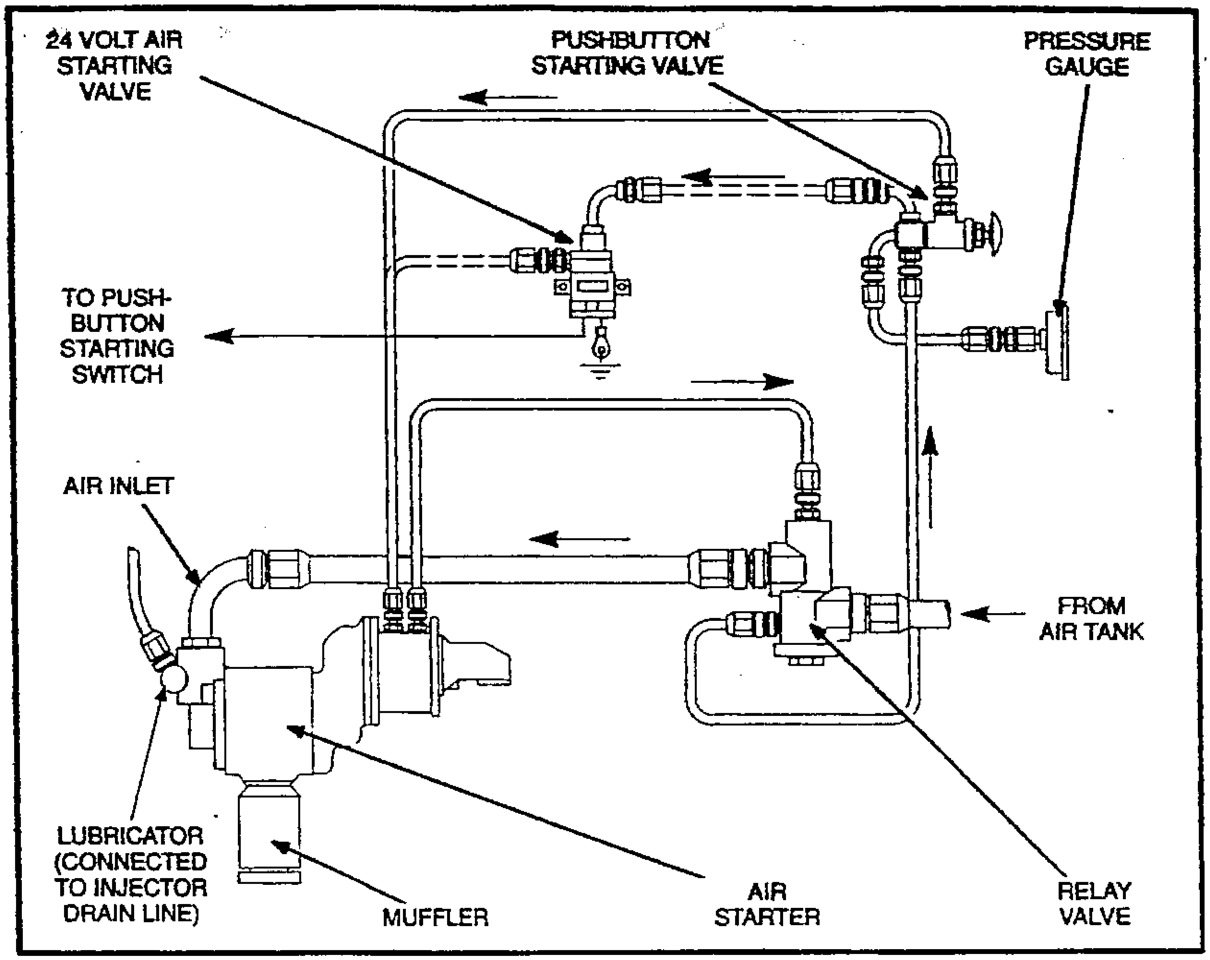


FIGURE 38. TYPICAL PIPING ARRANGEMENT FOR AN AIR STARTER

ELECTRICAL CONNECTIONS

General

Installation of electrical wiring should follow the requirements of the applicable electrical code and be done by qualified persons.

AC Power Conductors

If the generator set is not factory-supplied with a main-line circuit breaker, the ampacity of the field-installed AC phase conductors from the generator output terminals to the first overcurrent device should be at least equal to 115 percent of the generator full-load current. See Table 16 and Schematics (a) and (b) in Figure 39. The length of run for generator tap conductors to the first overcurrent device should be kept as short as possible (generally not more than 25 feet).

If the generator is supplied with leads, the size of the leads may be smaller than required for field-installed conductors because generator leads have type CCXL insulation rated 125° C.

If the generator set is factory-equipped with a main-line circuit breaker, the ampacity of the field-installed AC phase conductors connected to the load terminals of the circuit breaker should be equal to or greater than the circuit breaker rating. See Schematic (c) in Figure 39.

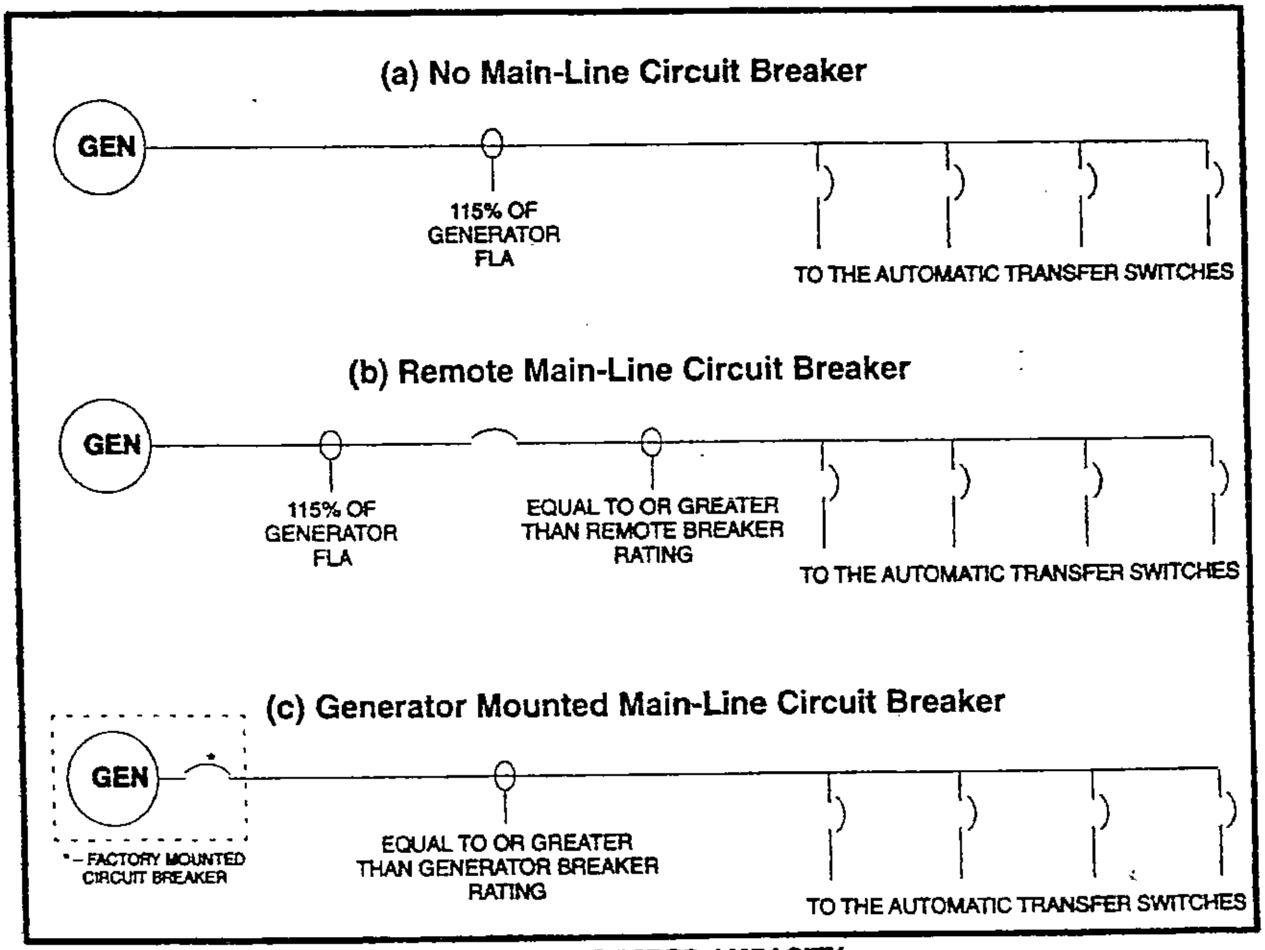


FIGURE 39. FEEDER AMPACITY

The ampacity of the neutral conductor is generally permitted to be equal to or greater than the calculated maximum single-phase unbalance of the load. Where a significant portion of the load is non-linear, the neutral should be full size.

The generator neutral supplied by **TPS** *is equal in ampacity to the phase conductors.*

Flexible metal conduit and stranded conductors must be used for connections to the generator set to take up generator set movement and vibration. The flexible conduit should be at least 18 inches (460 mm) long.

Medium voltage cable must be installed and terminated exactly as recommended by the cable manufacturer, by persons who have learned the procedures through training and practice under close supervision.

TABLE 16. THREE-PHASE AC GENERATOR AMPERAGE AT 80 % POWER FACTOR

KW	KVA	208V	220V	240V	380V	440V	480V	600V	2400V	3300V	4160V
20	25	69	66	60	38	33	30	24	-	-	-
35	44	122	115	105	67	57	53	42	-	-	-
40	50	139	131	120	76	66	60	48	-	-	-
45	56	156	148	135	86	74	68	54	-	-	-
50	63	174	164	151	95	82	75	60	-	-	-
60	75	208	197	181	114	99	90	72	-	-	-
65	81	226	213	196	124	107	98	78	-	-	-
70	88	243	230	211	133	115	105	84	-	-	-
75	94	261	246	226	143	123	113	90	-	-	-
80	100	278	263	241	152	131	120	96	-	-	-
100	125	347	328	301	190	164	151	120	-	-	-
125	156	434	411	376	238	205	188	151	-	-	-
150	188	521	493	452	285	246	226	181	-	-	-
175	219	608	575	527	333	287	263	211	-	-	-
200	250	695	657	602	380	328	301	241	-	-	-
230	288	799	755	692	437	378	346	277	-	-	-
250	313	868	821	753	475	411	376	301	-	-	-
275	344	955	903	828	523	452	414	331	-	-	-
300	375	1042	985	903	570	493	452	361	-	-	-
350	438	1216	1150	1054	666	575	527	421	-	-	-
400	400	1390	1314	1204	761	657	602	482	-	-	-
450	563	1563	1478	1355	856	739	677	542	-	-	-
500	625	1737	1642	1505	951	821	753	602	151	109	87
600	750	2084	1971	1806	1141	985	903	723	181	131	104
750	938	2605	2463	2258	1426	1232	1129	903	226	164	130
800	1000	2779	2627	2408	1521	1314	1204	963	241	175	139
900	1125	3126	2956	2710	1711	1478	1355	1084	271	197	156
1000	1250	3474	3284	3011	1901	1642	1505	1204	301	219	174
1100	1375	-	-	-	2092	1806	1656	1325	331	241	191
1200	1500	-	-	-	2282	1971	1806	1445	361	263	208
1250	1563	-	-	-	2377	2053	1882	1505	376	274	217
1500	1875	-	-	-	2852	2463	2258	1806	452	328	261

Grounding

System Grounding: As shipped, the neutral terminal of a **TPS** generator is not grounded. If the generator is a separately-derived power source (i.e. 4-pole transfer switch) then the neutral will have to be connected to a grounding electrode system by the installing electrician.

If the generator neutral interconnects with a service-supplied grounded neutral, typically at the neutral block of a 3-pole transfer switch, then the generator neutral should not be grounded at the generator. The electrical code may require a sign to be placed at the service supply indicating that the generator neutral is grounded at that location.

Equipment Grounding: A grounding terminal is provided on the skid of the generator set. If a set-mounted circuit breaker is provided, a grounding terminal may be provided inside the circuit breaker enclosure. The electrical code may require a grounding conductor so that the section of flexible conduit required because of vibration is not relied on as a means for equipment grounding.

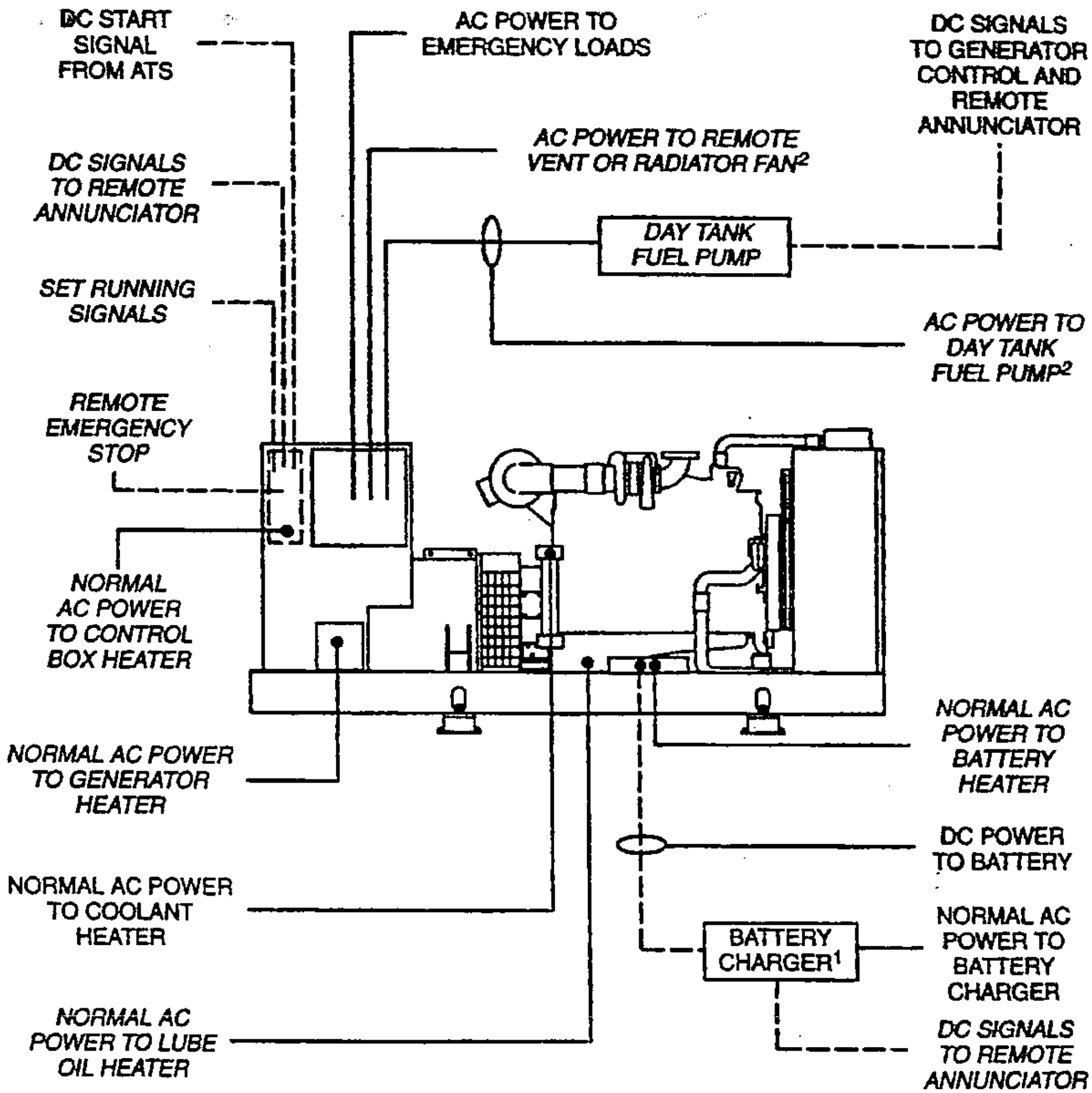
Control Wiring

AC and DC control wiring (to the transfer switch and remote annunciators) must be run in separate conduit from the power cables. Stranded conductors and a section of flexible conduit must be used for connections at the set.

Accessory Branch Circuits

Branch circuits must be provided for all accessory equipment necessary for operation of the generator set. These circuits must be fed either from the load terminals of an automatic transfer switch or from the generator terminals. Examples of accessories include the fuel transfer pump, coolant pumps for remote radiators, and motorized louvers for ventilation.

Branch circuits, fed from the normal power panelboard, must be provided for the battery charger and coolant heaters, if used. See Figure 40.



NOTES:

1. THESE LOADS CAN BE POWERED DIRECTLY OFF THE GENERATOR (WITH APPROPRIATE OVERCURRENT PROTECTION) OR FROM THE LOAD SIDE OF THE FIRST PRIORITY ATS.
2. THE ITEMS IN *ITALICS* ARE NOT ALWAYS USED.

FIGURE 40. TYPICAL GENERATOR SET CONTROL AND ACCESSORY WIRING

Allowable Single-Phase Load Unbalance

Single-phase loads should be distributed as evenly as possible between the three phases of a three-phase generator set in order to fully utilize the rated capacity (kVA and kW) of the set and to limit voltage unbalance. Figure 41 can be used to determine the maximum permissible percentage of unbalanced single-phase load, as illustrated by the example calculation.

Single phase power can be taken up to 67 percent of the three-phase rating on **TPS** generator sets not larger than 175 kW. (Note that this will result in line currents for Y-connected generators that will exceed nameplate ratings by approximately 15 percent.)

Generally, the larger the generator set, the lower the percentage of single-phase power that can be taken. Figure 41 includes single-phase percentage lines for **TPS** intermediate-size Frame-4 and Frame-5 generators. Confirm the frame size by referring to the applicable Alternator Data Sheet referenced by the generator set Specification Sheet. For generator sets rated more than 500kW, load unbalance should not exceed 10 percent.

Example Calculation: Find the maximum single-phase load that can be powered in conjunction with a total three-phase load of 62 kVA by a generator set rated 100kW / 125 kVA.

1. Find the three-phase load as a percentage of the generator kVA rating:

$$\text{Three-Phase Load Percentage} = \left(\frac{62\ \text{kVA}}{125\ \text{kVA}}\right) \times 100\% = 50\%$$

2. Find the percentage of allowable single-phase load, as shown by the arrows in Figure 41. In this case, it is approximately 34 percent of the three-phase rating.

3. Find the maximum single-phase load:

$$\text{Maximum Single-Phase Load} = \frac{125\ \text{kVA} \times 34\%}{100\%} = 42.5\ \text{kVA}$$

4. Note, as follows, that the sum of the three-phase and maximum permissible single-phase loads is less than the kVA rating of the generator set:

$$62\ \text{kVA (3-Phase Load)} + 42.5\ \text{kVA (1-Phase Load)} = 104.5\ \text{kVA}$$

and

$$104.5\ \text{kVA} < 125\ \text{kVA (Rating of the Generator Set)}$$

Unbalanced loading of a generator set causes unbalanced phase voltages. The levels of load unbalance anticipated by these guidelines should not result in harm to the generator set itself. The corresponding levels of voltage unbalance, however, may not be acceptable for loads such as three-phase motors.

Because of unbalanced phase voltages, critical loads should be connected to the phase which the voltage regulator uses as the reference voltage (L_1-L_2 as defined in the generator set schematic) when only one phase is used as a reference. (All three phases are used for voltage reference on **TPS** *PMG-excited generators)* **with 3 phase sensing option.**

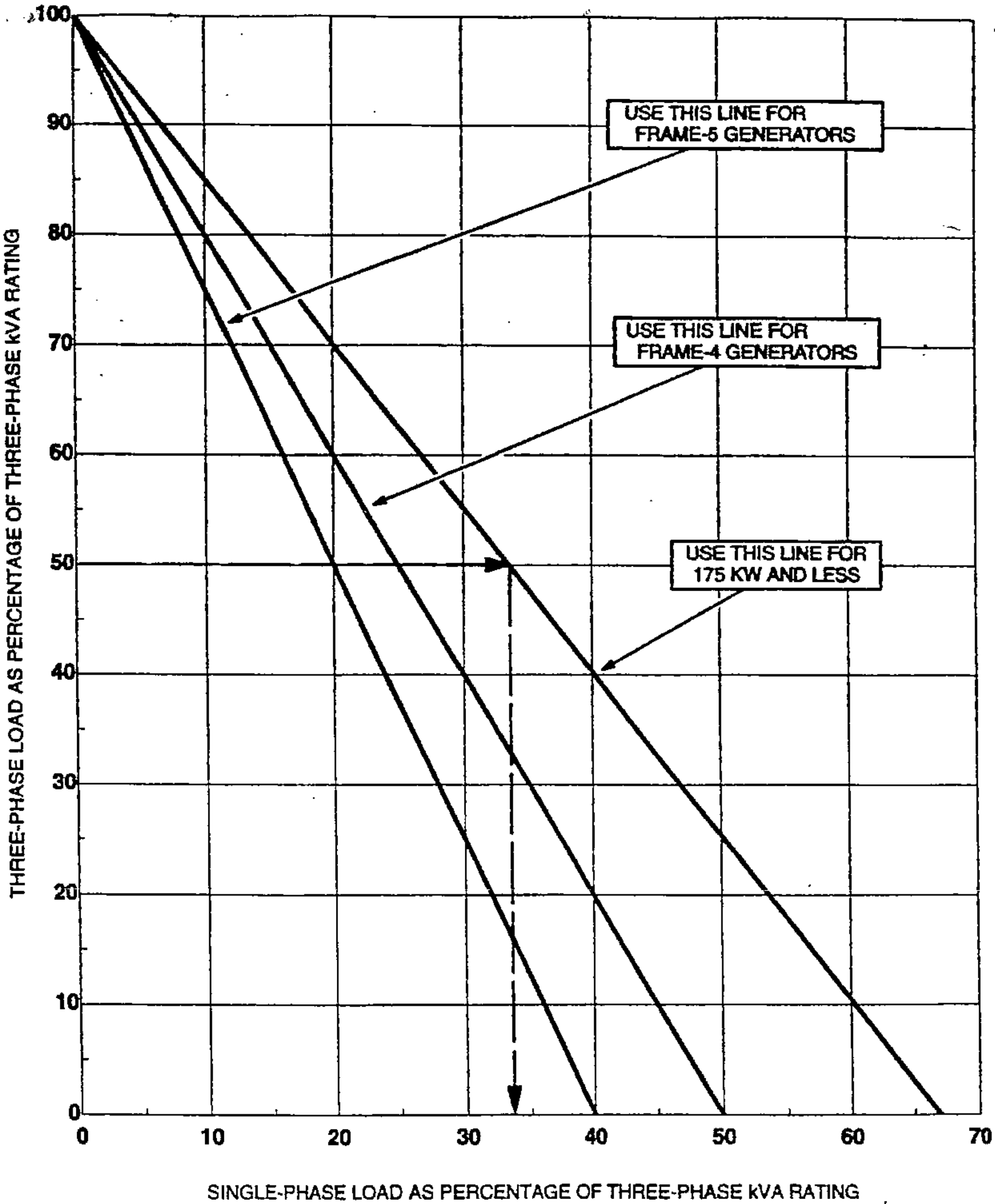


FIGURE 41. ALLOWABLE UNBALANCED SINGLE-PHASE LOAD

OPERATION

WARNING! <u>BE SURE PROPER START UP HAS BEEN PERFORMED ON YOUR TPS GENERATOR SET BEFORE ATTEMPTING TO OPERATE THE UNIT ON YOUR OWN.</u>

If proper start up has taken place, then the following events have already occurred.

1) The start up technician has reviewed the installation and has tested the unit by applying the load and making sure all generator installation requirements have been met.

2) The start up technician has reviewed the overall requirements for the **SAFE** operation of the unit with the personnel assigned to the daily inspection and operation of the unit.

3) The warranty forms and documentation are being processed and the unit is ready for operation.

The following should occur before any witnessed start of the unit.

1) Check fluid levels such as radiator water level, engine oil level, fuel level and battery fluid level. Correct any that may appear either to high or to low. Refer to the engine manufacturers guide for assistance in determining these proper levels.

2) Inspect the unit for any noticeable loose connections or leaks. Refer to the applicable manual for remedy of the problem or call TPS' service department for assistance.

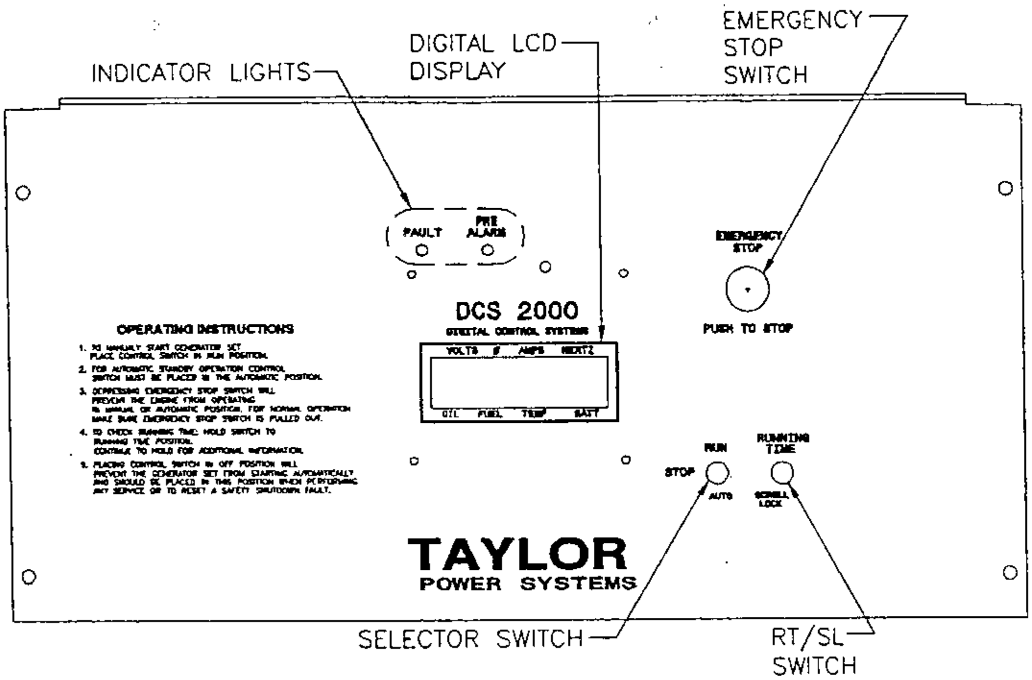
The unit has a manual position that will start the unit as soon as the switch is placed in the manual position. There will be a slight time delay through the control module and then the starter will engage and crank the engine over. If everything is in proper running condition the engine will accelerate to rated no load speed and run until the switch is returned to the 'OFF' position or the 'AUTO' position. The unit will not start in the 'AUTO' position unless the automatic transfer switch is requiring it to start. If the unit starts when the control switch is placed in the 'AUTO' position then it means that the utility is no longer supplying the transfer switch. This is an unusual occurrence and therefore will not likely happen on testing the unit.

The unit, once running, will operate at rated speed which is generally 1800 RPM plus the droop setting if the unit load is not applied. Initial readings on oil pressure and water temperature should be monitored to make sure they appear to be working properly. Also, monitor the frequency and voltage on the AC meters to verify that the generator is producing voltage at the proper level. If any of the observations appear abnormal according to the respective operator guides, then make note of the apparent discrepancy and turn the unit to the 'OFF' position. Tag the unit as out of service and call TPS' service department for assistance.

If the unit is operating satisfactorily, then you may apply the load if you wish in your normal prescribed method. Some units may have a manual means of applying the load and some may have an automatic transfer switch which may have a with or without load test selector switch. The start up technician will have set the automatic exercise clock if the unit was purchased with one. This feature starts the generator set and applies the load once a month or sometimes once a week depending on the type of transfer switch ordered.

If the transfer switch has the test with load feature, witness of this test should be done periodically to verify the exercise period is occurring and keeping the unit battery charged up. Some units may also have a battery charger hooked up which is powered by the utility system to assist in maintaining the battery in a properly charged condition. A battery charger is recommended in automatic standby operation of a TPS generator set. Always replace the control switch back in the automatic position when completing an inspection of the unit so that the automatic transfer switch can start the unit if a utility power failure occurs. When an inspection of the unit detects any unusual meter readings, noises or vibrations notify an authorized TPS DEALER to correct the problem.

GENERATOR CONTROL



GENERAL DESCRIPTION

The Generator Control System is a micro processor based, digital read out control system consisting of:

ENGINE CONTROL BOARD

The Engine Control Board houses the Engine Control Relays, Engine Interconnect Receptacles, Speed Sensing, Power Supply, and Signal Conditioning. The control utilizes a Magnetic Pickup, for speed sensing. The Engine Control Relays for fuel solenoid and cranking motor relay shall be rated at 10 Amps. Standard automotive senders are used for temperature, fuel level, and pressure readings and safety set point monitoring. Speed sensor and sender out of tolerance monitoring as pre-alarms along with engine Cooldown are available Out of tolerance conditions are logged in EEPROM and displayed until corrective action is taken. There is a 10 Amp dry relay closures for Pre-alarm and Fault annunciation.

AC MONITORING BOARD

The AC Monitoring Board senses the AC Voltage, and AC Current through its respective plugs. The AC Monitoring Board is internally connected to the Engine Control Board, and shall accept full rated AC voltage.

The Control System is compatable with diesel, natural gas, LP, and gasoline engines with either 12 or 24 VDC battery. The engine vitals: Oil Pressure, Running Time, Engine Temperature, Battery Voltage, and Safeties are monitored on the large two line Super Twist, extended temperature, Back-Lighted LCD display. Automotive type senders are provided with the control system. Generator AC Voltage, AC Amperage, and Frequency are also displayed on the LCD display. Current transformers are provided with the Generator Control System.

The Oil Pressure, Water Temperature, Frequency, and Battery Voltage are displayed constantly, with AC Volts and AC Amps are scrolled, Phase 1-2, Phase 2-3, and Phase 3-1. Emergency Stop, Over/Under Voltage, Over/Under Frequency, Under Speed, Overcurrent, Fuel Level features with pre-alarm and fault set points are available features.

The Control has a pre-programmed custom message display with diagnostics for safety set points and sender condition. A digital input is used to defeat the sender monitoring during test.

ENGINE SEQUENCE OF OPERATION

A. With the Selector Toggle in OFF the LCD display will pulse NOT IN AUTO.

B. An amber Pre-alarm LED will turn on.

C. The Pre-alarm relay will close.

D. Engine Temperature, Fuel Level and Battery Voltage will be displayed

SELECTOR SWITCH IN RUN POSITION

Placing the Selector Switch in the RUN mode will initiate the start sequence:

A. The engine Start Contact will close battery positive (+), to the Cranking Motor Slave Relay.

B. The Engine Fuel Contact will close battery positive (+) to the Fuel system.

C. The LCD display will read STARTING ENGINE during cranking. There are multiple Crank and Crank Rest cycles. The default is 5 cranking cycles 10 seconds on and 10 seconds of crank rest. The LCD display will read Crank Rest between cranks.

D. When Crank Termination is reached the Start Contact will open, disengage the Cranking Motor Slave Relay and lock out the starting circuit. The LCD display will read Oil Pressure Bypass. Should the Speed Sender fail during cranking. The Secondary crank termination will activate and disconnect the Cranking Motor Slave Relay. The engine will continue to run with Speed Sender Failure pre-alarm message unit scrolled on the LCD display, and hertz reading "0". The engine can be restarted utilizing the secondary method of crank termination, but it is advised that the speed sender be replaced ASAP.

E. Upon Crank Termination the control enters Oil Pressure Bypass and checks for false crank termination. The START CHECK™ feature monitors the engine speed immediately after crank termination. If a false start is detected the control will wait for zero speed and a restart sequence will be initiated.

F. After Oil Pressure Bypass and START CHECK™ the engine and generator information is displayed.

G. The Oil Pressure, Fuel Level, Water Temperature, Frequency and Battery Voltage are displayed while the AC volts and amperage values are scrolled. Should a monitored Pre-alarm condition occur the Pre-alarmed value will flash on the display, an amber LED will turn on, and the Pre-alarm relay will close.

H. Should a monitored Fault occur, the Fuel Contact will be opened and locked out. The LCD display will display the Fault Condition with its' associated value, the red LED will turn on, and the Fault Relay will close. Manual Reset is required before a Restart can be initiated.

Continuing to hold the RT toggle will scroll the custom message units, safety set points and sender condition on the LCD display.

J. Placing the spring loaded toggle in the SL or maintained position will lock the AC scrolling on a specific phase. The SL toggle must be placed in the OFF position during engine starting.

SELECTOR IN THE AUTO POSITION

Placing the selector in the Auto position, the LCD display will read the following:

A. IN AUTO with Temperature, Fuel Level, and Battery Voltage displayed.

B. Closing ground to the Remote Start Terminal will start the RUN SEQUENCE as described above. Removing the Remote Start signal will stop the Generator placing the controls back into the Automatic mode awaiting another Remote Start signal.

C. If any faults occur in Auto, a manual reset is required before a restart can be initiated.

FAULT TEST PROCEDURE

OVERCRANK

Disconnect the Fuel system and place toggle switch in RUN position. The engine will crank 5 times with 10 seconds cranking efforts with 10 seconds rest. The crank Relay and Fuel Relay will lock out, the Fault Relay will close, the red LED will turn on, and the LCD display will read FAULT OVERCRANK. Manual reset is required before restart can be initiated. It is recommended that the cranking motor also be disconnected while doing the test to preserve cranking battery charge.

OVERSPEED

Place the Engine selector in the RUN position allowing the engine to run. Manually increase the fuel until OVERSPEED speed is achieved. The Fuel Contact will open and lock out, the Fault Relay will close, the red LED will turn on, and the LCD will display FAULT OVERSPEED. Manual reset is required before another start can be initiated.

HIGH ENGINE TEMPERATURE FAULT

NOTE: Ground the digital input, as referenced on the drawings, to deactivate the sender fault feature for testing. Place the Engine Selector in the RUN position allowing the engine to run. Manually ground the Engine Temperature Sender to the engine block. The Fuel Contact will open and lock out, the Fault Relay will close, the red LED will turn on, and the LCD will display FAULT HIGH ENGINE TEMPERATURE. Manual reset is required before a restart can be initiated. There is a 5 second delay on this fault. (If there are not enough digital inputs to allow sender deactivation utilizing a digital input. A fixed resistor must be utilized in place of the engine sender for testing. Use a 47 ohm resister for High Temperature testing)

LOW OIL PRESSURE FAULT

NOTE: Ground the digital input, as referenced on the drawings, to deactivate the sender fault feature for testing. Place the Engine Selector in the RUN position allowing the engine to run. Manually remove the Oil Pressure Sender wire. The Fuel Contact will lock out, the Fault Relay will close, the red LED will turn on, and the LCD will display FAULT LOW OIL PRESSURE. Manual reset is required before a restart can be initiated. There is a 5 second delay on this fault. (If there are not enough digital inputs to allow sender deactivation utilizing a digital input. A fixed resistor must be utilized in place of the engine sender for testing. Use a 240 ohm resister for Low Oil Pressure testing)

DIGITAL INPUTS

A contact closure to ground will activate individual inputs. The inputs will be as follows depending upon customer definition:

A. Pre-Alarm at all times or when running only.

B. Pre-Alarm when selector is in OFF or AUTO, Fault when engine is running.

C. Fault when engine is running only.

EMERGENCY STOP

A contact closure to ground will activate Emergency Stop. The fuel will be turned off, the fault relay will close, the red LED will turn on, and the display will read EMERGENCY STOP. If a push to Emergency Stop and pull to reset type push button is used, reset of the push button is required prior to manual reset of the controls before restart..

SENDER FAILURE

NOTE: Follow the same procedure for shut downs, but without the deactivation digital grounded. Grounding the sender will scroll a sender failure pre-alarm message on the LCD read out. The running Time of the failure will be stored in Sender Condition section of the custom message readout display. The diagnostic screen will be cleared and the message unit corrected when the engine is started and run with in-tolerance senders.

CALIBRATION PROCEDURES

All units are calibrated at the factory. If field adjustment is required follow the procedure listed below.

AC VOLTAGE

Should AC Volts require adjustment, there is a single 20 turn pot located on the AC Monitor board. Turning the pot clockwise raises voltage.

AC AMPS

Should AC Amps require adjustment, there is a single 20 turn pot adjustment located on the AC Monitor board. Turning the pot clockwise raises amperage.

DC VOLTAGE

Should DC Volts require adjustment, there is a single 20 turn pot adjustment located on the Engine Monitor board, assessable through a hole on the AC board. Turning the pot clockwise raises voltage.

NOTE: Depending on job specific programming the pre-alarm and fault relays may operate differently than described above. I.e. Air Damper or Glow Plug

TEST PROCEDURE FOR OPTIONAL FEATURES IF ACTIVATED

UNDERSPEED MONITORING AND PROTECTION

Underspeed does not activate until the programmed speed set point is reached. The default activation set point on a 60 Hz unit would be 55 Hz. This allows the engine to be started and idled without Underspeed monitoring.

When the programmed set point is reached the Underspeed protection is activated for the duration of the engine run. The default set point on a 60 Hz unit would be 55 Hz for 5 seconds. Should the engine speed drop and stay below the Underspeed set point. The engine will be shut down and require manual reset. The controls will pre-alarm Underspeed until shut down occurs.

Underspeed can be tested by reducing engine speed to below the programmed set point.

OVER/UNDER VOLTAGE PROTECTION

Over/Under Voltage does not activate until the programmed set point is achieved. The default activation set point on a 60 Hz unit would be 55 Hz. This allows the engine to be started and idled without Over/Under Voltage monitoring.

When the programmed speed set point and time delay are met the Over/Under Voltage protection is automatically activated for the duration of the engine run. A typical set point would be plus 10% and minus 15% for 10 seconds. If an Over/Under Voltage condition exists the generator will shut down and require manual reset. The controls will pre-alarm Over/Under Voltage until shut down occurs.

Over/Under voltage can be tested by turning the AC volts calibration pot on the AC board.

OVER/UNDER FREQUENCY

Over/Under Frequency does not activate until the programmed speed set point is achieved. The default activation set point on a 60 Hz unit would be 55 Hz. This allows the engine to be started and idled without Over/Under Frequency monitoring.

When the programmed speed set point and time delay are met the Over/Under Frequency pre-alarm is activated. The LCD display will indicate the pre-alarm. The percentage of Over and Under Frequency is set the EEPROM along with the time delay before pre-alarming. A typical setting is +/- .5 Hz.

Over/Under Frequency can be tested by adjusting the electronic governor.

OVERCURRENT PROTECTION

The default activation set point on a 60 Hz unit would be 55 Hz. Overcurrent is automatically set for each run based on the operating voltage for that run. This allows for customer changing voltage between runs. i.e. 480 or 208 The controls will pre-alarm the Overcurrent until shut down occurs.

Overcurrent can be tested by turning the Amps calibration pot on the AC board.

SERVICE REMINDER Pre-alarm. At Crank Termination the hours left to service are displayed during the oil pressure bypass time delay. When the Service Time equals ZERO the Pre-alarm message unit will be displayed. Holding the Running Time Toggle switch in the RT positions will scroll to the Time left to service screen. When the value is zero and the Time to Service screen is displayed the time will automatically reset to the original Service Hours that in the EEPROM. The Service Reminder can be reset any time by holding the Running Time Toggle switch in the RT position for 30 seconds. (This is the time required for the Service Time screen to be displayed three times)

DATA LOGGING FAULTS ANDEMUNM

The last five faults are stored in EEPROM. As each fault occurs the fault is stored with the running time at the time of failure. I.e. Fault High Temperature 500.5. To readout the Fault History Log depress the running time toggle switch. The Faults will be listed with the most recent first to the fifth fault. If an eleventh fault occurs the oldest fault will be eliminated form the readout.

Holding down the running time toggle for 60 seconds can erase the stored History Log. This is enough time for 2 complete scrolling of all data stored including custom message units, sender faults and safety set points.

The running time and History Log can be read without starting the engine by holding down the running time toggle and placing the engine control switch in run. The engine will not start as long as the running tie toggle is depressed. If the running time toggle is released before the engine control switch is placed in the off position. The engine will start.

Maintenance and Service

GENERAL

A well-planned program of preventive maintenance and service should be integral to the design of an on-site power system. Failure of a standby generator set to start and run could lead to loss of life, personal injury, property damage and loss of business income. Failure to start and run due to low battery charge because of careless maintenance is the most common type of failure. A comprehensive program carried out on a scheduled basis by qualified persons can prevent such failures and their possible consequences. The maintenance and service programs most generator set distributors offer on a contract basis should be considered. Typically, they include performance of scheduled maintenance, repairs, parts replacement and service documentation.

SCHEDULED MAINTENANCE

The maintenance schedule for prime power sets should be on the basis of running time, as published by the manufacturer. Since standby sets run infrequently, the maintenance schedule is usually in terms of daily, weekly, monthly, semi-annual and annual tasks. See the manufacturer's instructions for details; but scheduled maintenance should include at least:

Daily

- Checking for oil, coolant and fuel leaks.
- Checking operation of the engine coolant heater(s). If the block is not warm, the heaters are not working and the engine might not start.
- Checking to see that the switchgear is in the AUTOMATIC position.

Weekly

- Checking engine oil and coolant levels.
- Checking the battery charging system.

Monthly

- Checking for air cleaner restrictions.
- Exercising the generator set by starting it and running it for at least 30 minutes under not less than one-half rated load and checking for unusual vibrations, noises and exhaust, coolant and fuel leaks while the set is running. (Regular exercising keeps engine parts lubricated, improves starting reliability, prevents oxidation of electrical contacts and consumes fuel before it deteriorates and has to be disposed of.)
- Checking for radiator restrictions, coolant leaks, deteriorating hoses, loose and deteriorating fan belts, non-functioning motorized-louvers and concentration of engine coolant conditioner.

- Checking for holes, leaks and loose connections in the air cleaner.
- Checking fuel level and fuel transfer pump operation.
- Checking for exhaust system leaks and restrictions and draining the condensate trap.
- Checking all meters, gauges and indicator lamps for proper operation.
- Checking the battery cable connections and recharging the batteries if specific gravity is less than 1.260.
- Checking for ventilation restrictions in the inlet and outlet openings of the generator.
- Checking that all required service tools are readily available.

Semi-Annually

- Changing engine oil and the full-flow and the by-pass oil filters.
- Changing the filter(s) in the coolant conditioner circuit.
- Cleaning or replacing the crankcase breather filter(s).
- Changing the fuel filter(s), draining sediment from fuel tanks, checking flexible fuel hoses for cuts and abrasions and checking the governor linkage.
- Checking electrical safety controls and alarms.
- Cleaning up accumulations of grease, oil and dirt on the set.
- Checking power distribution wiring, connections, circuit breakers and transfer switches.
- Simulating a utility power outage. This should test the the ability of the set to start and assume rated load and check operation of the automatic transfer switches, related switchgear and controls and all other components in the standby power system.

Annually

- Checking the fan hub, pulleys and water pump.
- Changing the day tank breather.
- Tightening the exhaust manifold and turbocharger capscrews.
- Tightening the set mounting hardware.
- Cleaning the generator power output and control boxes, checking for and tightening all loose wiring connectors, measuring and recording generator winding insulation resistances, checking operation of the generator heater strips and greasing bearings.
- Checking operation of the main generator circuit breaker (if used) by manually operating it and testing the trip unit according to the manufacturer's instructions.
- Running the set for at least three hours, with one hour at near rated load, if the set is normally exercised at no-load or carries only light loads.
- Generator insulation tests should be conducted annually throughout the life of a generator set. The initial tests should be done before final load connections are made to serve as benchmarks for the annual tests. **These tests are mandatory for medium voltage generator sets.** ANSI/IEEE Standard 43, *Recommended Practice for Testing Insulation Resistance of Rotating Machinery* should be referenced.

TROUBLESHOOTING

What are some of the most often found reasons for a failure of the generator set to start? Below is a list of some of the areas overlooked when maintaining a generator set.

1) **Battery cables!** A battery cable often looks as if it is in good condition but in fact may be the cause of a non-start of the generator set. Corrosion often starts on the inside of the cable insulation and is not visible from the outside without testing the resistance value from one end to the other. Battery cable checks are listed in most operator guides and in order to keep the units running properly the cables must be kept clean and free from corrosion.
2) **Bad fuel!** Fuel systems are the second highest cause for failure to start or fail during an outage without being able to supply power for the full period of the outage. The major factor is usually algae or water in the fuel tank which develops from not exchanging the fuel regularly or not adding algae or water preventive additives to prevent this contamination. There are test substances which allow testing of the tank to see if water is present and this should be performed quarterly.
3) **Corrosion!** Electrical connections are subject to corrosion even though TPS units are treated at the factory to help prevent corrosion from occurring. Check terminal connections periodically.
4)**Operator adjustments-** Often times there is a problem with personnel adjusting units without checking the proper method in the operator guides which lead to an unsuccessful start attempt and damage to property or worse injury or death to personnel. <u>DO NOT</u> adjust the generator set controls without the proper training in performance of the work.
5)**Rodent/pest contamination-** Insulation on electrical wires is often a treat for rodents which can lead to a failure to start of the generator set. Another problem is rodent or pest nesting which can lead to plugging of the air cleaner or radiator(cap left off!). Inspect the unit carefully for rodent or pest contamination.
6)**Improperly maintained coolant heater-** The coolant heater is an integral part of an automatic starting system and is often overlooked when checking out a unit. Generally this occurs because the unit is turned off in the summer time and is merely left off after winter comes. The diesel unit will not start properly when the coolant heater is turned off and the air temperature falls below 80 degrees Fahrenheit.
7)**Dead battery-** This is the most unfortunate reason for a failure to start and can be prevented if proper maintenance is performed on a scheduled basis.

Other troubleshooting is provided in each of the operator guides supplied with the unit and should be reviewed for other problem solving.

Taylor Power Systems

Manufacturer's Limited Warranty

Taylor Generator Sets

Taylor Power Systems extends to the original purchaser of goods for use, the following warranty covering goods manufactured or supplied by Taylor Power Systems, subject to the qualifications indicated.

There is no other express warranty.

Implied warranties including merchantability and fitness for a particular purpose, are limited to periods of warranty set forth below and to the extent permitted by law, any and all implied warranties are excluded.

In no event is Taylor Power Systems liable for incidental or consequential damages.

NOTE: Some states do not allow limitations on how long an implied warranty lasts, so the above limitations may not apply in every instance.

1. Taylor Power Systems warrants to original purchaser for the period set forth below that goods manufactured or supplied by it will be free from defects in workmanship and material, provided such goods are installed, operated, and maintained in accordance with Taylor Power Systems instructions, and further provided, that installation inspection and initial start–up on Commercial–Industrial Generator Set or Power Systems installations are conducted by a Taylor Power Systems authorized distributor or its designated service representative.

Product	Period of Warranty
Commercial – Industrial Standby Generator Sets	Two (2) years or 1500 hours from date of initial Start–Up or 30 months from date of shipment from manufacturer's plant, whichever comes first.
Commercial – Industrial Prime Power and Marine Generator Sets	One (1) year or 3000 hours from date of initial Start–Up or 18 months from date of shipment from manufacturer's plant, whichever comes first.
Chassis Mounted and Clip–on Refrigeration Generator Sets	One year from the date of original installation or 18 months from date of shipment from manufacturer's plant, whichever comes first.
Repair of Replacement Parts	Ninety (90) days from date of purchase, excludes labor.

To be covered by this warranty your purchase must be registered within thirty (30) days of initial Start–Up, warranty registration form to be provided and completed by seller.

2. Taylor Power Systems liability and purchaser's sole remedy for a failure of goods under this warranty and for any and all other claims arising out of the purchase and use of goods, including negligence on the part of the manufacturer, shall be limited to the repair of the product by the repair or replacement, at Taylor Power Systems option, of parts that do not conform to this warranty, provided that the product or parts are returned to Taylor Power Systems factory at 461 Highway 49 South, Richland, Mississippi 39218, or to a Taylor Power Systems authorized distributor or its designated service representative, transportation prepaid. In the event warranty repairs are not performed by a Taylor Power Systems authorized distributor or its designated service representative, said warranty repair claim will be administered through Taylor Power Systems, Richland, Mississippi Warranty Department. Claimant will be reimbursed labor expenses at the rate of thirty (30) U.S. dollars per hour for the time allowed for the applicable repair or for the actual labor expense, whichever is less. Parts will be reimbursed at Taylor Power Systems current list price, less the applicable discount from the parts depot in the local geographic area, plus 5% for handling. Taylor Power Systems will provide replacement parts to claimants location within the continental United States. If claimant is located outside the continental United States, all parts shipments are f.o.b. point of debarkation. In the event warranty repairs are effected outside the boundaries of the United States of America, Taylor Power Systems is not responsible for any duties, taxes, or associated charges as may be applicable in accordance with the regulations of the country where such warranty repair is performed.

3. All claims must be brought to the attention of Taylor Power Systems or an authorized distributor or its designated service representative within thirty (30) days after discovery that goods or parts fail to meet this warranty.

4. This warranty does not apply to:

   a. Cost of maintenance, adjustments, installation and start-up.

   b. Failures due to normal wear, accident, misuse, abuse, negligence or improper installation.

   c. Damage due to faulty repairs not performed by an authorized service representative.

   d. Products which are altered or modified in a manner not authorized by manufacturer in writing.

   e. Failure of goods caused by defects in the system or application in which the goods are installed.

   f. Failure caused by operations at speeds, load or conditions contrary to published specifications or recommendations.

   g. Negligent maintenance such as:

      1). Failure to perform scheduled maintenance.

      2). Failure to provide sufficient lubricating oil.

      3). Failure to provide sufficient cooling.

      4). Failure to keep air intake and cooling fin areas clean.

      5). Failure to properly service air cleaner.

      6). Use of other than factory supplied or approved, repair parts and/or procedures.

   h. Telephone, Telegraph, Teletype or other communication expenses.

   i. Living and travel expense of person performing service.

   j. Rental equipment used while warranty repairs are being performed.

   k. Overtime labor.

   l. Batteries (Batteries are warranted by the battery manufacturer).

   m. Starters and battery charging alternators (Warranted by Component Manufacturer).

   n. Consumable items including, but not restricted to:

      1). Engine oil.

      2). Grease and lubricants.

      3). Fuel.

      4). Filters and filter elements.

      5). Injector nozzles.

      6). Glow plugs.

      7). Cleaning materials.

      8). Belts.

      9). Light bulbs and fuses.

      10). Antifreeze coolant.

No person is authorized to give any other warranties or to assure any other liabilities on Taylor Power Systems behalf, unless made or assumed in writing by an officer of Taylor Power Systems, and no person is authorized to give any warranties or assume any other liability on behalf of seller unless made or assumed in writing by seller.

5. This warranty gives the user specific rights, and the user may also have other rights which vary from state to state.

6. Check component manufacturer's warranties to determine if their coverage exceeds Taylor Power Systems' warranty coverage.

TAYLOR ®

POWER SYSTEMS

CELL UNIT CONTROLLER
OPERATING SECTION

General Description of Operation for Taylor Power Cell Unit Controller

The control unit is designed to operate on 12 volt DC systems and has a constant power draw. Fuel level, oil pressure, water temperature are designed to operate on Stewart Warner match senders. Low coolant level and fuel leak inputs are designed to operate with normally open switches to ground.

It contains analog inputs for oil pressure, water temperature, speed (mag pickup), battery voltage, fuel tank level, AC voltage and Amperage (single phase). It provides digital inputs for Low Coolant Level, Fuel Tank Leak, and Remote Start (through the ATS Interface Board).

It contains 30 amp, 12 v outputs, for a fuel solenoid and crank relay. A 10 amp relay drives the ATS Interface Board. Four, dry contact, 10 amp relays are located on the AC board. They provide contact closures for Common Fault (R1), Generator Ready (R2), Generator Running (R3), and Common PreAlarm (R4).

Operation:

Selector Switch in OFF

1. The control will display "NOT IN AUTO" and the engine parameters.
2. While in this mode, the unit cannot be started.
3. R4 is closed and the corresponding LED is lit.
4. Any out of tolerance value is flashed on the display to indicate a prealarm such as low battery voltage.

Selector Switch in RUN

1. The control will begin a starting sequence of 5 cranks for 10 seconds each with 10 second rest in between and the fuel is energized constantly.
2. Once the controller measure 15 Hertz (450 rpm) the crank relay disconnects and the control enters a RUN mode.
3. R3 is closed and the corresponding LED is lit.
4. The engine runs *without* LOAD TRANSFER.
5. While running, all displayed parameters are monitored.
6. If a prealarm condition exists, R4 is closed and the corresponding LED is lit.
7. If a fault occurs, R3 will open and the corresponding LED goes out and R1 closes and the corresponding LED is lit. The fuel relay opens and the LCD will display the reason for the fault.

8. If the switch is placed back into the OFF position from a running state, the fuel relay will open stopping the engine without cool down, R3 will open and R4 will close. The controller is now back in the "NOT IN AUTO" mode.

Selector Switch in AUTO

1. The control will display "UNIT IN AUTO" and the engine parameters. R2 is closed and the corresponding LED is lit.
2. While in this mode, the unit is capable of starting either by receiving a remote start signal from the ATS Interface Board or starting from the Plant Excersizer
3. If a Remote Start signal is received, the controller will enter a "Load" starting sequence. There is a Time Delay to Engine Start of 3 seconds. The fuel and crank relays close. Once started the crank relay opens and R3 will close. After a 3 second "Time Delay to Emergency", if 90% voltage and 95% frequency is present, the ATS relay will close sending a signal to the transfer switch to change to the emergency power source. Once utility power is re-established, the controller will wait 10 minutes before opening the ATS relay allowing the transfer switch to return to utility power. After 5 minutes of cool down, the unit opens the fuel relay, stopping the engine, and returns to the UNIT IN AUTO" mode awaiting another Remote Start signal. R3 opens.
4. If, while generator is running in the Auto mode and the selector switch is placed in OFF position, the fuel relay will open, stopping the engine without cool down, R3 and R2 will open and R4 will close. The transfer switch will transfer the load back to the utility source if and when the utility becomes available. The unit is back in the "NOT IN AUTO" mode.

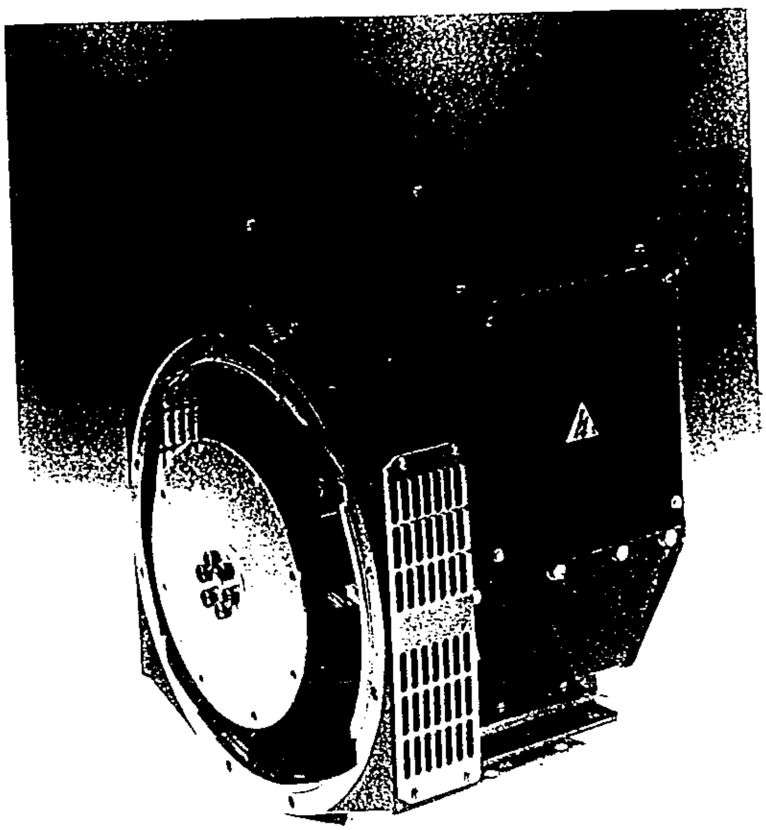
Plant Excersizer Mode

1. The Plant Excersizer is activated when the toggle switch is in the "Activated" position.
2. "PE Activated" will be displayed approx. every 30 seconds while in the "NOT IN AUTO" or "UNIT IN AUTO" modes.
3. It will only start and run the engine unloaded for ½ hour each week from the time it was activated if the Selector Switch is in the AUTO position and it is not already running from a remote start signal.
4. While running in the Plant Excersizer mode R3 will be closed.
5. If while the engine is running due to the Plant Excersizer cycle and the Selector Switch is placed in the OFF position, the current PE cycle will be cancelled, the fuel relay will open stopping the engine, R2 and R3 will open and R4 will close.
6. If while running in the Plant Excersizer mode and the utility fails. the PE cycle is canceled and the load is transferred to the generator.

STAMFORD

AC GENERATORS FROM

NEWAGE INTERNATIONAL



Installation, Service & Maintenance Manual

For the BC Range of Generators.

SECTION 1

INTRODUCTION

1.1 INTRODUCTION

The BC16/18 range of generators is of brushless rotating field design, available up to 660V/50Hz (1500 rpm, 4 pole and 3000 rpm, 2 pole) or 60Hz (1800 rpm, 4 pole and 3600 rpm, 2 pole), and built to meet B.S. 5000 Part 3 and international standards.

The BC16/18 range are self-excited with excitation power derived from the main output windings, using either the SX460/SA465 AVR or transformer controlled excitation system.
The BC184 may be supplied fitted with an auxiliary winding in the main stator, using the SA465 AVR.

Detailed specification sheets are available on request.

1.2 DESIGNATION

To provide standardisation of systems with minimal change to customers.

B	C	L	I	1	6	4	A	1
B	C	.	I	1	6	2	D	1
B	C	A	I	1	6	2	D	1
B	C	.	M	1	8	4	F	2

GENERATOR TYPE BC

SPECIFIC TYPE L = TS OR TR ENGINE
A = ALPHA ENGINE

INDUSTRIAL = (I) OR MARINE = (M)

SHAFT HEIGHT IN CM ON BC/UC

NUMBER OF POLES 2 or 4

CORE LENGTH

NUMBER OF BEARINGS 1 OR 2

1.3 PACKAGED LOOSE ADAPTOR HARDWARE

Several adaptors are only partially fitted to generators to simplify removal prior to engine-generator assembly. The remaining hardware is contained within a plastic bag located in the terminal box.

Adaptor Types

SAE2
SAE3
SAE5 Spacer Rings
SAE6
Coupling Plate Dowel Pins

1.4 SERIAL NUMBER LOCATION

Each generator has its unique serial number stamped into the upper section of the non-drive end frame.

Inside the terminal box two adhesive rectangular labels have been fixed, each carrying the generator's unique identity number. One to the inside of the terminal box sheet metal work, and the second label fixed to the main frame of the generator.

1.5 RATING PLATE AND CE MARK

The generator has been supplied with a self adhesive rating plate label to enable fitting after final assembly and painting. It is intended that this label will be stuck to the outside of the terminal box on the left hand side when viewed from the drive-end. To assist with squarely positioning the label, location protrusions have been made in the sheet metalwork.

A CE Mark label is also supplied loose for fitment after final assembly and painting. This should be attached to an external surface of the Generator at a suitable location where it will not be obscured by the customer's wiring or other fittings.

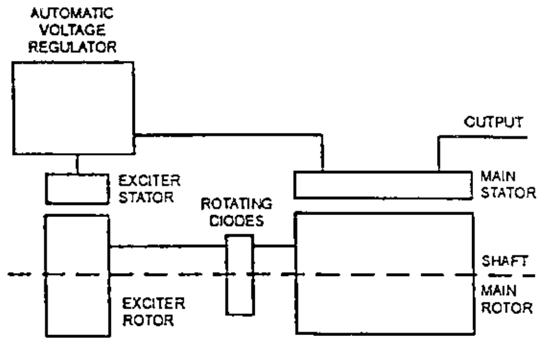
The surface on the area where a label is to be stuck must be flat, clean and any paint finish must be fully dry before attempting to attach label. Recommended method for attaching label is peel and fold back sufficient of the backing paper to expose some 20mm of label adhesive along the edge which is to be located against the sheet metal protrusions. Once this first section of label has been carefully located and stuck into position the backing paper can be progressively removed, as the label is pressed down into position. The adhesive will achieve a permanent bond in 24 hours.

SECTION 2

PRINCIPLE OF OPERATION

2.1 SELF-EXCITED AVR CONTROLLED GENERATORS

2.1.1 MAIN STATOR POWERED AVR



The main stator provides power for excitation of the exciter field via the SX460 (SA465) AVR which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

The AVR senses average voltage on two phases ensuring close regulation. In addition it detects engine speed and provides voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine.

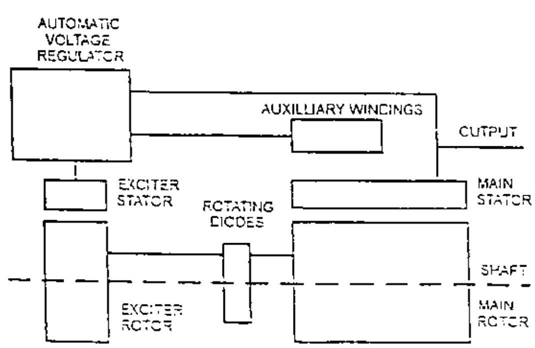
The detailed function of the AVR circuits and their adjustment are covered in the load testing section.

In addition the SA465 AVR incorporates circuits which, when used in conjunction with accessories, can provide for parallel operation either with 'droop' or 'astatic' control and VAR/PF control.

Function and adjustment of the accessories which can be fitted inside the generator terminal box are covered in the accessories section of this book.

Separate instructions are provided with other accessories available for control panel mounting.

2.1.2 AUXILIARY WINDING POWERED AVR



The auxiliary winding provides power for excitation of the exciter field via the SA465 AVR which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature. The AVR senses average voltage on two phases ensuring close regulation. In addition, it detects engine speed and provides voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine.

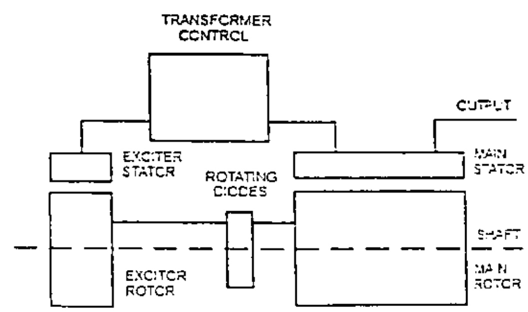
Under fault conditions on the main stator output the auxiliary winding continues to generate voltage from the harmonic content of the magnetic field in the main stator core providing the necessary power via the SA465 AVR, to maintain short circuit fault currents.

The detailed function of the AVR circuits and their adjustment are covered in the load testing section.

Function and adjustment of the accessories which can be fitted inside the generator terminal box are covered in the accessories section of this book.

Separate instructions are provided with other accessories available for control panel mounting.

2.2 TRANSFORMER CONTROLLED GENERATORS



The main stator provides power for excitation of the exciter field via a transformer rectifier unit. The transformer combines voltage and current elements derived from the main stator output to form the basis of an open-loop control system, which is self regulating in nature. The system inherently compensates for load current magnitude and power factor and provides short circuit maintenance in addition to a good motor starting performance.

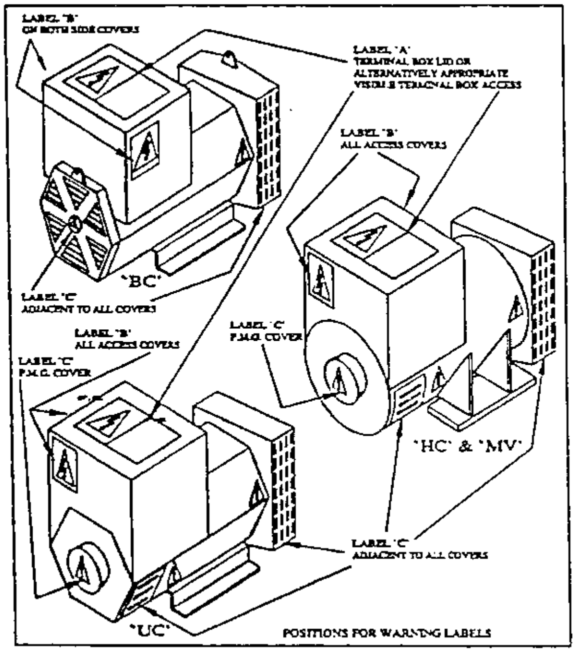
Three phase generators normally have a three phase transformer control for improved performance with unbalanced loads but a single phase transformer option is available.

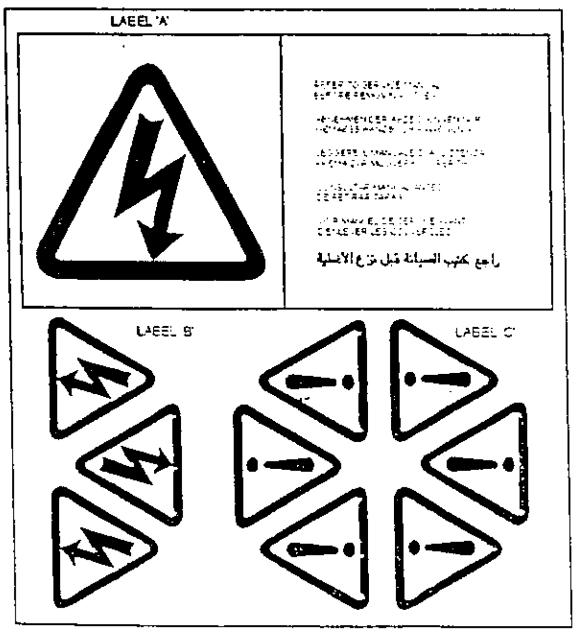
No accessories can be provided with this control system.

SECTION 3

APPLICATION OF THE GENERATOR

The generator is supplied as a component part for installation in a generating set. It is not, therefore, practicable to fit all the necessary warning/hazard labels during generator manufacture. The additional labels required are packaged with this Manual, together with a drawing identifying their locations.





It is the responsibility of the generating set manufacturer to ensure that the correct labels are fitted, and are clearly visible.

The generators have been designed for use in a maximum ambient temperature of 40°C and altitude less than 1000 metres above sea level in accordance with BS 5000.

Ambients in excess of 40°C and altitudes above 1000 metres can be tolerated with reduced ratings - refer to the generator nameplate for rating and ambient. In the event that the generator is required to operate in an ambient in excess of the nameplate value or at altitudes in excess of 1000 metres above sea level, refer to the factory.

The generators are of air-ventilated screen protected drip-proof design and are not suitable for mounting outdoors unless adequately protected by the use of canopies. Anti-condensation heaters are recommended during storage and for standby duty to ensure winding insulation is maintained in good condition.

When installed in a closed canopy it must be ensured that the ambient temperature of the cooling air to the generator does not exceed that for which the generator has been rated.

The canopy should be designed such that the engine air intake to the canopy is separated from the generator intake, particularly where the radiator cooling fan is required to draw air into the canopy. In addition the generator air intake to the canopy should be designed such that the ingress of moisture is prohibited, preferably by use of a 2 stage filter.

The generator air intake is through the non drive end cover and the generating set and canopy design must be such that the intake is not restricted. It is recommended that a minimum clearance of 50mm is allowed between the generator air intake and any vertical flat surface.

The air intake/outlet must be suitable for the air flow given in the following table with additional pressure drops less than or equal to those given below:

Frame	Air Flow 50Hz	Air Flow 60Hz	Additional (intake/outlet) Pressure Drop
EC164	0.13m³/sec	0.16m³/sec	3mm water gauge (0.1")
	277cfm	341cfm	
EC184	0.13m³/sec	0.16m³/sec	
	277cfm	341cfm	
EC162	0.19m³/sec	0.23m³/sec	
	398cfm	490cfm	
EC182	0.19m³/sec	0.23m³/sec	
	398cfm	490cfm	

If specified at the time of ordering, the generator itself may be fitted with air filters.

The ECL construction has no fan fitted to the generator. The engine flywheel fan draws air through the generator and additional restrictions on air flow such as filters on the generator or canopies are not permissible.

Important ! Reduction in cooling air flow or inadequate protection to the generator can result in damage and/or failure of windings.

Dynamic balancing of the generator rotor assembly has been carried out during manufacture in accordance with BS 6861 Part 1 Grade 2.5 to ensure vibration limits of the generator are in accordance with BS 4999 Part 142.

The main vibration frequencies produced by the component generator are as follows:-

4 pole	1500 r.p.m.	25 Hz
4 pole	1800 r.p.m.	30 Hz
2 pole	3000 r.p.m.	50 Hz
2 pole	3600 r.p.m.	60 Hz

However, vibrations induced by the engine are complex and contain frequencies of 1, 3, 5 or more times the fundamental frequency of vibration. These induced vibrations can result in generator vibration levels higher than those derived from the generator itself. It is the responsibility of the generating set designer to ensure that the alignment and stiffness of the bedplate and mountings are such that the vibration limits of BS 5000 Part 3 are not exceeded.

In standby applications where the running time is limited and reduced life expectancy is accepted, higher levels than specified in BS 5000 can be tolerated, up to a maximum of 18mm/sec.

Two bearing generators require a substantial bedplate with engine/generator mounting pads to ensure a good base for accurate alignment. Close coupling of engine to generator can increase the overall rigidity of the set. For the purposes of establishing set design the bending moment at the engine flywheel housing to generator adaptor interface should not exceed 125ft.lb. (17 kgm). A flexible coupling, designed to suit the specific engine/generator combination, is recommended to minimise torsional effects.

Belt driven applications of two bearing generators require the pulley diameter and design to be such that the side load or force applied to the shaft is central to the extension and does not exceed the values given in the table below:-

Frame 2/4 Pole	Side Load		Shaft extension mm
	kgf	N	
BC16	92	900	82
BC18	173	1700	82

In instances where shaft extensions greater than specified in the table have been supplied, reference must be made to the factory for appropriate loadings.

Alignment of single bearing generators is critical and vibration can occur due to the flexing of the flanges between the engine and generator. As far as the generator is concerned the maximum bending moment at this point must not exceed 125ft.lb. (17 kgm).

Single bearing generators require a substantial bedplate with engine/generator mounting pads to ensure a good base for accurate alignment.

It is expected that the generator will be incorporated into a generating set operating in an environment, where the maximum shock load experienced by the generator will not exceed 3g. in any plane. If shock loads in excess of 3g are to be encountered, anti-vibration mountings must be incorporated into the generating set to ensure they absorb the excess.

The maximum bending moment of the engine flange must be checked with the engine manufacturer.

Important ! Single bearing drive end brackets are designed to be bolted to the engine flywheel housing using cap head screws.

Torsional vibrations occur in all engine-driven shaft systems and may be of a magnitude to cause damage at certain critical speeds. It is therefore necessary to consider the torsional vibration effect on the generator shaft and couplings.

It is the responsibility of the generator set manufacturer to ensure compatibility, and for this purpose drawings showing the shaft dimensions and rotor inertias are available for customers to forward to the engine supplier. In the case of single bearing generators coupling details are included.

Important ! Torsional incompatibility and/or excessive vibration levels can cause damage or failure of generator and/or engine components.

The terminal box is constructed with removable panels for easy adaptation to suit specific glanding requirements. Within the terminal box there are insulated terminals for line and neutral connections and provision for earthing. A hole is provided on the generator foot which may be tapped to give an additional earthing point.

The neutral is NOT connected to the frame.

The main stator winding has 12 leads brought out to the terminals in the terminal box.

Warning ! No earth connections are made on the generator and reference to site regulations for earthing must be made. Incorrect earthing or protection arrangements can result in personal injury or death.

Fault current curves (decrement curves), together with generator reactance data, are available on request to assist the system designer to select circuit breakers, calculate fault currents and ensure discrimination within the load network.

Warning ! Incorrect installation, service or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.

SECTION 4

INSTALLATION - PART 1

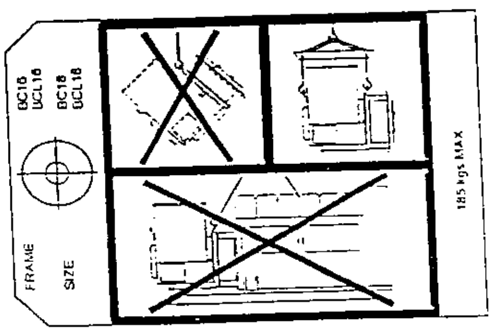
4.1 LIFTING

> **Warning !** Incorrect lifting or inadequate lifting capacity can result in severe personal injury or equipment damage. MINIMUM LIFTING CAPACITY REQUIRED IS 250Kg. Generator lifting lugs should NOT be used for lifting the complete generator set.

Lifting lugs are provided at each end of the generator for use with a shackle and pin type lifting aid or lifting hooks. Chains of suitable length and lifting capacity, with spreader bar to avoid damage to the terminal box, must be used.

The correct lifting arrangement is shown on a label attached to the generator. A typical example is shown below.

> **IMPORTANT**
>
> REFER TO SERVICE MANUAL BEFORE REMOVING COVERS.
> IT IS THE GENERATOR SET MANUFACTURER'S RESPONSIBILITY TO FIT THE SELF ADHESIVE WARNING LABELS SUPPLIED WITH THE GENERATOR. THE LABEL SHEET CAN BE FOUND WITH THE INSTRUCTION BOCK.



BCL generators have no fan to support the drive end and are supplied fitted with a transit strap clamping the coupling hub to the drive end adaptor ring.

Once the transit strap is removed the rotor is free to move in the frame, and care is needed during coupling and alignment to ensure the frame is kept in the horizontal plane.

4.2 ASSEMBLY TO ENGINE

ENGINE TO GENERATOR COUPLING ASSEMBLY

During the assembly of the Generator to the Engine it will be necessary to firstly carefully align, then rotate, the combined Generator rotor - Engine crankshaft assembly, as part of the construction process, to allow location, insertion and tightening of the coupling bolts. This requirement to rotate the combined assemblies exists for both single and two bearing units.

During the assembly of single bearing units it is necessary to align the generator's coupling holes with the engine flywheel holes: it is suggested that two diametrically opposite location dowel pins are fitted to the engine flywheel, over which the generator coupling can slide into final location into the engine flywheel spigot recess. The dowels must be removed and replaced by coupling bolts before the final bolt tightening sequence.

While fitting and tightening the coupling bolts it will be necessary to rotate the Engine crankshaft - Generator rotor assembly. Care should be taken to ensure that rotation is carried out in an approved manner that ensures safe working practice when reaching inside the machine to insert or tighten coupling bolts, and that no component of the assembly is damaged by non-approved methods of assembly rotation.

Engine Manufacturers have available a proprietary tool designed to enable manual rotation of the crankshaft assembly. This tool must always be used, having been engineered as an approved method of assembly rotation, by engaging the manually driven pinion with the engine flywheel starter ring-gear.

UNDER NO CIRCUMSTANCES SHOULD A LEVER BE USED AGAINST THE FAN BLADES OR BAFFLE TO ROTATE THE GENERATOR ROTOR / ENGINE CRANKSHAFT ASSEMBLY.

> **Danger !** Before working inside the generator, during the aligning and fitting of coupling bolts, care should be taken to lock the assembly to ensure there is no possibility of assembly rotational movement.

4.2.1 TWO BEARING GENERATORS

A flexible coupling should be fitted and aligned in accordance with the coupling manufacturer's instruction.

If a close coupling adaptor is used the alignment of machined faces must be checked by offering the generator up to the engine. Shim the generator feet if necessary. Ensure adaptor guards are fitted after generator/engine assembly is complete. Open coupled sets require a suitable guard, to be provided by the set builder.

In the case of belt driven generators, ensure alignment of drive end and driven pulleys to avoid axial load on the bearings. Screw type tensioning devices are recommended to allow accurate adjustment of belt tension whilst maintaining pulley alignment.

Belt and pulley guards must be provided by the set builder.

Important ! Incorrect belt tensioning will result in excessive bearing wear.

> **Caution !** Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.

4.2.2 SINGLE BEARING GENERATORS

Alignment of single bearing generators is critical. If necessary shim the generator feet to ensure alignment of the machined surfaces.

For transit and storage purposes the generator frame spigot and rotor coupling plates have been coated with a rust preventative. This MUST BE removed before assembly to engine.

A practical method for removal of this coating is to clean the mating surface areas with a de-greasing agent based on a petroleum solvent.

Caution ! Care should be taken not to allow any cleaning agent to come into prolonged contact with skin.

For coupling to the various engine flywheel housings, the generators can be supplied with an endbracket-adaptor arrangement as outlined below.

EndBracket/Adaptor

SAE5
SAE4
SAE3
SAE2
SAE5 Plus SAE6 Adaptor Ring

Important ! **Drive end adaptors are designed for use with cap head screws. BC18 generators fitted with an SAE 5 drive end adaptor must also be fitted with a reduced diameter fan and must be operated at reduced output. Fan securing screws should be tightened to 0.59kgm (6Nm 4.4lb. ft.)**

The sequence of assembly to the engine should generally be as follows:

1. On the engine check the distance from the coupling mating face on the flywheel to the flywheel housing mating face. This should be within 0.5mm of nominal dimension. This is necessary to ensure that a thrust is not applied to the a.c. generator bearing or engine bearing.

2. Check that the bolts securing the coupling disc to the coupling hub are tight and locked into position. Torque tightening is 7.6kgm (75Nm; 55 lb ft).

3. Remove covers from the drive end of the generator to gain access to coupling disc and adaptor bolts.

4. Check that coupling disc is concentric with adaptor spigot. This can be adjusted by suspending the rotor by means of a rope sling through the adaptor opening.

5. Offer the a.c. generator to engine and engage both coupling disc and housing spigots at the same time, finally pulling home by using the housing and coupling bolts. Use heavy gauge washers between bolt head and discs on disc to flywheel bolts.

6. Tighten coupling disc to flywheel. Refer to engine manual for torque setting of disc to flywheel bolts.

Important ! **When fitting drive disc ensure that flywheel fixing bolt holes fall between fan blades to allow access for flywheel bolts. Use engine pulley to turn rotor.**

4.2.2.1 SINGLE BEARING 4-POLE & 2-POLE GENERATORS

Generators offered in the BCA range can be specified to suit different engine build configurations of specific flywheel and flywheel housing combinations.

Important ! **It is most important that the appropriate generator build is ordered with prior knowledge of the intended engine flywheel/ housing arrangement.**

Important ! **During assembly, loss of residual voltage may occur. Refer to subsection 7.4.3 for field flashing.**

GENERATOR TO ENGINE ASSEMBLY INSTRUCTIONS

1. Remove louvered cover "A" from non-drive endbracket "B"

2. Assemble locating bar "E" (Newage No AF1609) by screwing into shaft.

3. Remove transit bar "K".

4. Remove side screens "G".

5. If the adaptor ring is an individual item, as indicated "F", bolted to the generator D.E. bracket, remove from generator and fit to engine flywheel housing.

6. Thread two locating pins "H" into two top flywheel holes.

7. Fit two locating pins "J" into two top holes of the engine flywheel housing/adaptor location holes.

8. Pick up generator by the cast lifting lugs on both ends with 1/2 ton shackles (TO ES3032' or lifting hooks (Newage No.LE130) using suitable lifting equipment.

9. Rotate generator rotor such that two top holes of coupling disc are in close axial alignment.

10. Push the generator rotor forward only half (50mm) the available movement provided by locating bar "E". It may be necessary to tap bar "E" with a hide mallet to ease the bearing out of housing.

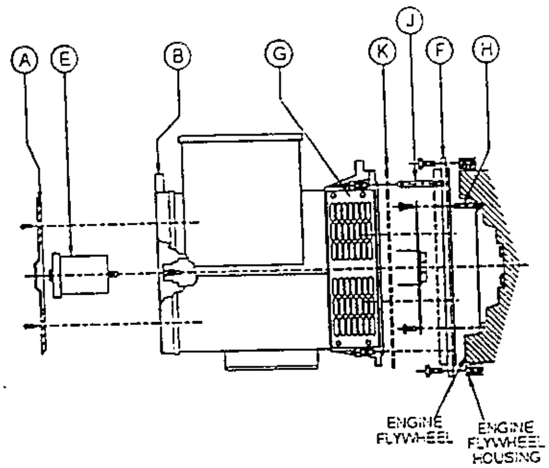
Important ! **Do not push the rotor forward too far. There is a risk that the rotor will rest on the stator winding outhang resulting in winding damage especially if any rotational movement occurs during alignment with pins "H".**

11. Support the weight of the rotor at the coupling end whilst sliding the rotor forward to locate coupling disc holes over support pins "H". Locating bar "E" will allow the rotor to move forward a further 50mm, the total movement bar "E" allows being 100mm. With coupling discs positioned against flywheel location fit securing screws and washers. Remove pins "H" and fit two final securing screws and washers

12. Push generator onto engine guiding adaptor over locating pins "J" and onto engine flywheel housing location, or ring "F", secure with screws and washers. Remove pins and replace with two screws and washers

13 Remove locating bar "E" Replace M10 screw "C" for barring purposes.

14 Remove lifting tackle and replace side screens "G" and louvered cover "A".



4.2.2.2 SINGLE BEARING 2-POLE GENERATOR TO ENGINE ASSEMBLY INSTRUCTIONS (WITH DOWELED FLYWHEELS)

1-5. Follow steps 1-5 from 4 pole instruction procedure.

6. Fit the two location dowels pins into appropriate diametrically opposite holes in engine flywheel, leaving sufficient parallel diameter exposed to allow for positive location of the disc-spacer-ring and coupling discs.

7. Fit the disc-spacer-ring over the two dowel pins and position firmly against the flywheel face.

8. Follow steps 6-8 from 4 pole instruction procedure.

9. Rotate generator rotor such that the two coupling disc dowel holes align with flywheel dowel pins, and two top holes of coupling discs are in close axial alignment with the two flywheel location pins "H".

10. Follow step 10 from 4 pole instruction procedure.

11. Support the weight of the rotor at the coupling end whilst sliding the rotor forward to locate coupling disc holes over support pins "H".

Important ! Ensure coupling disc dowel pin holes are in correct alignment.

With the coupling disc positioned against flywheel location fit securing screws and washers.

Remove pins "H" and fit two final securing screws and washers.

12. Follow steps 12-14 from 4 pole instruction procedure.

4.2.3 TAPER SHAFT ARRANGEMENTS

This arrangement is used on the BCL style generators.

As with single bearing generators alignment is critical. If necessary shim the generator feet to ensure alignment of the machined surfaces.

The following procedure should be adopted to assemble the generator to the engine:-

1. Remove louvred endcover "G" from non drive endbracket "H" and M10 Hex Nut "D" from shaft securing stud "AA"." Remove transit bar "E" and withdraw stub shaft/shaft securing stud "A/B" from rotor.

2. Ensure alternator, engine flywheel and flywheel housing locating spigots, faces and recesses are free from paint or preservatives.

3. Locate stub shaft/shaft securing stud assembly "A"/"B" on engine flywheel spigot and secure with studs "J", M12 hex. nut "L" or bolts. Refer to engine manual for torque settings. .

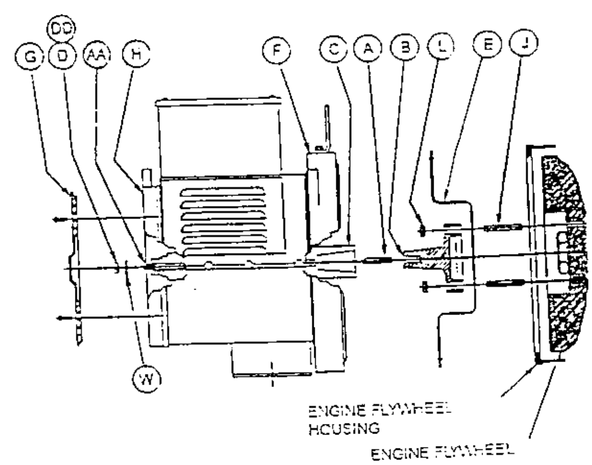
4. Ensure both tapers are clean and free of burrs, oil or grease. Slide alternator complete with rotor towards engine, ensuring that shaft securing stud "A" enters central hole in rotor shaft. Refer to engine manual for torque settings.

5. Secure alternator adaptor "F" to engine flywheel housing. Tap adaptor into place before tightening. Refer to engine manufacturer for torque setting.

6. Fit M10 Binx nut "DD" to protruding shaft securing stud "AA". M10 Binx nut tightening torque 45.0Nm (33.0 lbs.ft).

7. Fit louvred endcover "G" to non drive endbracket "H".

8. Check for excessive vibration at time of initial run-up.



Caution ! Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.

4.3 EARTHING

The generator frame should be solidly bonded to the generating set bedplate. If anti vibration mounts are fitted between the generator frame and its bedplate a suitably rated earth conductor (normally one half of the cross sectional area of the main line cables) should bridge across the anti vibration mount.

> **Warning !** **Refer to local regulations to ensure that the correct earthing procedure has been followed.**

4.4 PRE-RUNNING CHECKS

4.4.1 INSULATION CHECK

Before starting the generating set, both after completing assembly and after installation of the set, test the insulation resistance of windings.

The AVR should be disconnected during this test.

A 500V Megger or similar instrument should be used. Disconnect any earthing conductor connected between neutral and earth and megger an output lead terminal U, V or W to earth. The insulation resistance reading should be in excess of 5M to earth. Should the insulation resistance be less than 5M the winding must be dried out as detailed in the Service and Maintenance section of this Manual.

Important ! **The windings have been H.V. tested during manufacture and further H.V. testing may degrade the Insulation with consequent reduction in operating life. Should it be necessary to demonstrate H.V. testing, for customer acceptance, the tests must be carried out at reduced voltage levels i.e. Test Voltage= 0.8 (2 X Rated Voltage + 1000)**

4.4.2 DIRECTION OF ROTATION

All machines are fitted with a radial bladed fan and are suitable for running in either direction of rotation. The generator is supplied to give a phase sequence of U V W with the generator running clockwise looking at the drive end (unless otherwise specified at the time of ordering). If the generator phase rotation has to be reversed after the generator has been dispatched apply to factory for appropriate wiring diagrams.

4.4.3 VOLTAGE AND FREQUENCY

Check that the voltage and frequency levels required for the generating set application are as indicated on the generator nameplate.

Three phase generators normally have a 12 ends out reconnectable winding. If it is necessary to reconnect the stator for the voltage required, refer to diagrams in the back of this manual.

4.4.4 AVR INITIAL SETTINGS

To make AVR selections remove the AVR cover and refer to the following sections depending upon type of AVR fitted.

Reference to the generator nameplate will indicate AVR type.

AVR type SX460 - Refer to Section 4.4.4.1
AVR type SA465 - Refer to Section 4.4.4.2

Most of the AVR adjustments are factory set in positions which will give satisfactory performance during initial running test. Subsequent adjustment may be required to achieve optimum performance of the set under operating conditions. Refer to section 4.7 for details.

4.4.4.1 TYPE SX460 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 1 for location of selection links.

1. Frequency selection

50Hz operation	LINK C-50
60Hz operation	LINK C-60

2. External hand trimmer selection

No external hand trimmer	LINK 1-2
External hand trimmer required -	REMOVE LINK 1-2 and connect trimmer across terminals 1 and 2.

3. AVR Input Selection

High Voltage	(220/240V)	INPUT	No Link
Low Voltage	(110/120V)	INPUT	LINK 3-4

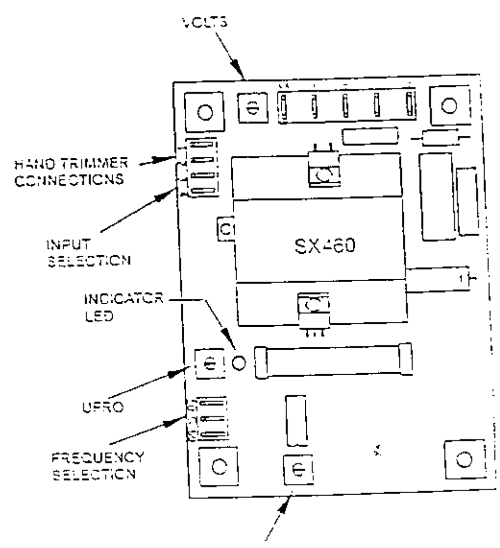


Fig. 1

4.4.4.2 TYPE SA465 AVR

The following switch and jumper connections on the AVR should be checked to ensure they are correctly set for the generating set application.
Refer to Fig. 2 for selector locations.

1. Frequency selection

50Hz operation	Set Switch SW1 to position 5
60Hz operation	Set Switch SW1 to position 6

2. External Hand Trimmer selection

No external hand trimmer	LINK 1-2
External hand trimmer required	REMOVE LINK 1-2 and connect trimmer across terminals 1 and 2.

3. AVR Input Selection

High Voltage	(220/240V)	INPUT	No Link
Low Voltage	(110/120V)	INPUT	LINK L-L

4. Stability selection

Set switch SW2 to position 4

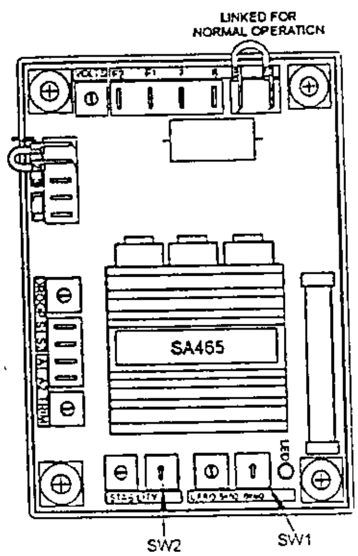


Fig. 2

4.4.5 TRANSFORMER CONTROLLED EXCITATION SYSTEM

This control system is identified by the word 'TRANSF' against AVR type on the nameplate.

The excitation control is factory set for the specific voltage shown on the nameplate and requires no adjustment.

4.5 GENERATOR SET TESTING

> **Warning!** During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments.

4.5.1 TEST METERING/CABLING

Connect any instrument wiring and cabling required for initial test purposes with permanent or spring-clip type connectors.

Minimum instrumentation for testing should be line - line or line to neutral voltmeter, Hz meter, load current metering and kW meter. If reactive load is used a power factor meter is desirable.

Important ! **When fitting power cables for load testing purposes, ensure cable voltage rating is at least equal to the generator rated voltage. The load cable termination should be placed on top of the winding lead termination and clamped with the nut provided.**

> **Caution !** Check that all wiring terminations for internal or external wiring are secure, and fit all terminal box covers and guards. Failure to secure wiring and/or covers may result in personal injury and/or equipment failure.

4.6 INITIAL START-UP

> **Warning !** During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.

On completion of generating set assembly and before starting the generating set ensure that all engine manufacturer's pre-running procedures have been completed, and that adjustment of the engine governor is such that the generator will not be subjected to speeds in excess of 125% of the rated speed.

Important ! **Overspeeding of the generator during initial setting of the speed governor can result in damage to the generator rotating components.**

In addition remove the AVR access cover (on AVR controlled generators) and turn VOLTS control fully anti-clockwise. Start the generating set and run on no-load at nominal frequency. Slowly turn VOLTS control potentiometer clockwise until rated voltage is reached. Refer to Fig. 1, 2 or 3 for control potentiometer location.

Important ! **Do not increase the voltage above the rated generator voltage shown on the generator nameplate.**

The STABILITY control potentiometer should be set to the midway position (refer to fig 1, 2 or 3 for its location) and with the stability selection correctly set should not normally require adjustment. Should adjustment be required, usually identified by oscillation of the voltmeter proceed as follows:-

On SA465 major adjustment of the stability can be made by selection on switch SW2.

Switch position 8 will give SLOW AVR response
Switch position 0 will give FAST AVR response

1. Run the generating set on no-load and check that speed is correct and stable.

2. Turn the STABILITY control potentiometer clockwise, then turn slowly anti-clockwise until the generator voltage starts to become unstable. The correct setting is slightly clockwise from this position (i.e. where the machine volts are stable but close to the unstable region).

4.7 LOAD TESTING

> **Warning !** During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.

4.7.1 AVR CONTROLLED GENERATORS - AVR ADJUSTMENTS

Refer to Fig. 1, 2 or 3 for control potentiometer locations.

Having adjusted VOLTS and STABILITY during the initial start-up procedure, the AVR control function UFRO should not normally need adjustment.

If however, poor voltage regulation on-load is experienced, refer to the following paragraph to a) check that the symptoms observed do indicate adjustment is necessary, and b) to make the adjustment correctly.

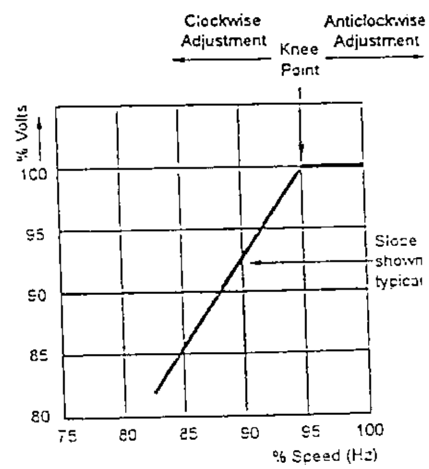
4.7.1.1 UFRO (Under Frequency Roll Off)

The AVR incorporates an underspeed protection circuit which gives a voltage/speed (Hz) characteristic as shown:

The UFRO control potentiometer sets the "knee point".

Symptoms of incorrect setting are a) the light emitting diode (LED) indicator, adjacent to the UFRO Control potentiometer, being permanently lit when the generator is on load, and b) poor voltage regulation on load, i.e. operation on the sloping part of the characteristic.

Clockwise adjustment lowers the frequency (speed) setting of the "knee point" and extinguishes the LED. For Optimum setting the LED should illuminate as the frequency falls just below nominal frequency, i.e. 47Hz on a 50Hz generator or 57Hz on a 60Hz generator.



4.7.2 TRANSFORMER CONTROLLED GENERATORS
TRANSFORMER ADJUSTMENT

Normally no adjustment is required but should the no-load voltage and/or on-load voltage be unacceptable, adjustment of the transformer air gap can be made as follows.

Stop the generator. Remove transformer cover box. (Normally left hand side of the terminal box when viewed from the non drive end).

Slacken the three transformer mounting bolts along the top of the transformer, and the two bolts holding the mounting bracket to the base plate.

Start the set with a voltmeter connected across the main output terminals.

Adjust the air gap between the transformer top lamination section and the transformer limbs to obtain required voltage on no-load. Slightly tighten the three mounting bolts. Switch load 'on' and 'off' two or three times. Application of load will normally raise the voltage setting slightly. With the load 'off' recheck the no-load voltage.

Readjust air gap and finally tighten mounting bolts.

Refit the access cover.

> **Failure to refit covers can result in operator personal injury or death.**
>
> **Warning !**

4.8 ACCESSORIES

Refer to the "ACCESSORIES" - Section 6 of this Manual for setting up procedures related to generator mounted accessories.

If there are accessories for control panel mounting supplied with the generator refer to the specific accessory fitting procedures inserted inside the back cover of this book.

SECTION 5

INSTALLATION - PART 2

5.1 GENERAL

The extent of site installation will depend upon the generating set build, e.g. if the generator is installed in a canopied set with integral switchboards and circuit breaker, on site installation will be limited to connecting up the site load to the generating set output terminals . In this case reference should be made to the generating set manufacturer's instruction book and any pertinent local regulations.

If the generator has been installed on a set without switchboard or circuit breaker the following points relating to connecting up the generator should be noted.

5.2 GLANDING

The terminal box will normally be supplied with the right hand side panel, viewed from the non drive end, available for cable exit. The side panel is removable for drilling/punching to suit glands or glanding boxes. Should the cable exit be required from the left hand side of the generator when viewed from the non drive end, the left and right hand panels may be interchanged. Sufficient length of wiring to the AVR has been provided for this purpose.

Incoming cables should be supported from either below or above the box level and at a sufficient distance from the centre line of the generating set so as to avoid a tight radius at the point of entry into the terminal box panel, and allow movement of the generator set on its anti-vibration mountings without excessive stress on the cable.

Before making final connections, test the insulation resistance of the windings. The AVR should be disconnected during this test.

A 500V Megger or similar instrument should be used. Should the insulation resistance be less than 5MW the windings must be dried out as detailed in the Service and Maintenance section of this manual.

When making connections to the terminals the incoming cable termination should be placed on top of the winding lead termination(s) and clamped with the nut provided.

Important ! To avoid the possibility of swarf entering any electrical components in the terminal box, panels must be removed for drilling.

5.3 EARTHING

The neutral of the generator is not bonded to the generator frame as supplied from the factory. An earth terminal is provided inside the terminal box adjacent to the main terminals. Should it be required to operate with the neutral earthed a substantial earth conductor (normally equivalent to one half of the section of the line conductors) must be connected between the neutral and the earth terminal inside the terminal box. A hole is provided on the generator foot which may be tapped to give an additional earthing point. The feet should be already bonded to the generating set bedplate by the generating set builder, but will normally be required to be connected to the site earth system

Caution ! Reference to local electricity regulations or safety rules should be made to ensure correct earthing procedures have been followed.

5.4 PROTECTION

It is the responsibility of the end user and his contractors/ sub-contractors to ensure that the overall system protection meets the needs of any inspectorate, local electricity authority or safety rules, pertaining to the site location.

To enable the system designer to achieve the necessary protection and/or discrimination, fault current curves are available on request from the factory, together with generator reactance values to enable fault current calculations to be made..

Warning ! Incorrect installation and/or protective systems can result in personal injury and/or equipment damage. Installers must be qualified to perform electrical installation work.

5.5 COMMISSIONING

Ensure that all external cabling is correct and that all the generating set manufacturer's pre-running checks have been carried out before starting the set.

The generator AVR controls will have been adjusted during the generating set manufacturer's tests and should normally not require further adjustment. Should adjustment on site be necessary refer to Section 4 for AVR details and/or Section 6 for paralleling adjustments.

Should malfunction occur during commissioning refer to Service and Maintenance section 'Fault Finding' procedure

SECTION 6

ACCESSORIES

Generator control accessories may be fitted, as an option, in the generator terminal box. If fitted at the time of supply, the wiring diagram(s) in the back of this book shows the connections. When the options are supplied separately, fitting instructions are provided with the accessory.

Accessories available are droop transformer for parallel operation applicable to generators with SA465 AVR, and remote voltage adjust (hand trimmer). The latter being available for all AVR types but not fitted on the generator.

NOTE:
None of the accessories can be fitted with a transformer controlled generator.

6.1 REMOTE VOLTAGE ADJUST (all AVR types).

A remote voltage adjust can be fitted to the control panel.

Remove link 1-2 on the AVR and connect adjuster to terminals 1 and 2.

6.2 PARALLEL OPERATION

Understanding of the following notes on parallel operation is useful before attempting the fitting or setting of the droop kit accessory. When operating in parallel with other generators or the mains, it is essential that the phase sequence of the incoming generator matches that of the busbar and also that all of the following conditions are met before the circuit breaker of the incoming generator is closed on to the busbar (or operational generator).

1. Frequency must match within close limits.
2. Voltages must match within close limits.
3. Phase angle of voltages must match within close limits.

A variety of techniques, varying from simple synchronising lamps to fully automatic synchronisers, can be used to ensure these conditions are met.

Important ! Failure to meet conditions 1, 2, and 3 when closing the circuit breaker, will generate excessive mechanical and electrical stresses, resulting in equipment damage.

Once connected in parallel a minimum instrumentation level per generator of voltmeter, ammeter, watt meter (measuring total power per generator), and frequency meter is required in order to adjust the engine and generator controls to share kW in relation to engine ratings and kVAr in relation to generator ratings.

It is important to recognise that

1. kW are derived from the engine, and speed governor characteristics determine the kW sharing between sets

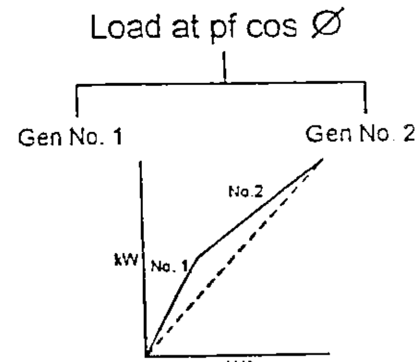
and

2. kVAr are derived from the generator, and excitation control characteristics determine the kVAr sharing. Reference should be made to the generating set manufacturers instructions for setting the governor controls.

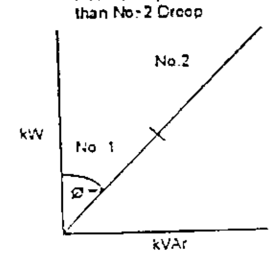
6.2.1 DROOP

The most commonly used method of kVAr sharing is to create a generator voltage characteristic which falls with decreasing power factor (increasing kVAr). This is achieved with a current transformer (C.T.) which provides a signal dependent on current phase angle (i.e. power factor) to the AVR. The current transformer has a burden resistor on the AVR board, and a percentage of the burden resistor voltage is summed into the AVR circuit. Increasing droop is obtained by turning the DROOP control potentiometer clockwise.

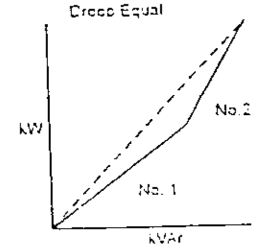
The diagrams below indicate the effect of droop in a simple two generator system:-



No. 1 Droop Greater than No. 2 Droop



No. 1 and No. 2 Droop Equal



No. 1 Droop less than No. 2 Droop

Generally 5% droop at full load current zero p.f. is sufficient to ensure kVAr sharing.

If the droop accessory has been supplied with the generator it will have been tested to ensure correct polarity and set to a nominal level of droop. The final level of droop will be set during generating set commissioning.

6.2.1.1 SETTING PROCEDURE

Depending upon available load the following settings should be used - all are based on rated current level.

0.8 P.F. LOAD (at full load current) SET DROOP TO 3%
0 P.F. LOAD (at full load current) SET DROOP TO 5%

Setting the droop with low power factor load is the most accurate.

Run each generator as a single unit at rated frequency or rated frequency + 4% depending upon type of governor and nominal voltage. Apply available load to rated current of the generator. Adjust 'DROOP' control potentiometer to give droop in line with above table. Clockwise rotation increases amount of droop. Refer to Fig 2, Fig 3, for potentiometer location. After adjustment check NO LOAD voltage level and adjust if necessary.

Note 1) Reverse polarity of the C.T. will raise the generator voltage with load. The polarities S1-S2 shown on the wiring diagrams are correct for clockwise rotation of the generator looking at the drive end. Reversed rotation requires S1-S2 to be reversed.

Note 2) The most important aspect is to set all generators equal. The precise level of droop is less critical.

Note 3) A generator operated as a single unit with a droop circuit set at rated load 0.8 power factor is unable to maintain the usual % regulation. A shorting switch can be connected across S1-S2 to restore regulation for single running.

Important ! **LOSS OF FUEL to an engine can cause its generator to motor with consequent damage to the generator windings. Reverse power relays should be fitted to trip main circuit breaker.**
LOSS OF EXCITATION to the generator can result in large current oscillations with consequent damage to generator windings. Excitation loss detection equipment should be fitted to trip main circuit breaker.

6.2.2 ASTATIC CONTROL

The 'droop' current transformer can be used in a connection arrangement which enables the normal regulation of the generator to be maintained when operating in parallel.

This feature is only supplied from the factory as a fitted droop kit, however, if requested at the time of order, the diagrams inside the back cover of this book will give the necessary site connections. The end user is required to provide a shorting switch for the droop current transformer secondary.

Should the generator be required to be converted from standard droop to 'astatic' control, diagrams are available on request.

The setting procedure is exactly the same as for DROOP. (Subsection 6.2.1.1).

Important ! **When using this connection arrangement a shorting switch is required across each C.T. burden (terminals S1 and S2).** The switch must be closed a) when a generating set is not running and b) when a generating set is selected for single running.

SECTION 7

SERVICE AND MAINTENANCE

Warning ! **Service and fault finding procedures present hazards which can result in severe personal injury or death. Only personnel qualified to perform electrical and mechanical service should carry out these procedures. Ensure engine starting circuits are disabled before commencing service or maintenance procedures. Isolate any anti-condensation heater supply.**

As part of routine maintenance procedures periodic attention to winding condition (particularly when generators have been idle for a long period) and bearings is recommended. Refer to subsections 7.1 and 7.2 respectively.

When generators are fitted with air filters regular inspection and filter maintenance is required. Refer to subsection 7.3.

7.1 WINDING CONDITION

The condition of the windings can be assessed by measurement of insulation resistance to earth.

The AVR should be disconnected during this test and the resistance temperature detector leads grounded. A 500V 'Megger' or similar instrument should be used.

The AVR should be disconnected during this test. A 500V 'Megger' or similar instrument should be used.

The insulation resistance to earth of all windings should be in excess of 1.0 MΩ.

Should the insulation resistances be less than these values, drying out of the generator windings is essential.

Drying out may be carried out by directing warm air from a fan heater or similar apparatus into the generator air inlets and/or outlets

Alternatively, the alternator main stator windings may be short circuited with a bolted 3 phase short at the main terminals and the generating set run with the AVR disconnected at terminals F1 and F2. A d.c. supply is connected to the leads F1 and F2 (F1 must be connected to the positive of the d.c. supply and F2 to the negative of the d.c. supply). The d.c. supply must be variable from 0 - 24 volts and capable of supplying 1.0 amp. An a.c. current clip-on ammeter or similar instrument is required to measure the winding lead current.

Set the d.c. supply voltage to zero. Start the generating set and slowly increase the d.c. voltage to pass current through the main stator winding. The current level should not exceed the rated current of the generator.

Normally - 1 hour is sufficient to dry out windings by this method.

Important ! The short circuit must not be applied with the AVR connected in circuit. Current in excess of the rated generator current will cause damage to the windings.

After drying out, the insulation resistances should be rechecked to verify minimum resistances quoted above are achieved.

On re-testing it is recommended that the main stator insulation resistance is checked as follows:-

Separate the neutral leads

Ground	V and W	phase and megger	U phase to ground
Ground	U and W	phase and megger	V phase to ground
Ground	U and V	phase and megger	W phase to ground

If the minimum value of 1.0MΩ is not obtained, drying out must be continued and the test repeated.

7.2 BEARINGS

All bearings are sealed for life and are not regreasable.

During major overhaul it is recommended that seals are checked for wear or loss of grease and replaced if necessary. Periodic checks for overheating or noise during the life of the bearing are recommended. If excessive vibration develops after a period of time, this may be due to bearing wear - the bearing should then be examined for damage or loss of grease and replaced if necessary. In any event the bearing should be replaced after 40000 hours in service.

Belt driven generator bearings are subjected to higher loadings than direct driven generators and bearings should be replaced after 25000 hours in service. It should be ensured that side loads do not exceed the levels quoted in SECTION 3 of this manual.

Important ! Bearing life is subject to working conditions and environment.

Important ! Long stationary periods in an environment where there is vibration can cause false brinnelling which puts flats on the ball and grooves on the races.
Very humid atmospheres or wet conditions can emulsify the grease causing corrosion.

Important ! High axial vibration from the engine or misalignment of the set will stress the bearing.

7.3 AIR FILTERS

Danger ! Removal of filter elements enables access to LIVE parts.
Only remove elements with the generator out of service.

The frequency of filter maintenance will depend upon the severity of the site conditions. Regular inspection of the elements will be required to establish when cleaning is necessary.

7.3 AIR FILTERS

Danger !	Removal of filter elements enables access to LIVE parts. Only remove elements with the generator out of service.

The frequency of filter maintenance will depend upon the severity of the site conditions. Regular inspection of the elements will be required to establish when cleaning is necessary.

7.3.1 CLEANING PROCEDURE

Remove the filter elements from the filter frames. Immerse or flush the element with a suitable degreasing agent until the element is clean.

Alternatively, after removing the filter elements a high pressure water hose with a flat nozzle can be used. Sweep the water spray back and forth across the element from the clean side (fine mesh side of element) hoding the nozzle firmly against the element surface. Cold water may be adequate depending upon type of contamination although hot water is preferable.

The element can be inspected for cleanliness by looking through the filter towards the light. When thoroughly clean, no cloudy areas will be seen.
Dry elements thoroughly before attempting to carry out the recharging procedure.

7.3.2 RECHARGING (Charging)

Charging is best done by totally immersing the dry element into a dip tank containing "Filterkote Type K" or commercial lubricating oil SAE 20/50. Oils of higher or lower viscosity are not recommended.

Allow elements to completely drain before refitting the elements into the frames and putting into service.

7.4 FAULT FINDING

Important ! Before commencing any fault finding procedures examine all wiring for broken or loose connections.

Three excitation control systems can be fitted to the range of generators covered by this manual, identified by the last digit of the generator frame size designation. Refer to the nameplate then proceed to the appropriate subsection as indicated below:-

SERIES	EXCITATION CONTROL	SUBSECTION
4	SA465 AVR	7.4.1
5	Transformer control	7.4.2
6	SX460 AVR	7.4.1

7.4.1 ALL AVR TYPES - FAULT FINDING

No voltage build-up when starting set	1. Check speed 2. Check residual voltage. - Refer to subsection 7.4.3. 3. Follow separate excitation test procedure to check generator and AVR. Refer to subsection 7.5.
Unstable voltage either on no-load or with load	1. Check speed stability. 2. Check stability setting. Refer to subsection 4.6.
High voltage either on no-load or with load	1. Check speed. 2. Check that generator load is not capacitive (leading power factor).
Low voltage no-load	1. Check speed. 2. Check link 1-2 or external hand trimmer leads for continuity.
Low voltage on-load	1. Check speed. 2. Check UFRO setting. Refer to subsection 4.7.1.1. 3. Follow separate excitation procedure to check generator and AVR. Refer to subsection 7.5.

7.4.2 TRANSFORMER CONTROL - FAULT FINDING

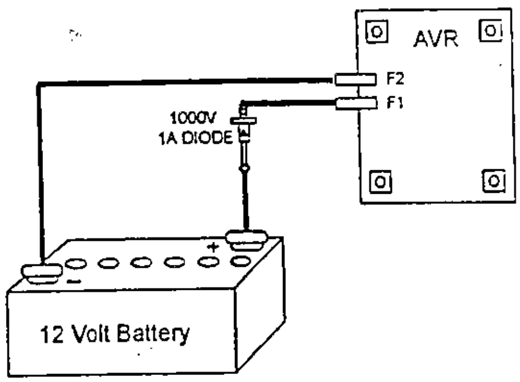
No voltage build-up when starting set	1. Check transformers rectifiers. 2. Check transformer secondary winding for open circuit.
Low voltage	1. Check speed. 2. Check transformer air gap setting. Refer to subsection 4.7.2.
High voltage	1. Check speed. 2. Check transformer air gap setting. Refer to subsection 4.7.2. 3. Check transformer secondary winding for short circuited turns.
Excessive voltage drop on-load	1. Check speed drop on-load. 2. Check transformer rectifiers. Check transformer air gap setting. Refer to subsection 4.7.2.

7.4.3 RESIDUAL VOLTAGE CHECK (Field Flashing)

This procedure applies to all generators fitted with AVR control. With the generator set stationary remove AVR access cover and leads F1 and F2 from the AVR.

Start the set and measure voltage across AVR terminals 7-8. A minimum level of 5 volts is required at these terminals. If the voltage is less than 5 volts stop the set,because it will be necessary to carry out the following Field Flashing procedure. Replace leads F1 and F2 on the AVR terminals. Using a 12 volt d.c. battery as a supply, clip leads from battery negative to AVR terminal F2, and from battery positive through a diode to AVR terminal F1. See Fig 5.

Important ! A diode must be used as shown below to ensure the AVR is not damaged.



Important ! If the generating set battery is used for field flashing, the generator main stator neutral must be diconnected from earth.

Restart the set and note output voltage from the main stator, which should be approximately nominal voltage, or voltage at AVR terminals 7 and 8 which should be between 170 and 250 volts.

Stop the set and unclip battery supply from terminals F1 and F2. Restart the set. The generator should now operate normally. If no voltage build-up is obtained it can be assumed a fault exists in either the generator or the AVR circuits. Follow the SEPARATE EXCITATION PROCEDURE to check generator windings, rotating diodes and AVR. Refer to subsection 7.5.

7.5 SEPARATE EXCITATION TEST PROCEDURE

The generator windings, diode assembly and AVR can be checked using this procedure.

1. With the generating set stationary remove AVR access cover and leads F1 and F2 from the AVR. On transformer controlled generators remove the terminal box lid for access and remove leads F1 and F2 from the control rectifier bridge.

2. Connect a 60W 240 volt household lamp (or two 120V lamps in series) to AVR terminals F1 and F2. (Only required for section 7.5.2.1). On transformer controlled generators refer to sub section 7.5.2.2 for transformer checks.

3. Connect a 0-12 volt, 1.0 Amp d.c. supply to leads F1 and F2. The positive of the d.c. supply is connected to the lead marked F1 and the negative to the lead marked F2.

The procedure is simplified by dividing into two sections:

7.5.1 GENERATOR WINDINGS AND ROTATING DIODES. and

7.5.2 EXCITATION CONTROL TEST.

7.5.1 GENERATOR WINDINGS AND ROTATING DIODES

Important! The resistances quoted apply to a standard winding. For generators having windings or voltages other than those specified refer to factory for details. Ensure all disconnected leads are isolated and free from earth.

This procedure is carried out with leads F1 and F2 disconnected at the AVR or transformer control rectifier bridge and using a 12 volt d.c. supply to leads F1 and F2.

Start the set and run at rated speed, on no-load.

Measure the voltages at the main output terminals U, V and W. These should be balanced and within 10% of the generator nominal voltage.

On generators fitted with an auxiliary winding in the main stator, applicable only with the SA665 AVR, the voltage at AVR terminals 8 and Z2 should be approximately 150 volts a.c.

7.5.1.1 BALANCED MAIN TERMINAL VOLTAGES

If all voltages are balanced within 1% at the main terminals, it can be assumed that all exciter windings, main windings and main rotating diodes are in good order, and the fault is in the AVR or transformer control. Refer to subsection 7.5.2 for test procedure.

If voltages are balanced but low, there is a fault in the main excitation windings or rotating diode assembly. Proceed as follows to identify:

Rectifier Diodes

The diodes on the main rectifier assembly can be checked with a multimeter. The flexible leads connected to each diode should be disconnected at the terminal end, and the forward and reverse resistance checked. A healthy diode will indicate a very high resistance (infinity) in the reverse direction, and a low resistance in the forward direction. A faulty diode will give a full deflection reading in both directions with the test meter on the 10,000 ohms scale, or an infinity reading in both directions.

Replacement of Faulty Diodes

The rectifier assembly is split into two plates, the positive and negative, and the main rotor is connected across these plates. Each plate carries 3 diodes, the negative plate carrying negative biased diodes and the positive plate carrying positive biased diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective plate. When fitting the diodes to the plates they must be tight enough to ensure a good mechanical and electrical contact, but should not be overtightened. The recommended torque tightening is 4.06 - 4.74Nm (36-42lb in).

Surge Suppressor

The surge suppressor is a metal-oxide varistor connected across the two rectifier plates to prevent high transient reverse voltages in the field winding from damaging the diodes. This device is not polarised and will show a virtually infinite reading in both directions with an ordinary resistance meter. If defective this will be visible by inspection, since it will normally fail to short circuit and show signs of disintegration. Replace if faulty.

Main Excitation Windings

If after establishing and correcting any fault on the rectifier assembly the output is still low when separately excited, then the main rotor, exciter stator and exciter rotor winding resistances should be checked (see Resistance Charts), as the fault must be in one of these windings. The exciter stator resistance is measured across leads F1 and F2. The exciter rotor is connected to six studs which also carry the diode lead terminals. The main rotor winding is connected across the two rectifier plates. The respective leads must be disconnected before taking the readings.

Resistance values should be within 10% of the values given in the table below:-

Frame Size	Main Rotor	Exciter Stator			Exciter Rotor
		Type 1	Type 2*	Type 3**	
BC164A	0.44	19	26	110	0.25
BC164B	0.48	19	26	110	0.25
BC164C	0.52	19	26	110	0.26
BC164D	0.56	19	26	110	0.26
BC184E	0.64	20	27	115	0.21
BC184F	0.74	22	30	127	0.23
BC184G	0.83	22	30	127	0.23
BC162D	0.81	18	-	-	0.26
BC162E	0.89	18	-	-	0.26
BC162F	0.95	18	-	-	0.26
BC162G	1.09	19	-	-	0.27
BC182H	1.17	20	-	-	0.21
BC182J	1.28	20	-	-	0.21
BC182K	1.4	20	-	-	0.21
BCA162L	1.55	20	-	-	0.21

* Used with 1 phase transformer controlled 3 phase or 1 phase generators

** Used with 3 phase transformer controlled 3 phase generators

Generators fitted with auxiliary stator windings.

Frame Size	Main Rotor	Exciter Stator	Exciter Rotor
BC184E	0.64	8	0.21
BC184F	0.74	8	0.23
BC184G	0.83	8	0.23

Incorrect resistances indicate faulty windings and component replacement is necessary. Refer to removal and replacement of component assemblies, subsection 7.5.3.

7.5.1.2 UNBALANCED MAIN TERMINAL VOLTAGES

If voltages are unbalanced, this indicates a fault on the main stator winding or main cables to the circuit breaker. NOTE. Faults on the stator winding or cables may also cause noticeable load increase on the engine when excitation is applied. Disconnect the main cables and separate the winding leads U1-U2, U5-U6, V1-V2, V5-V6, W1-W2, W5-W6 to isolate each winding section.

Measure each section resistance - values should be balanced and within 10% of the value given below:-

AVR CONTROLLED GENERATORS			
Frame Size	SECTION RESISTANCES		
	Winding 311	Winding 05	Winding 06
BC164A	0.81	0.41	0.31
BC164B	0.51	0.30	0.19
BC164C	0.36	0.21	0.13
BC164D	0.3	0.32	0.21
BC184E	0.20	0.20	0.13
BC184F	0.13	0.14	0.09
BC184G	0.11	0.11	0.07
BC162D	0.68	0.30	0.25
BC162E	0.42	0.21	0.15
BC162F	0.31	0.17	0.11
BC162G	0.21	0.10	0.095
BC182H	0.16	0.075	0.055
BC182J	0.13	0.06	0.042
BC182K	0.10	0.047	0.030
BCA162L	0.65	0.03	0.02

Generators fitted with auxiliary stator windings.

AVR CONTROLLED GENERATORS		
Frame Size	AVR CONTROLLED GENERATORS	
	Main Stator * Winding 311	Auxiliary
BC184E	0.19	1.88
BC184F	0.13	1.44
BC184G	0.1	1.32

TRANSFORMER CONTROLLED GENERATORS SECTION RESISTANCES							
Frame Size	3 Phase Windings					1 Phase Windings	
	380V	400V	415V	416V	460V	240V	240V
BC164A	2.4	2.56	2.62	1.98	2.36	0.37	0.25
BC164B	1.68	1.75	1.81	1.36	1.7	0.26	0.17
BC164C	1.16	1.19	1.21	0.91	1.16	0.17	0.12
BC164D	0.83	0.84	0.87	0.74	0.93	0.28	0.22
BC184E	0.59	0.60	0.63	0.48	0.61	0.16	0.12
BC184F	0.41	0.43	0.45	0.35	0.43	0.15	0.08
BC184G	0.33	0.34	0.36	0.26	0.33	0.09	0.07

Measure insulation resistance between sections and each section to earth.

Unbalanced or incorrect winding resistances and/or low insulation resistances to earth indicate rewinding of the stator will be necessary. Refer to removal and replacement of component assemblies subsection 7.5.3.

7.5.2 EXCITATION CONTROL TEST

7.5.2.1 AVR FUNCTION TEST

All types of AVR'S can be tested with this procedure:

1. Remove exciter field leads X &XX (F1 & F2) from the AVR terminals X & XX (F1 & F2).
2. Connect a 60W 240V household lamp to AVR terminals X & XX (F1 & F2).
3. Set the AVR VOLTS control potentiometer fully clockwise.
4. Connect a 12V, 1.0A DC supply to the exciter field leads X & XX (F1 & F2) with (F1) to the positive.
5. Start the generating set and run at rated speed.
6. Check that the generator output voltage is within +/- 10% of rated voltage.

Voltages at AVR terminals 7-8 on SX460 AVR or P2-P3 on SX421 AVR SHOULD BE BETWEEN 170 AND 250 VOLTS. If the generator output voltage is correct but the voltage on 7-8 (or P2-P3) is low, check auxiliary leads and connections to main terminals.

The lamp connected across X-XX should glow. In the case of the SX460 and SA465 AVRs the lamp should glow continuously. Failure to turn off indicates faulty protection circuit and the AVR should be replaced. Turning the "VOLTS" control potentiometer fully anti-clockwise should turn off the lamp with all AVR types.

Should the lamp fail to light the AVR is faulty and must be replaced.

Important ! After this test turn the VOLTS control potentiometer fully anti-clockwise.

7.5.2.2 TRANSFORMER CONTROL

The transformer rectifier unit can only be checked by continuity, resistance checks and insulation resistance measurement.

Rectifier Diodes

Separate primary leads T1-T2-T3-T4 and secondary leads 10-11. Examine windings for damage. Measure resistances across T1-T2 and T3-T4. These will be a low value but should be balanced. Check that there is resistance in the order of 5 ohms between leads 10 and 11. Check insulation resistance of each winding section to earth and to other winding sections.

Low insulation resistance, unbalanced primary resistance, open or short circuited winding sections, indicates the transformer unit should be replaced.

Three phase transformer

Separate primary leads T1-T2-T3 and secondary leads 6-7-8 and 10-11-12.

Examine windings for damage. Measure resistances across T1-T2, T2-T3, T3-T1. These will be low but should be balanced. Check that resistances are balanced across 6-10, 7-11 and 8-12 and in the order of 8 ohms.

Check insulation resistance of each winding section to earth and to other winding sections.

Low insulation resistance, unbalanced primary or secondary winding resistances, open or short circuited winding sections indicates the transformer unit should be replaced.

Rectifier units - Three phase and single phase

With the leads 10-11-12-F1 and F2 removed from the rectifier unit (lead 12 is not fitted on single phase transformer rectifier units), check forward and reverse resistances between terminals 10-F1, 11-F1, 12-F1, 10-F2, 11-F2 and 12-F2 with a multimeter.

A low forward resistance and high reverse resistance should be read between each pair of terminals. If this is not the case the unit is faulty and should be replaced.

7.5.3 REMOVAL AND REPLACEMENT OF COMPONENT ASSEMBLIES

Important ! The following procedures assume that the generator has been removed from the generating set.
On single bearing generators before removal from the engine, position the rotor such that a full pole face is at bottom dead centre. Use engine pulley to turn rotor.
Metric threads are used throughout.

Caution !	**When lifting single bearing generators, care is needed to ensure the generator frame is kept in the horizontal plane. The rotor is free to move in the frame and can slide out if not correctly lifted. Incorrect lifting can cause serious personal injury.**

7.5.3.1 REMOVAL OF BEARINGS

Important ! Position the main rotor so that a full pole face of the main rotor core is at the bottom of the stator bore.

Removal of bearings may be effected either after the rotor assembly has been removed or simply by removal of endbracket(s).

Refer to main rotor assembly section 7.5.3.2.

The bearings are pre-packed with grease and sealed for life.

1. The bearing(s) are a press fit on the shaft and can be removed with standard tooling, i.e. 2 or 3 legged manual or hydraulic bearing pullers.
2. Remove circlip from shaft at non drive end (only fitted on single bearing machines).

When fitting new bearings use a bearing heater to expand the bearing before fitting to the shaft. Tap the bearing into place ensuring that it contacts the shoulder on the shaft.

Refit the retaining circlip on single bearing generators.

7.5.3.2 MAIN ROTOR ASSEMBLY

Single Bearing Generator

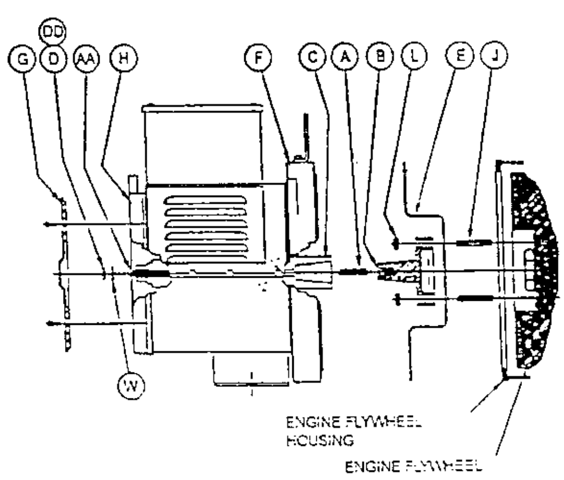
1. Remove four screws securing louvred cover at non drive end and remove cover.
2. Remove the screws and covers on each side of adaptor.
3. Ensure that rotor is supported at D.E. on a sling.
4. Tap the rotor from non-drive end bearing housing to push the bearing clear of the endbracket and its retaining 'O' ring.
5. Continue to push rotor through stator bore, gradually moving sling along rotor as it is withdrawn, to ensure full support at all times.

Important ! When re-assembing position the rotor such that full pole face is at bottom dead centre.

Two Bearing Generator

1. Remove eight bolts securing the close coupling adaptor to the drive endbracket.
2. Tap off adaptor after supporting weight with sling.
3. Remove the screens and louvres (if fitted) on either side of drive end adaptor. Turn rotor until a full pole face is at bottom dead centre.
4. Remove eight cap head screws securing the drive end bracket to the drive end adaptor.
5. Tap off drive end bracket from drive end adaptor.
6. Support rotor at drive end with a sling.
7. Remove four screws securing louvred cover at non-drive end and remove cover.
8. Tap the rotor from non-drive end bearing housing to push the bearing clear of the endbracket and its retaining 'O' ring.
9. Continue to push rotor through stator bore, gradually moving sling along rotor, as it is withdrawn, to ensure full support at all times.

Tapered Shaft Generator (BCL)



1. Remove louvred endcover 'G' from non drive endbracket 'H'.
2. Remove M10 "BINX" self locking nut "DD".
3. The shaft securing stud "AA" has been treated with a thread locking agent before being screwed into the stub shaft "B".

   This may make removal of shaft securing stud "AA" difficult.
4. If the shaft securing stud "AA" <u>can</u> be removed follow steps 5 to 12 to remove generator from engine.

   If the shaft securing stud "AA" <u>cannot</u> be removed follow steps 13 to 18 to remove complete generator from engine.
5. Locate a steel rectangular bar (or similar), with a central 15mm. hole, flush with rear vertical face of non-drive endbracket 'H'. Ensure that hole is aligned with tapped hole in shaft end.
6. Insert M14 X 25 hex. bolt through bar hole and screw into shaft end.

   The rotor will be drawn towards non-drive end thus releasing contact with engine taper stub shaft.
7. Remove M14 X 25 hed. hd. bolt.
8. Remove 10 bolts securing adaptor to engine.
9. Withdraw generator from engine.
10. Ensure rotor is supported at D.E. on a sling.
11. Tap the rotor from non-drive end bearing housing to push the bearing clear of the endbracket and a retaining 'O' ring.
12. Continue to push rotor through stator bore, gradually moving sling along rotor as it is withdrawn, to ensure full support at all times.
13. If it has not been possible to remove the shaft securing stud the following procedure is necessary.
14. Remove the 10 bolts securing adaptor to engine.
15. Using a hide mallet tap the sides of the non drive end bracket in order to release the generator adaptor from engine fly wheel housing spigot.

    Sometimes it is possible that the action of taping the sides of the non drive end bracket with the hide mallet will in fact free the taper-lock of the rotor shaft to stub shaft.
16. If stator frame assembly is freed from the engine flywheel housing, yet the rotor is still firmly fixed to the stub shaft the stator frame assembly should be supported by a crane and carefully pulled back over the rotor assembly, taking care not to damage any winding outhangs.
17. With the rotor now exposed it will be possible to apply a sharp blow to the rotor pole face with a hide mallet to shock the rotor free of the taper stub shaft.

    It may be necessary to apply the sharp blow to more than just one rotor pole.

    To ensure the rotor when released cannot fall and do damage, the M10 binx nut should be re-fitted finger tight to the shaft securing stud leaving at least some 2 mm clearance between nut and rotor shaft end face.

18. With the "Taper Lock" now broken the rotor can be removed from the stub-shaft, once the binx nut has been removed.

Care should be taken to ensure the rotor weight can be supported during removal in a manner which ensures no damage will occur to the rotor assembly.

Replacement of rotor assemblies is a reversal of the procedures above.

7.5.3.3 RE-ASSEMBLY OF GENERATOR ENGINE

Before commencing re-assembly, components should be checked for damage and bearing(s) examined for loss of grease.

Fitting of new bearing(s) is recommended during major overhaul.

Before re-assembling to the engine drive shafts and couplings or drive disc shold be checked for damage or wear.

Where fitted the drive disc should be examined for cracks, signs of fatigue or elongation of fixing holes.

Ensure that the disc to shaft end fixing bolts are fitted with the pressure plate and are torque tightened to 7.6Kgm (75Nm 55lbs.ft).
Taper shaft drive end arrangements should be checked for damage to the taper on both shaft and coupling hub. Ensure both tapers are free from oil before refitting.

Refer to 4.2.3. for assembly to engine.

NOTE:
The M10 "BINX" nut should always be renewed. Tightening torque 4.6Kgm; (45Nm; 33lbs.ft.)

Damaged or worn components must be replaced.

7.6 RETURNING TO SERVICE

After rectification of any faults found, remove all test connections and reconnect all control system leads.

Restart the set and adjust VOLTS control potentiometer on AVR by slowly turning clockwise until rated voltage is obtained.

Refit all terminal box covers/access covers and reconnect heater supply.

Caution !	Failure to refit all guards, access covers and terminal box covers can result in personal injury or death.

SECTION 8

SPARES AND AFTER SALES SERVICE

8.1 RECOMMENDED SPARES

Service parts are conveniently packaged for easy identification. Genuine parts may be recognised by the Nupart name.

We recommend the following for Service and Maintenance. In critical applications a set of these service spares should be held with the generator.

8.1.1 AVR CONTROLLED GENERATORS

1.	Diode Set (6 diodes with surge suppressor)	RSK	1101
2.	SA465 AVR	E000	24650
	SX460 AVR	E000	24602
3.	Non drive end Bearing	051	01058
4.	BC16 & BC18 Drive end Bearing	051	01032

8.1.2 TRANSFORMER CONTROLLED GENERATORS

1.	Diode Set (6 diodes with surge suppressor)	RSK	1101
2.	Diode Assembly	E000	22006
3.	Non drive end Bearing	051	01058
4.	BC16 & BC18 Drive end Bearing	051	01032

When ordering parts the machine serial number or machine identity number and type should be quoted, together with the part description. For location of these numbers see paragraph 1.4.

Orders and enquiries for parts should be addressed to:

Newage International Limited
Nupart Department
PO Box 17, Barnack Road
STAMFORD
Lincolnshire
PE9 2NB
ENGLAND

Telephone: 44 (0) 1780 484000
Fax: 44 (0) 1780 766074

Or any of our subsidiary companies listed on the back cover.

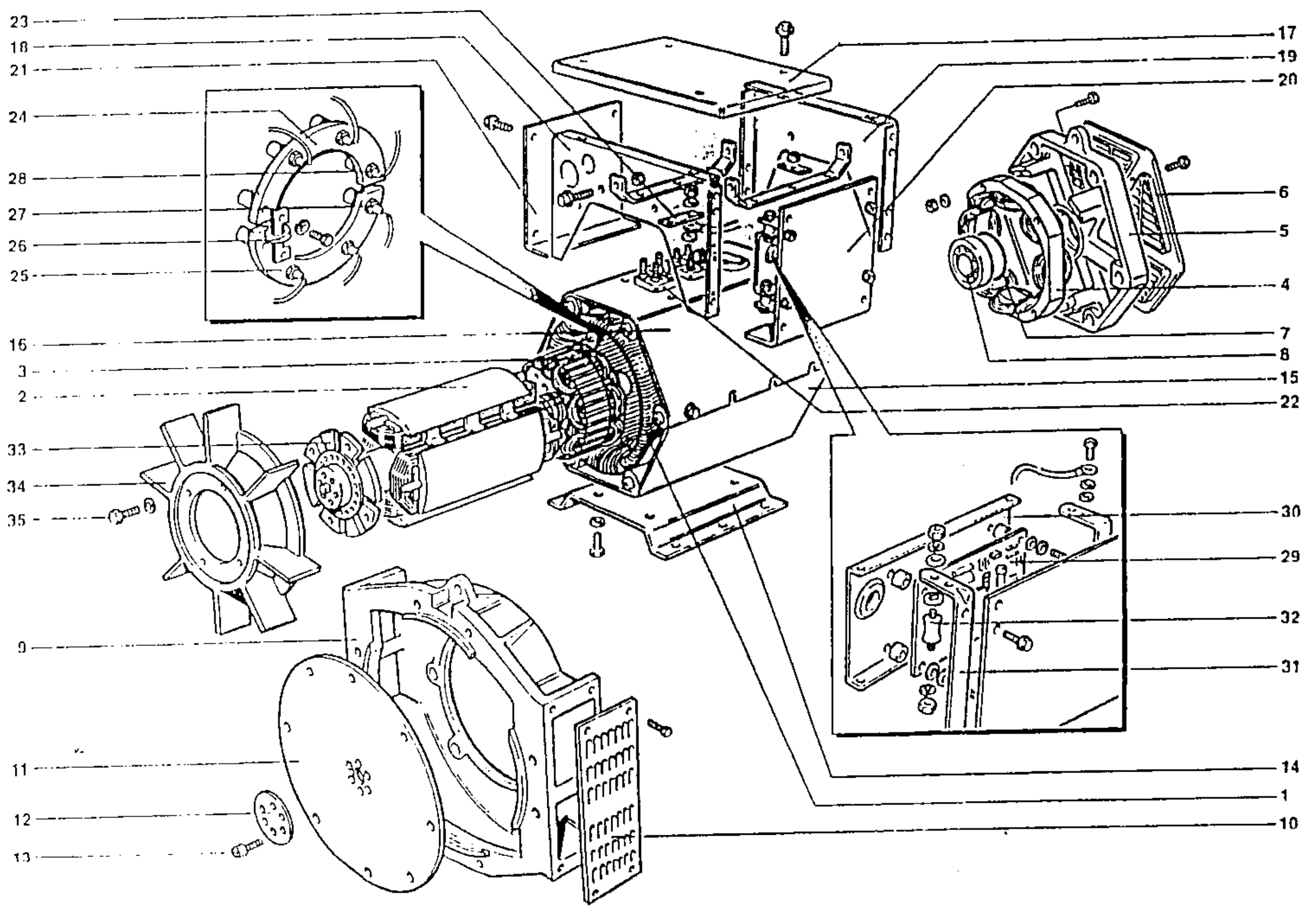
8.1.3 ASSEMBLY TOOLS

Locating Bar (Single Bearing)	AF1609.
8mm Rachet Box Wrench (for M10 socket screws)	AF1599.

8.2 AFTER SALES SERVICE

A full technical advice and on-site service facility is available from our Service Department at Stamford or through our Subsidiary Companies. A repair facility is also available at our Stamford Works.

Fig. 6
TYPICAL SINGLE BEARING GENERATOR

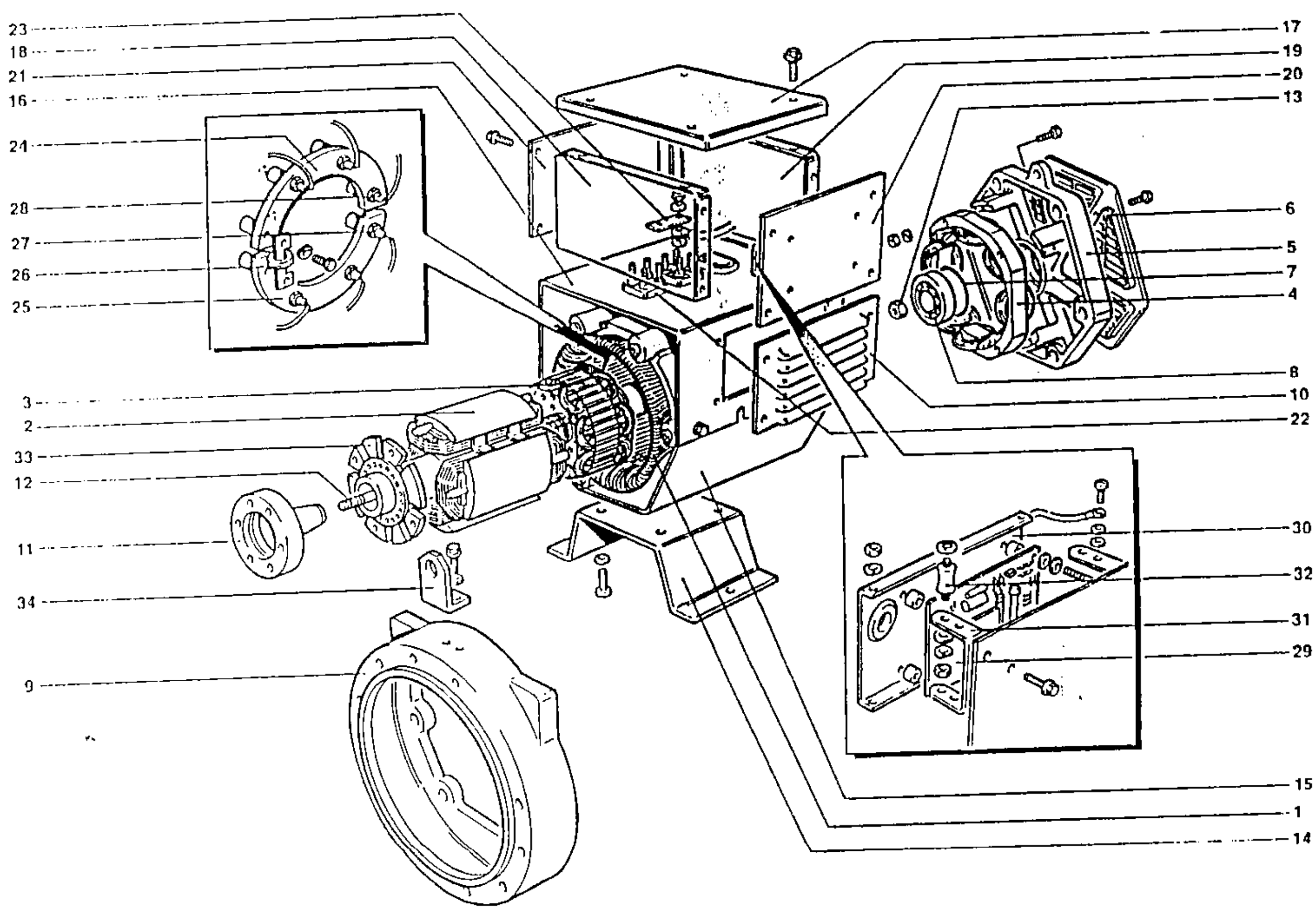


PARTS LIST
TYPICAL SINGLE BEARING GENERATOR

Plate Ref.	Description	Plate Ref.	Description
1	Stator	25	Main Rectifier Assembly - Reverse
2	Rotor	26	Varistor
3	Exciter Rotor	27	Diode Reverse Polarity
4	Exciter Stator	28	Diode Forward Polarity
5	N.D.E. Endbracket	29	AVR
6	Cover N.D.E.	30	AVR Mounting Plate
7	Bearing 'O' Ring N.D.E.	31	AVR Mounting Bracket
8	Bearing N.D.E.	32	AVM
9	D.E. Adaptor	33	Fan Hub
10	D.E. Screen	34	Fan
11	Coupling Hub	35	Fan Securing Screw
12	Pressure Plate		
13	Coupling Bolt		
14	Foot		
15	Frame Cover Bottom		
16	Frame Cover Top		
17	Terminal Box Lid		
18	Endpanel D.E.		
19	Endpanel N.D.E.		
20	Side Panel (AVR)		
21	Side Panel		
22	Main Terminal Panel		
23	Terminal Link		
24	Main Rectifier Assembly - Forward		

N.D.E. Non Drive End
D.E. Drive End
AVR Automatic Voltage Regulator
AVM Anti-Vibration Mount

Fig. 7.
TYPICAL SINGLE BEARING GENERATOR - TAPER SHAFT ARRANGEMENT (BCL)

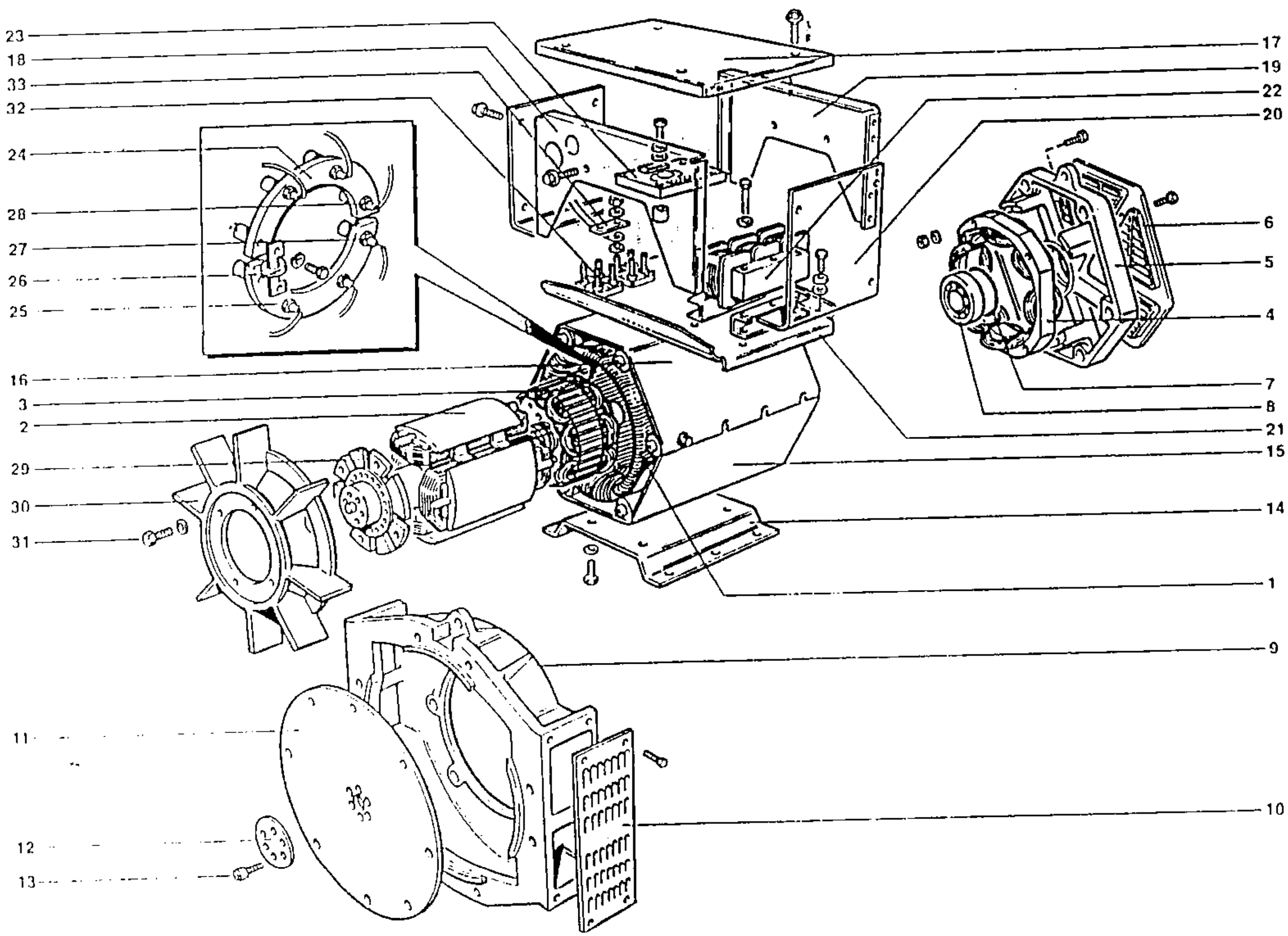


PARTS LIST
TYPICAL SINGLE BEARING GENERATOR - TAPER SHAFT ARRANGEMENT (BCL)

Plate Ref.	Description	Plate Ref.	Description
1	Stator	25	Main Rectifier Assembly - Reverse
2	Rotor	26	Varistor
3	Exciter Rotor	27	Diode Reverse Polarity
4	Exciter Stator	28	Diode Forward Polarity
5	N.D.E. Endbracket	29	AVR
6	Cover N.D.E.	30	AVR Mounting Plate
7	Bearing 'O' Ring N.D.E.	31	AVR Mounting Bracket
8	Bearing N.D.E.	32	AVM
9	D.E. Adaptor	33	Fan Hub (For Balancing Purposes Only)
10	Air Intake Side Panel	34	Lifting Lug
11	Coupling Hub		
12	Rotor Shaft Stud		
13	Binx Nut		
14	Foot		
15	Frame Cover Bottom		
16	Frame Cover Top		
17	Terminal Box Lid		
18	Endpanel D.E.		
19	Endpanel N.D.E.		
20	Side Panel (AVR)		
21	Side Panel		
22	Main Terminal Panel		
23	Terminal Link		
24	Main Rectifier Assembly - Forward		

N.D.E. Non Drive End
L.A. Drive End
PMG Permanent Magnet Generator
AVR Automatic Voltage Regulator

Fig. 8.
TYPICAL SINGLE BEARING (SERIES 5) TRANSFORMER CONTROLLED GENERATOR

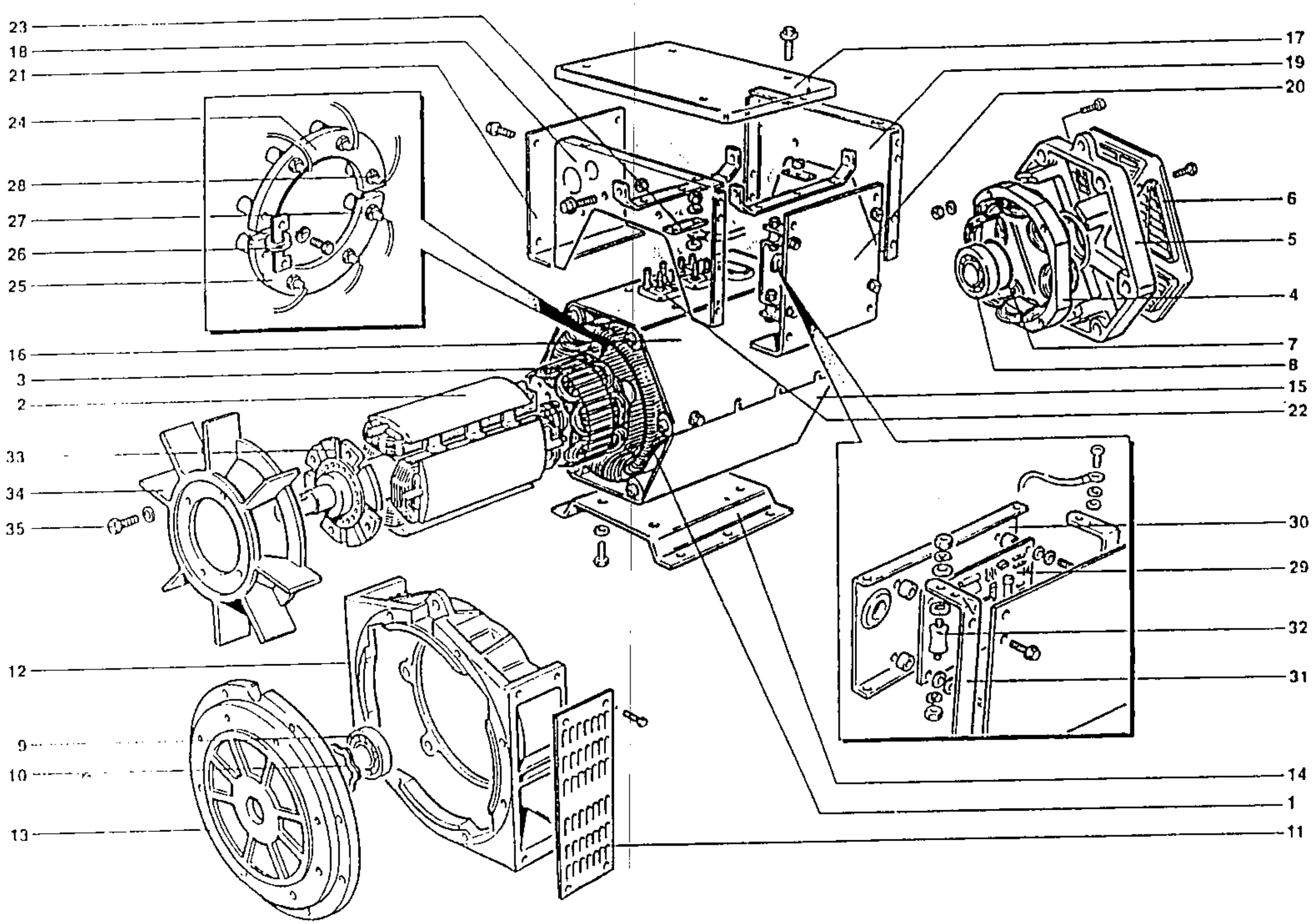


PARTS LIST
TYPICAL SINGLE BEARING (SERIES 5) TRANSFORMER CONTROLLED GENERATOR

Plate Ref.	Description	Plate Ref.	Description
1	Stator	25	Main Rectifier Assembly - Reverse
2	Rotor	26	Varistor
3	Exciter Rotor	27	Diode Reverse Polarity
4	Exciter Stator	28	Diode Forward Polarity
5	N.D.E. Endbracket	29	Fan Hub
6	Cover N.D.E.	30	Fan
7	Bearing 'O' Ring N.D.E.	31	Fan Securing Screw
8	Bearing N.D.E.	32	Main Terminal Panel
9	D.E. Adaptor	33	Terminal Link
10	D.E. Screen		
11	Coupling Disc		
12	Pressure Plate		
13	Coupling Bolt		
14	Foot		
15	Frame Cover Bottom		
16	Frame Cover Top		
17	Terminal Box Lid		
18	Endpanel D.E.		
19	Endpanel N.D.E.		
20	Side Panel		
21	Mounting Plate (Series 5)		
22	Transformer Control Assembly (Series 5)		
23	Control Rectifier Assembly		
24	Main Rectifier Assembly - Forward		

N.D.E. Non Drive End
D.E. Drive End

Fig. 9.
TYPICAL TWO BEARING GENERATOR



PARTS LIST
TYPICAL TWO BEARING GENERATOR

Plate Ref.	Description	Plate Ref.	Description
1	Stator	25	Main Rectifier Assembly - Reverse
2	Rotor	26	Varistor
3	Exciter Rotor	27	Diode Reverse Polarity
4	Exciter Stator	28	Diode Forward Polarity
5	N.D.E. Endbracket	29	AVR
6	Cover N.D.E.	30	AVR Mounting Plate
7	Bearing 'O' Ring N.D.E.	31	AVR Mounting Bracket
8	Bearing N.D.E.	32	AVM
9	Bearing D.E.	33	Fan Hub
10	Bearing Wave Washer D.E.	34	Fan
11	D.E. Screen	35	Fan Securing Screw
12	D.E. Adaptor		
13	D.E. Endbracket		
14	Foot		
15	Frame Cover Bottom		
16	Frame Cover Top		
17	Terminal Box Lid		
18	Endpanel D.E.		
19	Endpanel N.D.E.		
20	Side Panel (AVR)		
21	Side Panel		
22	Main Terminal Panel		
23	Terminal Link		
24	Main Rectifier Assembly - Forward		

N.D.E. Non Drive End
D.E. Drive End
AVR Automatic Voltage Regulator
AVM Anti-Vibration Mount

Fig. 10.
ROTATING RECTIFIER ASSEMBLY

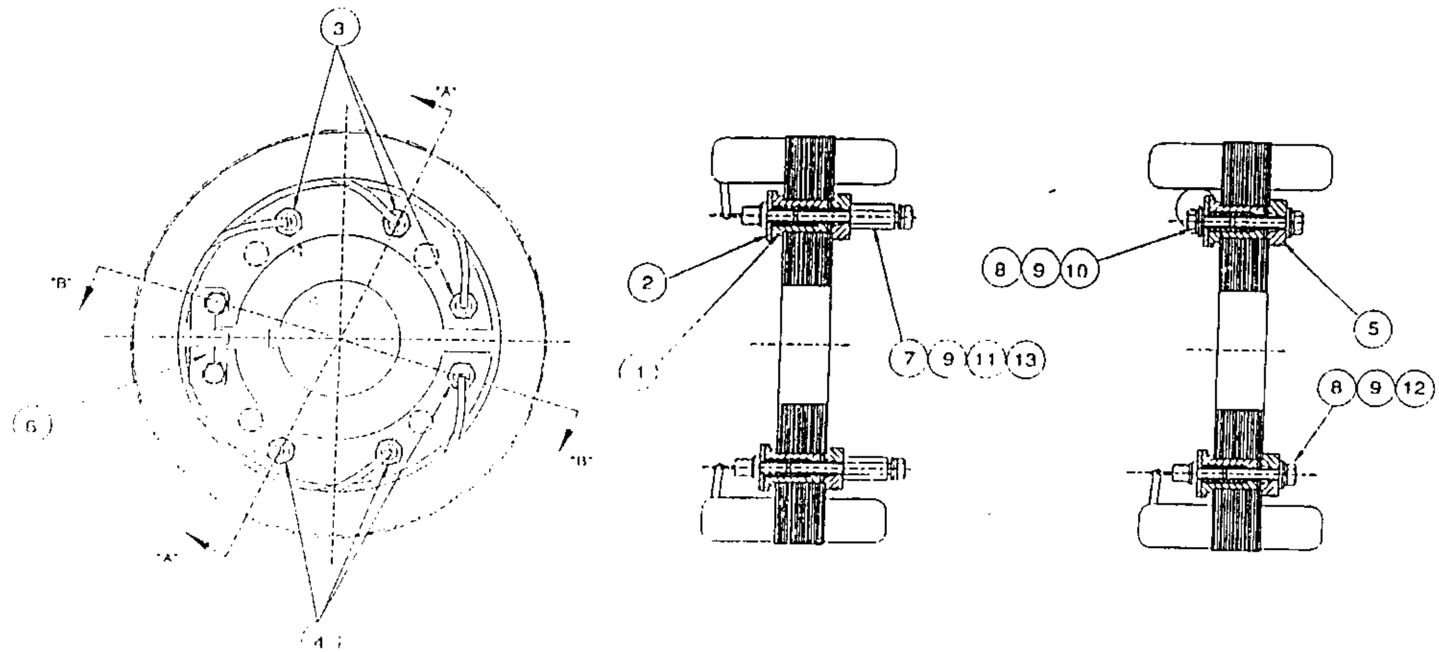


Plate Ref.	Description	Quantity
1	Diode Hub	2
2	Rectifier Fin	2
3	Forward Diode	3
4	Reverse Diode	3
5	Insulating Washer	4
6	Varistor	1
7	M5 Plain Washer	2
8	M5 Plain Washer (Large)	6
9	M5 Lockwasher	6
10	Tornillo hex.	2
11	No. 10 UNF Brass Screw	2
12	No. 10 UNF Brass Screw	2
13	Spacer	2

NOTE:
Underside of diodes to be smeared with Midland Silicons Heat Sink compund type MS2623 Newage Code No 030-02318. This compound must not be applied to diode thread.

'Diodes to be tightened to a torque load of 2.03\2.37Nm.

Strip insulation for 10mm from end of cable. If conductor is un-tinned this section should be tinned before threading through hole in diode tag solder in accordance with DD15500.

SX460 AUTOMATIC VOLTAGE REGULATOR (AVR)

SPECIFICATION, INSTALLATION AND ADJUSTMENTS

GENERAL DESCRIPTION

The SX460 is a half-wave phase-controlled thyristor type Automatic Voltage Regulator (AVR) and forms part of the excitation system for a brushless generator.

In addition to regulating the generator voltage, the AVR circuitry includes underspeed and sensing loss protection to ensure safe, reliable control of the generator. Excitation power is derived directly from the generator terminals.

Positive voltage build up from residual levels is ensured by the use of efficient semiconductors in the power circuitry of the AVR.

The AVR is linked with the main stator windings and the exciter field windings to provide closed loop control of the output voltage with load regulation of +/- 1.5%.

In addition to being powered from the main stator, the AVR also derives a sample voltage from the output windings for voltage control purposes. In response to this sample voltage, the AVR controls the power fed to the exciter field, and hence the main field, to maintain the machine output voltage within the specified limits, compensating for load, speed, temperature and power factor of the generator.

A frequency measuring circuit continually monitors the generator output and provides output underspeed protection of the excitation system, by reducing the output voltage proportionally with speed below a presettable threshold. A manual adjustment is provided for factory setting of the under frequency roll off point, (UFRO). This can easily be changed to 50 or 60 Hz in the field by push-on wire link selection.

Provision is made for the connection of a remote voltage trimmer, allowing the user fine control of the generator's output.

TECHNICAL SPECIFICATION

INPUT

Voltage	85-125 V ac 170-250 V ac	Jumper Selectable
Frequency	50-60 Hz nominal	
Phase	1	

OUTPUT

Voltage	max 90 V dc at 207 V ac input
Current	Continuous 4 A dc Transient 6 A for 10 seconds
Field Resistance	15 Ω minimum

REGULATION (See Note 1) +/- 1.5%

THERMAL DRIFT

(after 10 min)
1% for 40°C change in AVR ambient

TYPICAL SYSTEM RESPONSE

Field current to 90%	80ms
Machine Volts to 97%	300ms

EXTERNAL VOLTAGE ADJUSTMENT

+/- 5% with 1 K Ω trimmer

UNDER FREQUENCY PROTECTION

Set Point (See Note 2)	95% Hz
Slope	170% down to 30 Hz

UNIT POWER DISSIPATION

10 watts maximum

BUILD UP VOLTAGE

3.5 V ac @ AVR terminals

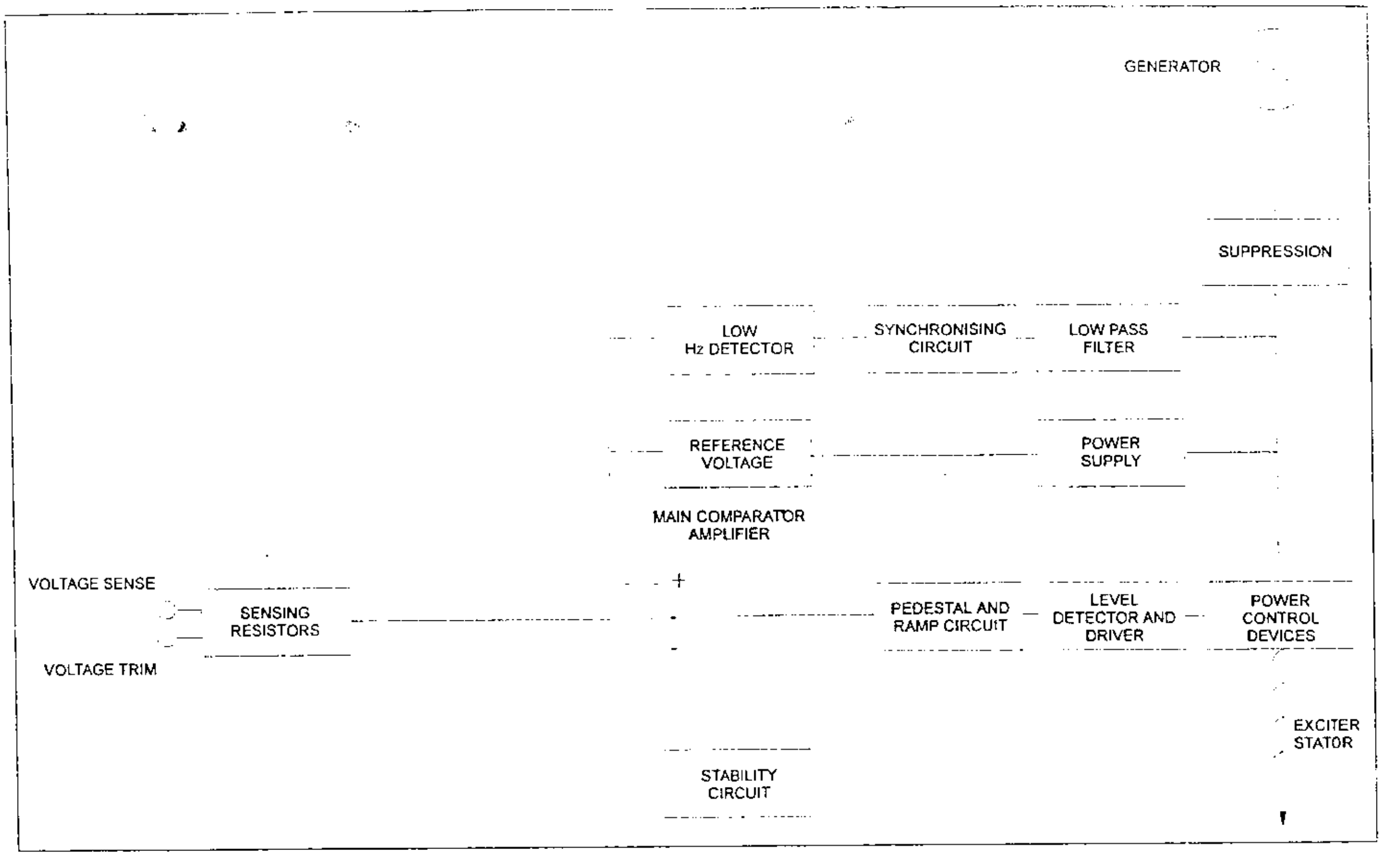
ENVIRONMENTAL

Vibration	20-100 Hz	50mm/sec
	100 Hz-2 kHz	3.3g
Relative Humidity	0-60°C	95%
Operating Temperature		-40°C to + 70°C
Storage Temperature		-55°C + 80°C

NOTES

1. With 4% engine governing.
2. Factory set, semi-sealed, jumper selectable.

DESIGN DETAILS



The main functions of the AVR are:

Sensing Resistors take a proportion of the generator output voltage and attenuate it. This input chain of resistors includes the range potentiometer and hand trimmer which adjust the generator voltage. An operational precision rectifier converts the a.c. for further processing.

Main Comparator/Amplifier compares the sensing voltage to the "**reference voltage**" and amplifies the difference (error) to provide a controlling signal for the power devices. The "**pedestal and ramp**" circuit and "**level detector and driver**" infinitely control the conduction period of the output device over each half cycle (phase control), and hence provide the exciter with the required power to maintain the generator voltage within specified limits. The **stability circuit** provides adjustable negative ac feedback to ensure good steady state and transient performance of the control system.

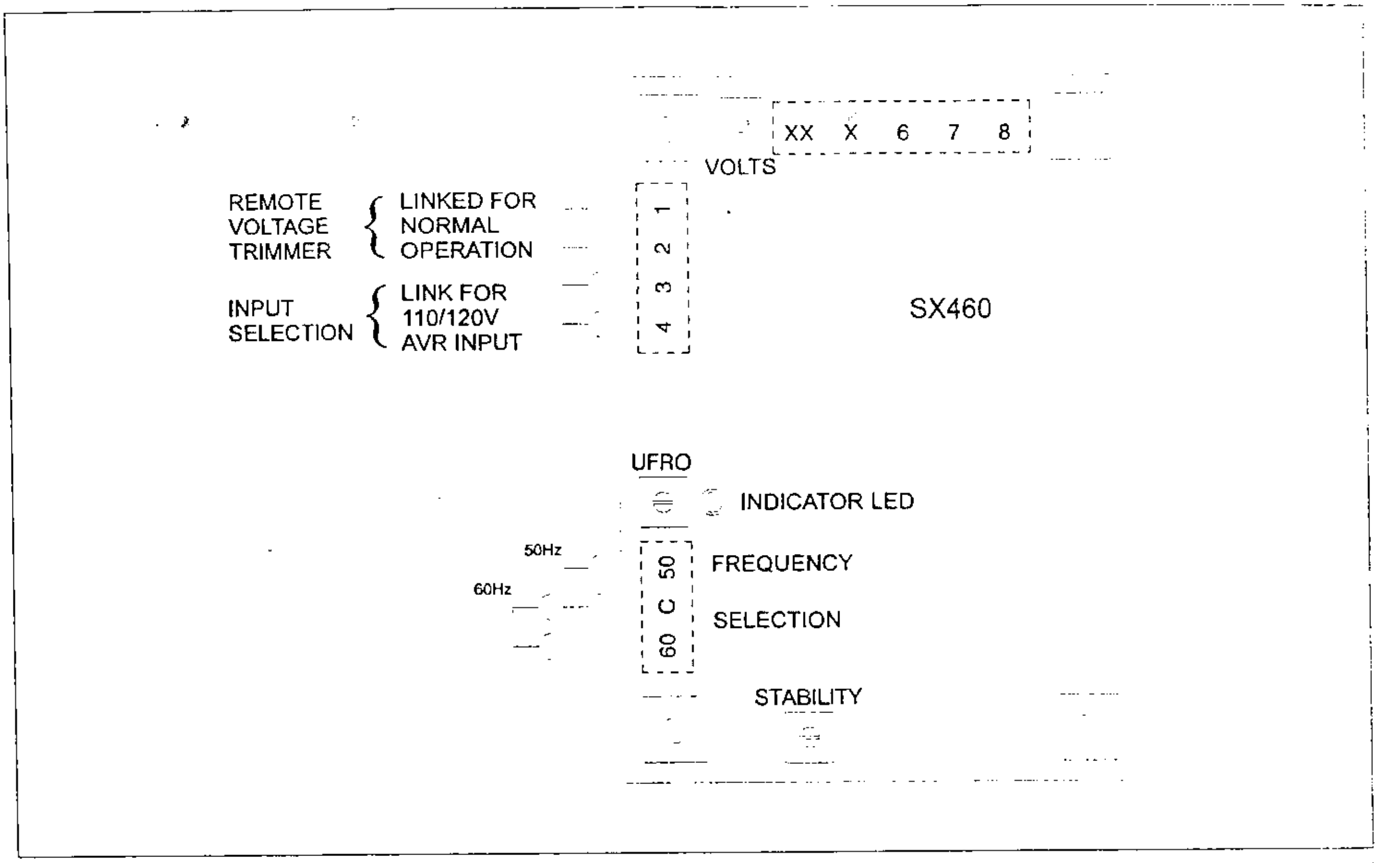
Low Hz detector measures the period of each electrical cycle and causes the reference voltage to be reduced approximately linearly with speed below a presettable threshold. A Light Emitting Diode gives indication of underspeed running.

Synchronising circuit provides a short pulse at zero crossing at each half cycle and is used to synchronise the underspeed and pedestal and ramp circuit to the generator waveform. The circuit is preceded by a low **pass filter** to prevent false zero crossing pulses caused by distorted waveforms.

Power devices are configured as half wave thyristor and freewheel diode to vary the amount of exciter field current in response to the error signal produced by the main comparator.

Suppression components are included to prevent sub cycle voltage spikes damaging the AVR components and also to reduce the amount of AVR thyristor noise on the main terminals of the generator.

Power Supply components consist of zener diodes with dropper resistor and smoothing to provide the required voltages for the integrated circuits and reference voltage.



SUMMARY OF AVR CONTROLS

CONTROL	FUNCTION	DIRECTION
VOLTS	TO ADJUST GENERATOR OUTPUT VOLTAGE	CLOCKWISE INCREASES OUTPUT VOLTAGE
STABILITY	TO PREVENT VOLTAGE HUNTING	CLOCKWISE INCREASES STABILITY OR DAMPING EFFECT
UFRO	TO SET UNDER FREQUENCY ROLL OFF KNEE POINT	CLOCKWISE REDUCES THE KNEE POINT FREQUENCY

The AVR is fully encapsulated to ensure long-trouble-free operation. It is usually fitted on a panel of the terminal box. It can also be separately fitted in a switchboard

ADJUSTMENT OF AVR CONTROLS

VOLTAGE ADJUSTMENT

The generator output voltage is set at the factory, but can be altered by careful adjustment of the volts control on the AVR board, or by the external hand trimmer if fitted. Terminals 1 and 2 on the AVR will be fitted with a shorting link if no hand trimmer is required. Terminals 3 and 4 are used for low voltage only, and are linked only for special low voltage applications.

> **Warning !**
> **Do not increase the voltage above the rated generator voltage. If in doubt, refer to the rating plate mounted on the generator case.**

If a replacement AVR has been fitted or re-setting of the VOLTS adjustment is required, proceed as follows:

1) Before running generator, turn VOLTS control fully anti-clockwise.

2) Turn remote volts trimmer (if fitted) to midway position.

3) Turn STABILITY control to midway position.

4) Connect a suitable voltmeter (0-300V ac) across line to neutral of the generator.

5) Start generator set, and run on no load at nominal frequency e.g. 50-53Hz or 60-63Hz.

6) If the red Light Emitting Diode (LED) is illuminated, refer to the Under Frequency Roll Off (UFRO) adjustment.

7) Carefully turn VOLTS control clockwise until rated voltage is reached.

8) If instability is present at rated voltage, refer to stability adjustment, then re-adjust voltage if necessary.

9) Voltage adjustment is now completed.

STABILITY ADJUSTMENT

The AVR includes a stability or damping circuit to provide good steady state and transient performance of the generator.

The correct setting can be found by running the generator at no load and slowly turning the stability control anti-clockwise until the generator voltage starts to become unstable.

The optimum or critically damped position is slightly clockwise from this point (i.e. where the machine volts are stable but close to the unstable region).

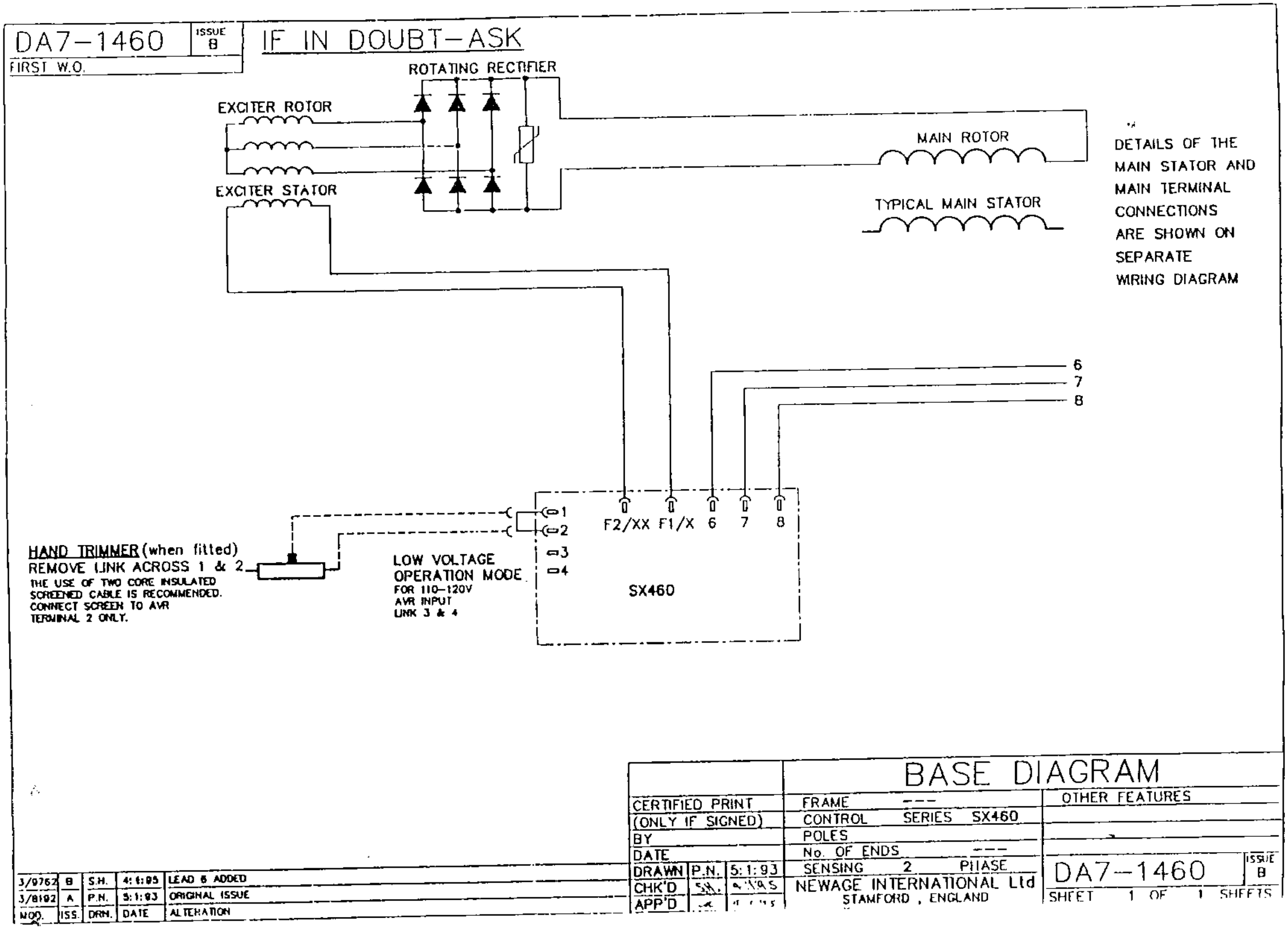
UNDER FREQUENCY ROLL OFF (UFRO) ADJUSTMENT

The AVR incorporates an underspeed protection circuit which gives a volts/Hz characteristic when the generator speed falls below a presettable threshold known as the "knee" point.

The red Light Emitting Diode (LED) gives indication that the UFRO circuit is operating.

The UFRO adjustment is preset and sealed and only requires the selection of 50/60Hz using the jumper link.

For optimum setting, the LED should illuminate as the frequency falls just below nominal, i.e. 47Hz on a 50Hz system or 57Hz on a 60Hz system.

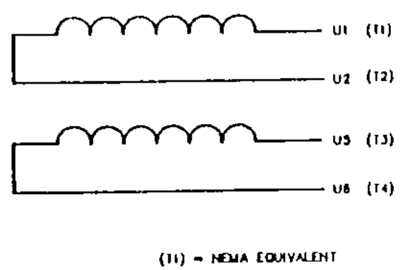

DA7-1460
ISSUE B
FIRST W.O.
IF IN DOUBT-ASK
ROTATING RECTIFIER
EXCITER ROTOR
EXCITER STATOR
MAIN ROTOR
TYPICAL MAIN STATOR
DETAILS OF THE MAIN STATOR AND MAIN TERMINAL CONNECTIONS ARE SHOWN ON SEPARATE WIRING DIAGRAM
6
7
8
F2/XX F1/X 6 7 8
1
2
3
4
SX460
HAND TRIMMER (when fitted)
REMOVE LINK ACROSS 1 & 2
THE USE OF TWO CORE INSULATED SCREENED CABLE IS RECOMMENDED. CONNECT SCREEN TO AVR TERMINAL 2 ONLY.
LOW VOLTAGE OPERATION MODE
FOR 110-120V AVR INPUT LINK 3 & 4
BASE DIAGRAM
CERTIFIED PRINT (ONLY IF SIGNED)
BY
DATE
DRAWN P.N. 5:1:93
CHK'D
APP'D
FRAME ---
CONTROL SERIES SX460
POLES
No. OF ENDS ---
SENSING 2 PHASE
NEWAGE INTERNATIONAL Ltd
STAMFORD, ENGLAND
OTHER FEATURES
DA7-1460
ISSUE B
SHEET 1 OF 1 SHEETS
3/9762 B S.H. 4:1:95 LEAD 6 ADDED
3/8192 A P.N. 5:1:93 ORIGINAL ISSUE
MOD. ISS. DRN. DATE ALTERATION

DA7-A401 | ISSUE E

FIRST W.O.

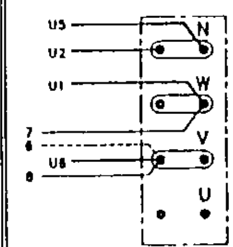
IF IN DOUBT-ASK

MAIN STATOR (4 ENDS)

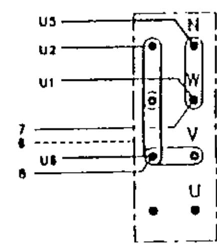


MAIN TERMINAL CONNECTIONS

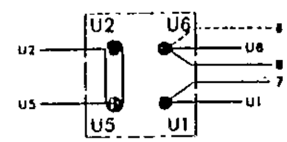
SERIES 1PH 3W
OUTPUT TERMINALS
HIGH VOLTS W.V.
LOW VOLTS W.N. AND N.V.



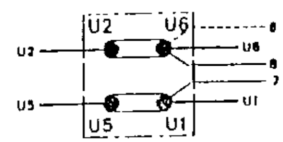
PARALLEL 1PH 2W
OUTPUT TERMINALS W.V.



SERIES 1PH 3W
OUTPUT TERMINALS U1,U6,U2.



PARALLEL 1PH 2W
OUTPUT TERMINALS U1,U6.



1. PARALLEL 1PH 2W CONNECTION ONLY. AVR MUST BE LINKED FOR LOW VOLTAGE OPERATION DETAILS ON BASE DIAGRAM.
2. TERMINAL ARRANGEMENT DEPENDS ON MACHINE SIZE
3. LEAD 6 ONLY REQUIRED FOR MACHINES FITTED WITH A MX321/MA325 AVR SEE BASE DIAGRAM FOR DETAILS.

ECO.	ISS.	DRN.	DATE	ALTERATION
[illegible]	E	[illegible]	[illegible]	LOW VOLT AVR OPERATION NOTE ADDED - PARALLEL 1PH 2W ONLY
[illegible]	D	[illegible]	[illegible]	LEADS 8 AND 3 WERE CONNECTED TO U3 (120V)
[illegible]	C	[illegible]	[illegible]	MAIN TERMINAL CONNECTIONS CHANGED
[illegible]	B	[illegible]	24:4:95	OPTIONAL LEAD 6 ADDED FOR MX321/MA325 AVR ONLY
[illegible]	A	P.H.	5:1:93	ORIGINAL ISSUE

CERTIFIED PRINT (ONLY IF SIGNED)
BY
DATE
DRAWN P.N. 5:1:93
CHK'D
APP'D

CONNECTION DIAGRAM

FRAME ---
CONTROL SERIES ---
POLES
No. OF ENDS 4
SENSING 2 PHASE

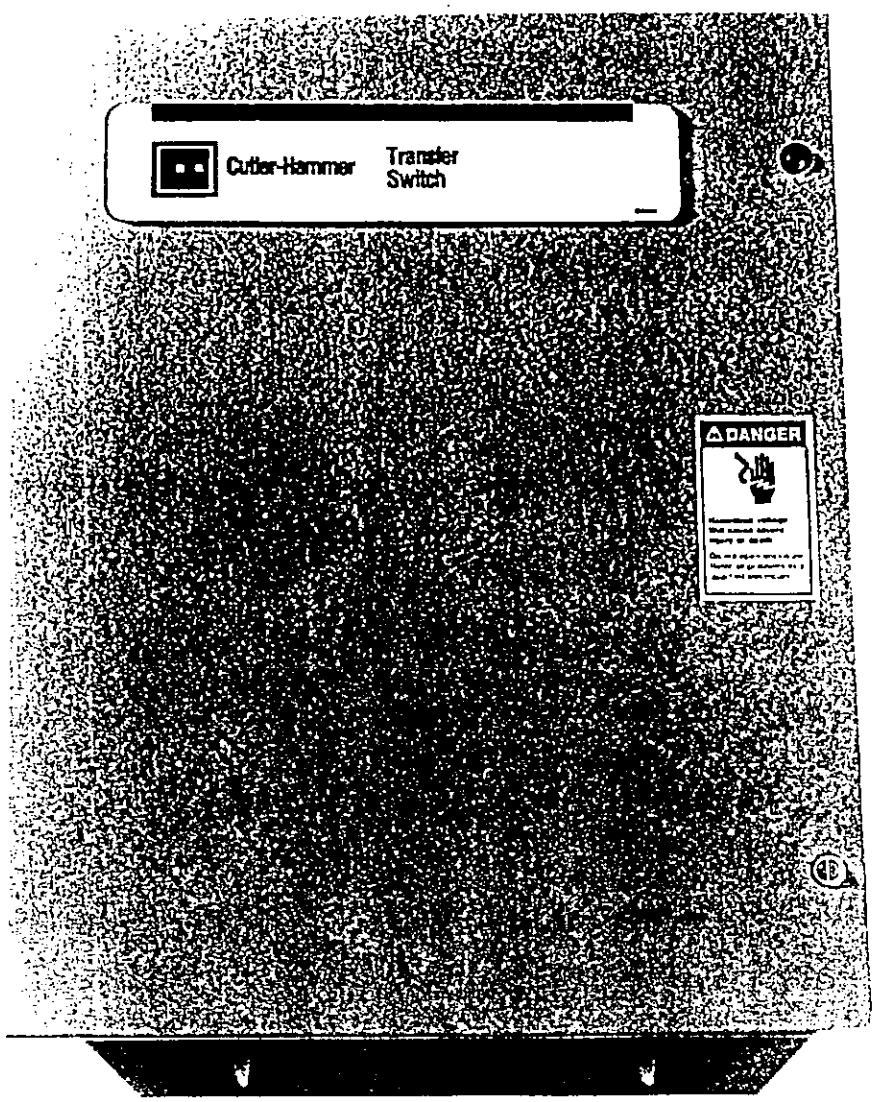
NEWAGE INTERNATIONAL Ltd
STAMFORD, ENGLAND

OTHER FEATURES

DA7-A401 | ISSUE E.

SHEET 1 OF 1 SHEETS

Instructions for Residential Automatic Transfer Switch for Optional Systems



WARNING

READ AND UNDERSTAND THE INSTRUCTIONS CONTAINED HEREINAFTER BEFORE ATTEMPTING TO UNPACK, ASSEMBLE, OPERATE OR MAINTAIN THIS EQUIPMENT.

HAZARDOUS VOLTAGES ARE PRESENT INSIDE TRANSFER SWITCH ENCLOSURES THAT CAN CAUSE DEATH OR SEVERE PERSONAL INJURY. FOLLOW PROPER INSTALLATION, OPERATION AND MAINTENANCE PROCEDURES TO AVOID THESE VOLTAGES.

TRANSFER SWITCH EQUIPMENT COVERED BY THIS INSTRUCTION BOOK IS DESIGNED AND TESTED TO OPERATE WITHIN ITS NAMEPLATE RATINGS. OPERATION OUTSIDE OF THESE RATINGS MAY CAUSE THE EQUIPMENT TO FAIL RESULTING IN DEATH, SERIOUS BODILY INJURY AND/OR PROPERTY DAMAGE. ALL RESPONSIBLE PERSONNEL SHOULD LOCATE THE DOOR MOUNTED EQUIPMENT NAMEPLATE AND BE FAMILIAR WITH THE INFORMATION PROVIDED ON THE NAMEPLATE. A TYPICAL EQUIPMENT NAMEPLATE IS SHOWN IN FIGURE 1.

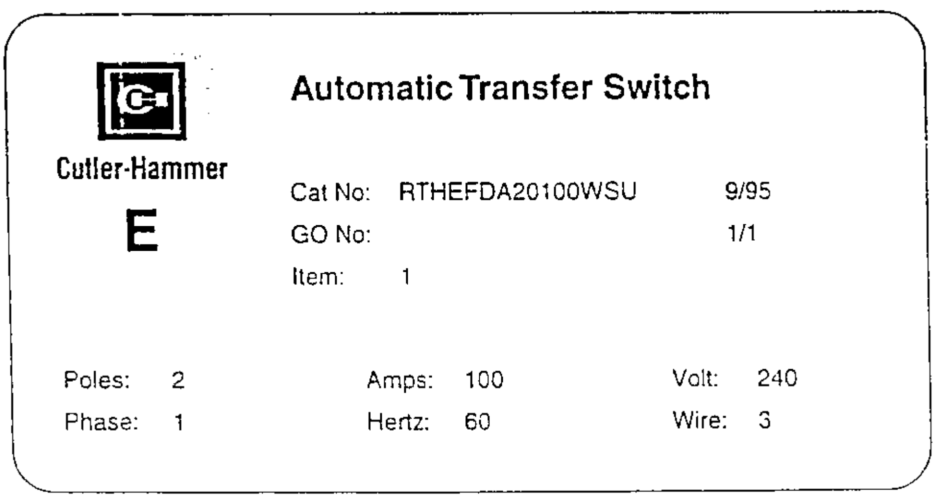


Figure 1 *Typical Automatic Transfer Switch Equipment Nameplate*

All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do no purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of particular equipment. contact a Cutler-Hammer representative.

SECTION 1: INTRODUCTION

1.1 PRELIMINARY COMMENTS AND SAFETY PRECAUTIONS

This technical document is intended to cover most aspects associated with the installation, application, operation and maintenance of the Residential Automatic Transfer Switch for optional systems. This pre-packaged transfer switch is designed to be used with pre-packaged control panels. Please refer to the specific WARNING and CAUTION in Section 1.1.2 before proceeding. If further information is required by the purchaser, a Cutler-Hammer representative should be contacted.

1.1.1 WARRANTY AND LIABILITY INFORMATION

No warranties, expressed or implied, including warranties of fitness for a particular purpose of merchantability, or warranties arising from course of dealing or usage of trade, are made regarding the information, recommendations and descriptions contained herein. In no event will Cutler-Hammer be responsible to the purchaser or user in contract, in tort (including negligence), strict liability or otherwise for any special, indirect, incidental or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information and descriptions contained herein.

1.1.2 SAFETY PRECAUTIONS

All safety codes, safety standards and/or regulations must be strictly observed in the installation, operation and maintenance of this device.

WARNING

THE WARNINGS AND CAUTIONS INCLUDED AS PART OF THE PROCEDURAL STEPS IN THIS DOCUMENT ARE FOR PERSONNEL SAFETY AND PROTECTION OF EQUIPMENT FROM DAMAGE. AN EXAMPLE OF A TYPICAL WARNING LABEL HEADING IS SHOWN ABOVE TO FAMILIARIZE PERSONNEL WITH THE STYLE OF PRESENTATION. THIS WILL HELP TO INSURE THAT PERSONNEL ARE ALERT TO WARNINGS, WHICH APPEAR THROUGHOUT THE DOCUMENT. IN ADDITION, CAUTIONS ARE ALL UPPER CASE AND BOLDFACE.

CAUTION

COMPLETELY READ AND UNDERSTAND THE MATERIAL PRESENTED IN THIS DOCUMENT BEFORE ATTEMPTING INSTALLATION, OPERATION OR APPLICATION OF THE EQUIPMENT. IN ADDITION, ONLY QUALIFIED PERSONS SHOULD BE PERMITTED TO PERFORM ANY WORK ASSOCIATED WITH THE EQUIPMENT. ANY WIRING INSTRUCTIONS PRESENTED IN THIS DOCUMENT MUST BE FOLLOWED PRECISELY. FAILURE TO DO SO COULD CAUSE PERMANENT EQUIPMENT DAMAGE.

1.2 GENERAL INFORMATION

Transfer switches are used to protect critical electrical loads against loss of power. The load's normal power source is backed up by a secondary (emergency) power source. A transfer switch is connected to both the normal and emergency power sources and supplies the load with power from one of these two sources. In the event that power is lost from the normal power source, the transfer switch transfers the load to the secondary (emergency) power source. Transfer can be automatic or manual, depending upon the type of transfer switch equipment being used. Once normal power is restored, the load is automatically or manually transferred back to

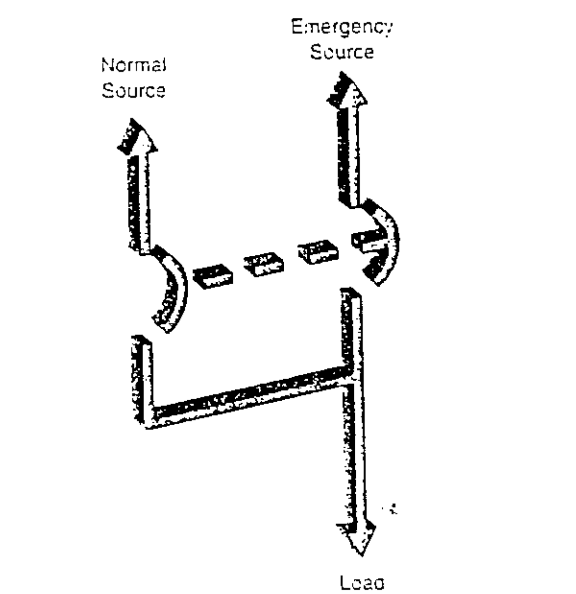


Figure 1-1 Typical Load Transfer Switch (circuit breaker type) Schematic

the normal power source, again depending upon the type of transfer equipment being used (Figure 1-1).

In automatic transfer switch equipment, the switch's intelligence system initiates the transfer when normal power fails or falls below a preset voltage. If the emergency power source is a standby generator, the transfer switch initiates generator starting and transfers to the emergency power source when sufficient generator voltage is available. When normal power is restored, the transfer switch automatically transfers back and initiates engine shutdown. In the event the normal power source fails and the emergency power source does not appear, the automatic transfer switch remains connected to the normal power source until the emergency power source does appear. Conversely, if connected to the emergency power source and the emergency power source fails while the normal power source is still unavailable, the automatic transfer switch remains connected to the emergency power source.

Automatic transfer switches automatically perform the transfer function, and include three basic elements:

(1) Main contacts to connect and disconnect the load to and from the source of power.
(2) A mechanism to make the transfer of the main contacts from source to source.
(3) Intelligence/supervisory circuits to constantly monitor the condition of the power sources and thus provide the intelligence necessary for the switch and related circuit operation.

1.2.1 DESIGN CONFIGURATION

The Cutler-Hammer transfer switch is a rugged, compact design that utilizes molded case switches to transfer essential loads from one power source to another (Figure 1-2). Molded case switches are interlocked to prevent both switches from being closed at the same time.

Mounting the enclosure is simple using top and bottom mounting flanges with elongated mounting holes.

1.3 TRANSFER SWITCH CATALOG NUMBER IDENTIFICATION

Transfer switch equipment catalog numbers provide a significant amount of relevant information pertaining to a specific piece of equipment. The Catalog Number Identification Table (Table 1.1) provides the required interpretation information. An example is offered to initially simplify the process.

Example: Catalog Number (circled numbers correspond to position headings in Table 1.1)

① to ②	③	④	⑤ to ⑥	⑦	⑧	⑨ to ⑫	⑬	⑭	⑮
RT	H	E	FD	A	2	0100	W	S	U

Table 1.1 *Transfer Switch Catalog Number Explanation*

Positions 1-2 Basic Device		Position 3 Switching Device Orientation		Position 4 Control Panel		Positions 5-6 Switching Device		
Residential	RT	Horizontal	H	Electromechanical	E	HFD	·Cutler-Hammer Series C	FD

Position 7 Switching Device Arrangement		Position 8 Number of Poles		Positions 9-12 Ampere Rating	Position 13 Voltage/Frequency		Position 14 Enclosure		Position 15 Listing	
Fixed Mount Molded Case Switches	A	Two	2 ①	100A - 0100	120VAC/60Hz	A	NEMA 1	S	UL Listed	U
				150A - 0150	240VAC/60Hz	W	NEMA 3R	R		
				200A - 0200						

① Only available with 120 or 240 volt systems (60 Hz Only)

SECTION 2: RECEIVING, HANDLING, AND STORAGE

2.1 RECEIVING

Every effort is made to ensure that the transfer switch equipment arrives at its destination undamaged and ready for installation. Packing is designed to protect internal components as well as the enclosure. Care should be exercised, however, to protect the equipment from impact at all times. Do not remove protective packaging until the equipment is ready for installation .

When transfer switch equipment reaches its destination, the customer should inspect the shipping container for any obvious signs of rough handling and/ or external damage that occurred during transportation. Record any external and internal damage for reporting to the transportation carrier and Cutler-Hammer, once a thorough inspection is complete. All claims should be as specific as possible and include Shop Order and General Order numbers.

A shipping label affixed to the shipping container includes a variety of equipment and customer information, such as General Order number and Customer Number. Make certain that this information matches other shipping paper information.

Each transfer switch enclosure is bolted through its top and bottom mounting flanges to a rigid wooden pallet. The pallet is open at two ends for movement by a forklift. Heavy duty cardboard sides surround the enclosure and are further supported with reinforced cardboard corner posts. An egg crate design cardboard protector covers the entire top of the enclosure with additional cardboard protectors over the indicating light panel and operating handle. A heavy duty cardboard lid covers the entire opening. The shipment is secured and further protected with shrink wrap. Do not discard the packing material until the equipment is ready for installation.

Once the top packaging is removed from the shipment, the enclosure door can be opened. A plastic bag of documents will be found in the enclosure, usually attached to the inside of the door. Important documents, such as test reports, wiring diagrams, appropriate instruction leaflets and a warranty registration card, are enclosed within the bag and should be filed in a safe place.

2.2 HANDLING

As previously mentioned, transfer switch equipment is packaged for forklift movement. Protect the equipment from impact at all times and do not double stack. Once the equipment is in the installation location and ready to be installed, packaging material can be removed. Once the enclosure is unbolted from the wooden pallet, it can be hand moved to its installation position. Be careful not to damage the top or bottom enclosure mounting flanges. Refer to Section 4 of this manual for specific installation instructions.

2.3 STORAGE

Although well packaged, this equipment is not suitable for storage outdoors. The equipment warranty will not be applicable if there is evidence of outdoor storage. If the equipment is to be stored indoors for any period of time, it should be stored with its protective packaging material in place. Protect the equipment at all times from excessive moisture, construction dirt, corrosive conditions, and other contaminants. It is strongly suggested that the package-protected equipment be stored in a climate-controlled environment of -20°C to 65°C with a relative humidity of 80 percent or less. Do not under any circumstance, stack other equipment on top of a transfer switch equipment enclosure, whether packaged or not.

SECTION 3: EQUIPMENT DESCRIPTION

3.1 INTRODUCTION

The Cutler-Hammer Residential Automatic Transfer Switch for optional systems is assembled and tested at the factory. It is designed to be used in conjunction with standby power distribution equipment to provide an alternate source of power to critical circuits in the event that a primary power source is interrupted.

3.2 STANDARDS

Cutler-Hammer transfer switch equipment enclosed in a NEMA 1 enclosure is listed for application by UL and UL-C. This type automatic transfer switch is intended for use in ordinary locations to provide lighting and power as follows:

a. In standby systems, in accordance with article 702 of the National Electrical Code and/or

Since Cutler-Hammer automatic transfer switches for optional systems use specially designed molded case switches as the main power switching contacts, these devices must also be listed under the additional UL Standard 1087. Underwriters laboratories uses two basic types of listing programs — label service and re-examination.

UL1087 employ a label service listing program which requires an extensive follow-up testing program for listed devices. Standard UL1008 for automatic transfer switches lists devices under the reexamination program which only requires a continual physical reexamination of the components used in the product to ensure consistency with the originally submitted device. Follow-up testing is not required by UL1008.

Representative production samples of molded case switches and molded case circuit breakers used in Cutler-Hammer automatic transfer switches are subjected to a complete test program identical to the originally submitted devices on an ongoing periodic basis per UL1087. The frequency of such a re-submittal can be as often as every quarter for a low ampere device. Any failure during one of these periodic re-submittals could result in a loss of the valued UL listing mark.

SECTION 4: INSTALLATION AND WIRING

4.1 GENERAL

Transfer switches are factory wired and tested. Installation requires solidly mounting the enclosed unit and connecting power cables and auxiliary pilot circuits. Physical mounting procedures and power cable connections are covered in this section. Once a transfer switch is properly installed and wired, it should be mechanically and electrically checked for proper installation and operation. The procedures for these initial mechanical and electrical checks are outlined in Section 5 of this instruction manual.

4.2 MOUNTING LOCATION

Choose a location that offers a flat, rigid mounting surface capable of supporting the weight of the enclosed transfer switch equipment (Figure 4-1). Avoid locations that are moist, hot, or dusty, however, there are enclosure designs available for special environments. If there are any doubts as to location suitability, discuss it with your Cutler-Hammer representative.

Check to make certain that there are no pipes, wires, or other mounting hazards in the immediate mounting area that could create a problem.

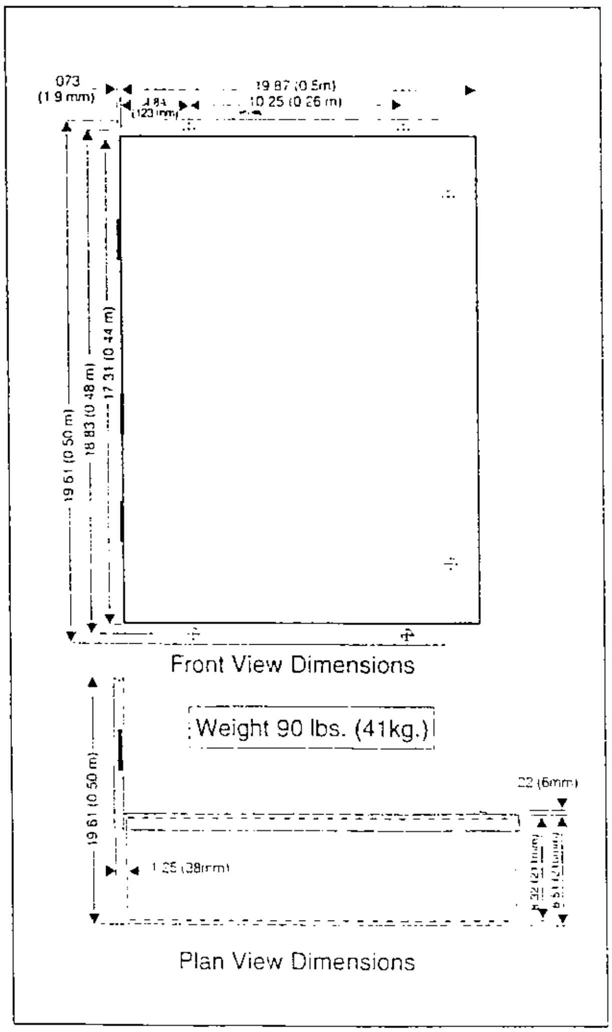


Figure 4-1 Dimensions and Plan View of Residential Automatic Transfer Switch (100A)

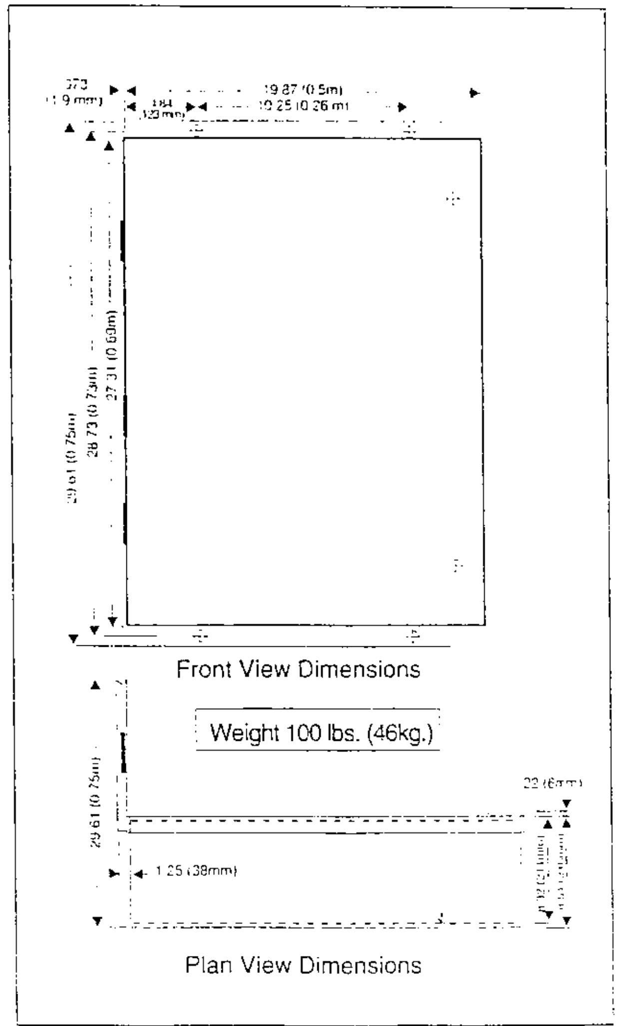


Figure 4-2 Dimensions and Plan View of Residential Automatic Transfer Switch (150-200A)

Carefully remove all packing material from the transfer switch at the mounting location. Even though an equipment inspection was made when the equipment was received, make another careful inspection of the enclosure and the enclosed transfer switch as packing material is removed and the enclosure readied for mounting. Be especially alert for distorted metal, loose wires or damaged components.

4.3 MOUNTING PROCEDURE

CAUTION

EXTREME CARE SHOULD BE TAKEN TO PROTECT THE TRANSFER SWITCH FROM DRILL CHIPS, FILINGS AND OTHER CONTAMINANTS WHEN MAKING THE CABLE ENTRY HOLES AND MOUNTING THE ENCLOSURE TO PREVENT COMPONENT DAMAGE OR A FUTURE MALFUNCTION.

With the enclosed transfer switch equipment unpacked and ready for mounting, proceed with these steps:

Step 1: The transfer switch enclosure door is hinge mounted with removable hinge pins. To simplify the mounting procedure and avoid damage, carefully remove the door and put it in a safe place until mounting is complete.

Step 2: Install required mounting bolt anchors and the two upper mounting bolts in the mounting surface.

Step 3: Gently lift the enclosure and guide the teardrop-shaped holes in the upper mounting flange over the upper mounting bolts, but do not completely tighten the bolts.

Step 4: While still supporting the enclosure, install the two lower mounting bolts in the lower mounting flange, but do not completely tighten. Use shims, if required, to prevent deformation of the enclosure when the mounting surface is distorted.

Step 5: Tighten all four mounting bolts after any required shimming is completed.

Step 6: Double check to ensure that all packing and shipping material has been removed.

4.4 POWER CABLE CONNECTIONS

WARNING

POWER CONDUCTORS MAY HAVE VOLTAGE PRESENT THAT CAN CAUSE SEVERE PERSONAL INJURY OR DEATH. DE-ENERGIZE ALL POWER OR CONTROL CIRCUIT CONDUCTORS TO BE CONNECTED TO THE TRANSFER SWITCH EQUIPMENT BEFORE BEGINNING TO WORK WITH THE CONDUCTORS AND/OR TERMINATING THEM TO THE EQUIPMENT.

CAUTION

USE OF CABLE LUGS, NOT DESIGNED FOR THE TRANSFER SWITCH MAY CAUSE HEATING PROBLEMS. BREAKER LUGS ONLY MOUNT TO THE BREAKER, WHILE TRANSFER SWITCH LUGS MOUNT TO BOTH THE BREAKER AND THE BUSBAR BEHIND THE BREAKER. FOR INSTALLATION INSTRUCTIONS, REFER TO THE INSTRUCTION LEAFLET SUPPLIED FOR THE SPECIFIC LUGS.

CAUTION

TO HELP PREVENT COMPONENT DAMAGE OR FUTURE MALFUNCTIONS, USE EXTREME CARE TO KEEP CONTAMINANTS OUT OF THE TRANSFER SWITCH EQUIPMENT WHEN MAKING POWER CABLE CONNECTIONS.

Test all power cables prior to connection to the unit to ensure that conductors or cable insulation has not been damaged while being pulled into position.

Power cables are to be connected to solderless screw type lugs located on the transfer switch switching devices. Verify that the lugs supplied will accommodate the power cables being used. Also verify that the cables comply with local electrical codes. Standard transfer switch equipment, as supplied from the factory, will accommodate the wire sizes shown in Table 4.1.

Table 4.1 Wire Size for Automatic Transfer Switch

Transfer Switch Amp Rating	Wire Size Range	Number of Cables per Phase
100	#14 - 1.0	1
150	#14 - 3.0	1
200	#6 - 300MCM	1

Carefully strip insulation from the power cables to avoid nicking or ringing of the conductor strands. Prepare the stripped conductor termination end by cleaning it with a wire brush. If aluminum conductors are used, apply an appropriate joint compound to the clean conductor surface area.

CAUTION

IMPROPER POWER CABLE CONNECTIONS CAN CAUSE EXCESSIVE HEAT AND SUBSEQUENT EQUIPMENT FAILURE.

Tighten cable lugs to the torque identified on the label affixed to the unit immediately adjacent to the lugs.

4.5 WIRING

WARNING

POWER CONDUCTORS AND CONTROL WIRING MAY HAVE VOLTAGE PRESENT THAT CAN CAUSE SEVERE PERSONAL INJURY OR DEATH. DE-ENERGIZE ALL POWER OR CONTROL CIRCUIT CONDUCTORS BEFORE BEGINNING TO PERFORM ANY WIRING ACTIVITY TO OR WITHIN THE TRANSFER SWITCH EQUIPMENT.

CAUTION

CHECK THE TRANSFER SWITCH EQUIPMENT NAMEPLATE FOR RATED VOLTAGE. IT SHOULD BE THE SAME AS THE NORMAL AND EMERGENCY LINE VOLTAGES. OPERATING THE EQUIPMENT ON IMPROPER VOLTAGE CAN CAUSE EQUIPMENT DAMAGE.

4.6 INSTALLATION

In a typical installation (Figure 4-3), the automatic transfer switch (ATS) for optional systems (1) and the generator (2) are connected to the residential power supply. The ATS for optional systems (1) and emergency distribution panel (3) receive normal power from a dedicated breaker in the utility service panel (4). The ATS for optional systems and emergency panel receive emergency power from the generator (2). Power from the utility feeds the utility panel. A line breaker is required between the emergency source (generator) and the transfer switch (Figure 4-4)

4.7 PRELIMINARY CHECKS

After the ATS enclosure is installed and power cables are connected to the equipment, thoroughly inspect the unit to ensure that no tools were left inside and that the cabinet is free of debris. If necessary, use a vacuum cleaner to remove any and all construction or installation debris from the equipment.

Read and understand all labels on the equipment. Review and understand the wiring diagrams supplied with the equipment. Note any optional accessories that may have been furnished with this unit and review their operation.

Verify that the phase-to-phase line voltages of both the normal and emergency power sources are the same and that they match rated voltage as indicated on the ATS ratings label.

CAUTION

SEVERE EQUIPMENT DAMAGE CAN RESULT IF UNIT IS NOT APPLIED AT PROPER VOLTAGE. DO NOT ENERGIZE EQUIPMENT IF SUPPLY VOLTAGES DO NOT MATCH EQUIPMENT RATINGS LABEL. CONTACT THE FACTORY FOR INSTRUCTIONS TO MODIFY THE VOLTAGE RATING IN THE FIELD.

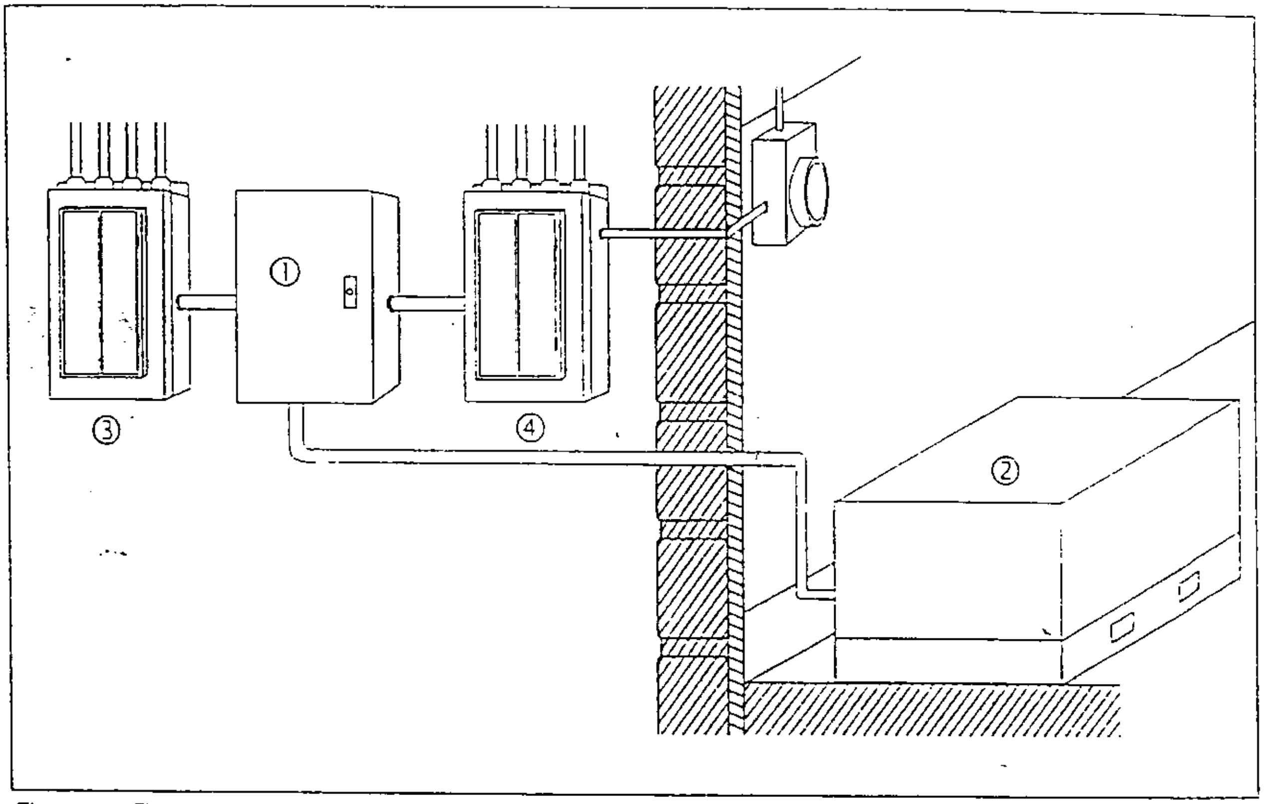


Figure 4-3 Typical installation of a residential or light duty automatic transfer switch for optional systems. The switch (1) and generator (2) are connected to the power supply. The automatic transfer switch is located between the emergency distribution (3) and the utility panel (4)

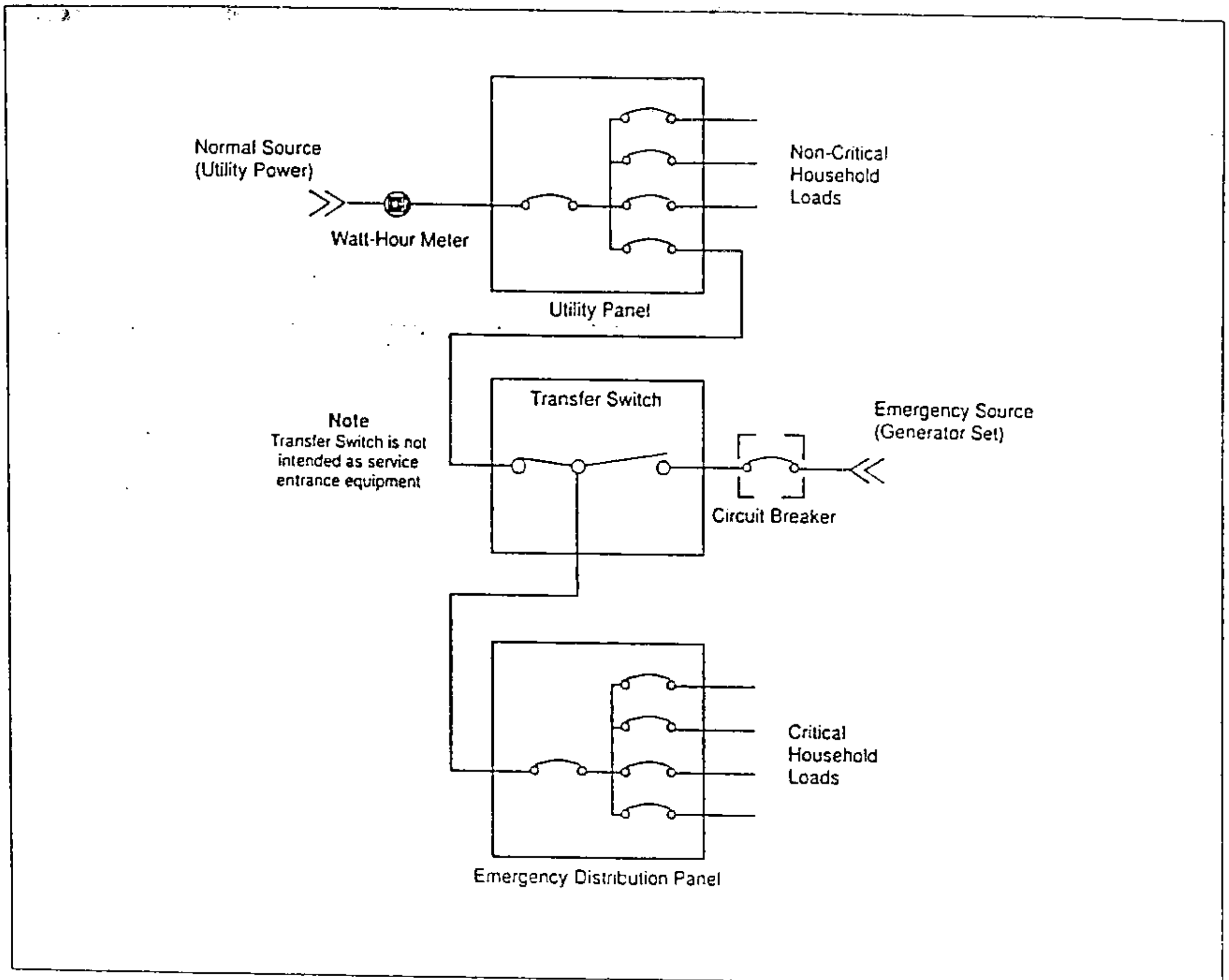


Figure 4-4 Diagram of Typical Installation

SECTION 5: MAINTENANCE

5.1 INTRODUCTION

WARNING

HIGH VOLTAGES ARE PRESENT IN AND AROUND TRANSFER SWITCH EQUIPMENT. BEFORE INSPECTING OR MAINTAINING THIS EQUIPMENT, DISCONNECT LINE POWER FROM THE EQUIPMENT BEING SERVICED BY OPENING AND LOCKING OUT, IF POSSIBLE, THE NEXT HIGHEST DISCONNECT DEVICE. FAILURE TO FOLLOW THIS PROCEDURE COULD CAUSE PERSONAL INJURY AND/OR DEATH.

In general, transfer switch equipment is designed to be relatively maintenance free under normal usage. However, because of the variability of application conditions and the importance placed on dependable operation by this type of equipment, inspection and maintenance checks should be made on a regularly scheduled basis. Since equipment maintenance will consist mainly of keeping the equipment clean, the frequency of maintenance will depend, to a large extent, on the cleanliness of the surroundings. If a significant amount of dust or foreign matter is present, a more frequent maintenance schedule should be followed.

It is suggested that visual inspections of the equipment be made on a regular basis, not just during regularly scheduled periods. Always be alert for an accumulation of dirt in and around the structure, loose parts and/or hardware, cracks and/or discoloration to insulation, and damaged or discolored components.

Figure 5-1 is the wiring diagram for the residential automatic transfer switch for optional systems. Only qualified and experienced personnel should attempt any diagnostic work using this diagram.

5.2 PROCEDURES

A suggested maintenance procedure to follow is outlined in Table 5.1.

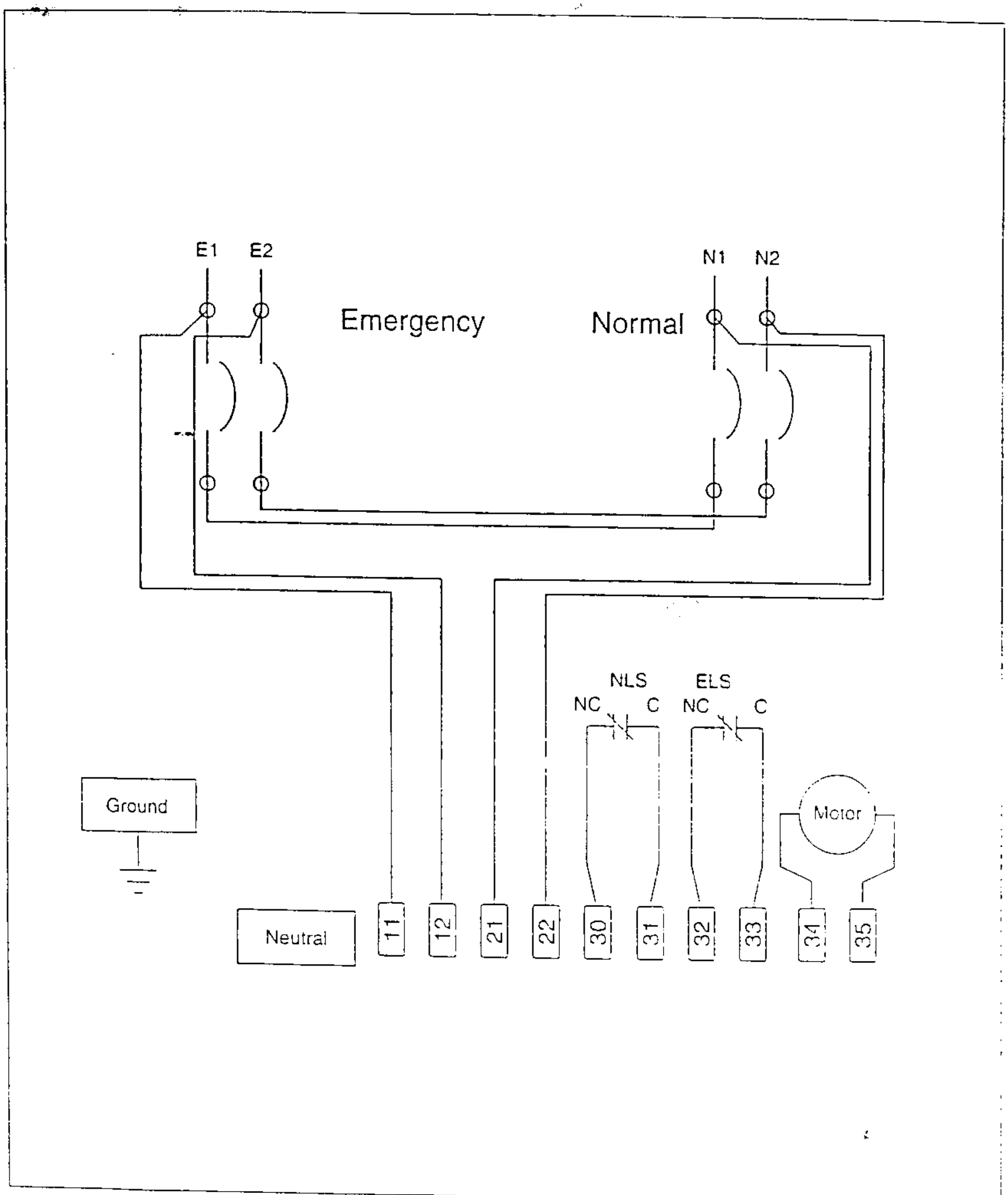


Figure 5-1 Wiring Diagram for Residential Automatic Transfer Switch for optional systems

Table 5.1 Periodic Maintenance Procedures

Step	Action
a. Make transfer switch equipment safe for inspection and/or maintenance.	Disconnect line power from equipment being serviced by opening next highest disconnect device. Make certain that any accessory control power is switched off.
b. Inspect structure area for safety hazards or potential maintenance problems.	Inspect area, especially where molded case switching devices are installed, for any safety hazards, including personnel safety and fire hazards. Exposure to certain chemical vapors can cause deterioration of electrical connections.
	Inspect for accumulated dirt, loose hardware or physical damage.
	Examine primary insulation for evidence of cracking or overheating. Overheating will show as discoloration, melting, or blistering of conductor insulation, or as pitting or melting of conductor surfaces due to arcing.
	Inspect secondary control connections for damage, and control wiring for insulation integrity.
c. Inspect molded case switching devices for dust, dirt, soot, grease, moisture or corrosion.	Remove dust, dirt, soot, grease, moisture and corrosion contamination from the surface of the switching device using a dry soft lint-free cloth, dry soft bristle brush and vacuum cleaner. Do not blow debris into circuit breaker or nearby breaker structure. If contamination is found, look for the source and fix the problem.
d. Check for material integrity, uneven wear, discoloration or loose hardware.	Severe material cracking will require replacement and loose hardware will need to be tightened.
e. Check terminals and connectors for looseness or signs of overheating.	Overheating will show as discoloration, melting, or blistering of conductor insulation.
	Connections that do not have signs of looseness or overheating should not be disturbed.
f. Exercise the molded case switching devices if they are not often exercised while in operation. This will permit wiping action by the contacts.	If a switching device is used for frequent switching during normal operation, this step can be disregarded.
g. Return transfer switch equipment to service.	Make certain all barriers are in place and doors closed. Re-apply secondary and primary power.

ELECTRONIC GOVERNOR CONTROL
OPERATING MANUAL
GS25
20KW RATED & 25KW RATED UNITS

CALIBRATION & WIRING FOR DYN1-10744-000-0-12

1.0 CALIBRATION PROCEDURE

1.1 Wire the system as shown.

1.2 Start the engine and adjust the speed by turning the speed potentiometer clockwise to increase speed.

1.3 At no load, turn the gain potentiometer clockwise until engine begins to hunt. If engine does not hunt, physically upset the governor linkage.

1.4 Turn the gain potentiometer counterclockwise until stable. If gain potentiometer is turned fully counterclockwise, and engine still hunts, remove wire from the controller gain change to battery negative.

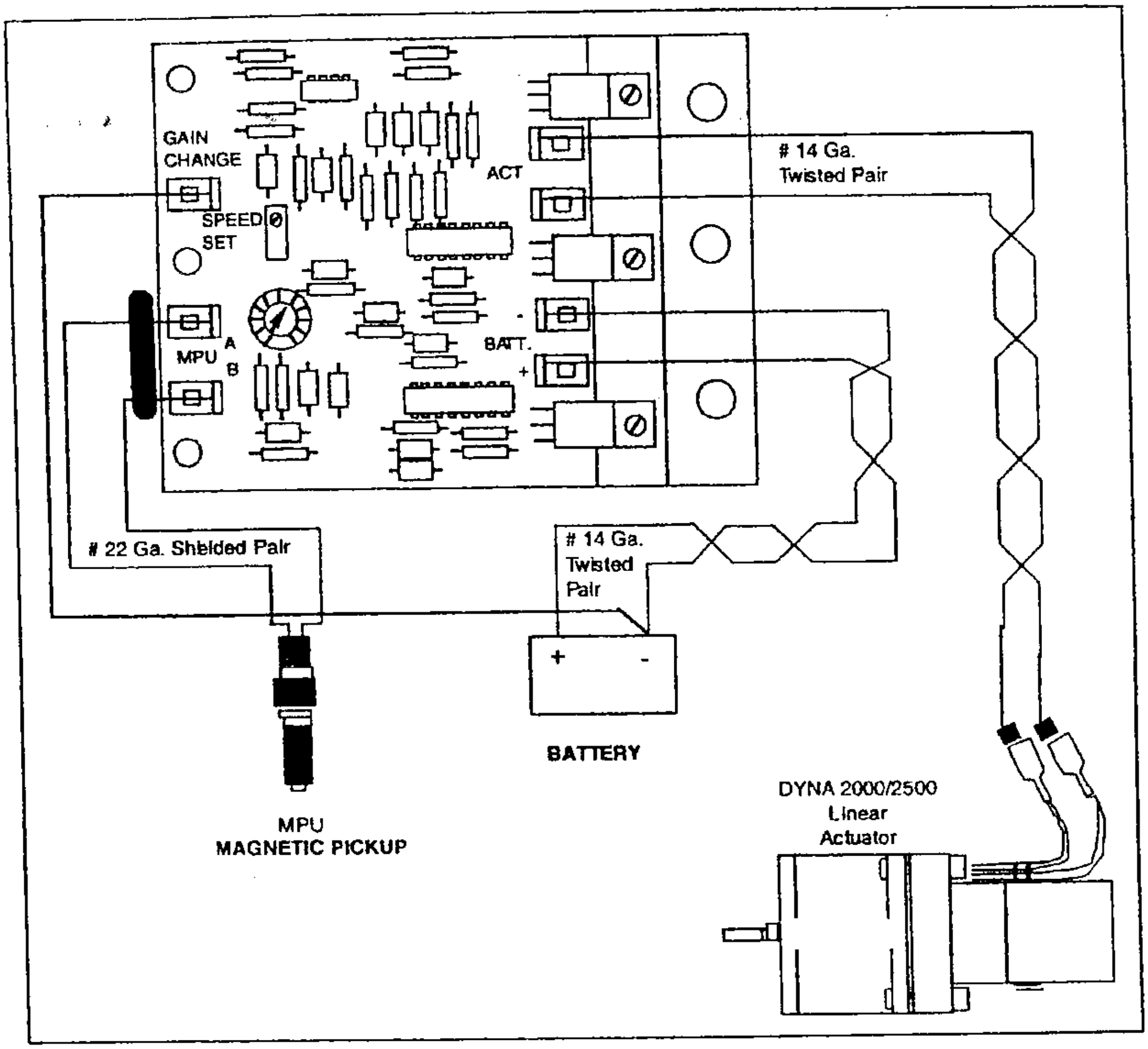
1.5 Removing the controller gain change reduces the over-all gain by 25%. Repeat steps 1.3 through 1.6 until engine is stable.

1.6 Recheck engine speed and adjust the speed potentiometer accordingly.

NOTE

Controllers are factory set to minimum RPM, but for safety, it should be possible to disable the engine if overspeed should occur.

Wiring Diagram for a DYN1-10744-000-0-12



Linear Troubleshooting Chart for DYN1-10744-000-0-12

1. PROBLEM: SYSTEM IS COMPLETELY DEAD. ACTUATOR LEVER STAYS AT MINIMUM.

	Means of Detection	Corrective Action
1.1	Check for battery voltage at controller on battery positive and battery negative.	Check battery connections and contacts for turning power "ON" to the controllers.
1.2	Check for proper linkage set up.	Correct and free linkage.
1.3	Magnetic pickup signal absent or too low. Measure AC volt across MPU A & B while cranking the engine. Voltage should be at least 2.5 VAC. **NOTE:** The voltmeter should have an impedance of 5000 ohms/volts or higher.	Check pole tip gap over gear tooth. It should be 0.37 ± 0.127mm (0.015" ± 0.005") or adjusted to obtain 2.5 VAC or greater. Verify magnetic pickup wiring.
1.4	Measure the resistance of the magnetic pickup coil. This should be approximately150 to 5000 ohms max.	If there is an open or shorted coil, replace the magnetic pickup.
1.5	Measure the resistance of each pin to the metal case of the magnetic pickup. No continuity should be evident.	If there is continuity to case, replace the magnetic pickup.
1.6	**DC SUPPLY OFF.** Remove actuator leads from terminals. Place actuator battery system power leads on. Actuator should go to full stroke.	If the actuator still does not move to full stroke, continue with steps below.
1.7	Measure actuator coil resistance: • 12 VDC unit. Coil resistance 1.4 ± 0.2 ohms. • 24 VDC unit. Coil resistance 7.3 ± 1.0 ohms.	If actuator coil is open or shorted to case, replace actuator. If governor still does not operate, continue with steps below.
1.8	Measuring the resistance of each coil lead to the actuator case should indicate an open circuit on a low scale of the ohm meter.	If continuity is detected, replace the actuator.
1.9	While cranking the engine, the following should be found when measuring current in series with one of the actuator leads from actuator: 12 V Act. - 2.5A to 5.9A 24 V Act. - 1.0A to 3.0A (Values may indicate negative if polarity of meter reversed.)	If no output current, replace the controller.

2. PROBLEM: ACTUATOR LEVER GOES TO FULL STROKE WHEN DC POWER IS TURNED "ON" (ENGINE IS NOT OPERATING.)

Means of Detection	Corrective Action
2.1 Check magnetic pickup leads for proper shielded wire or open shield.	Verify and correct wiring as necessary.
2.2 With DC power "OFF" remove leads at actuator. Check continuity of each terminal to heat sink. There should be no continuity between any terminal and heat sink.	If continuity is detected, replace the controller.
2.3 Check for shorted actuator lead.	Correct or replace actuator leads as necessary.

3. PROBLEM: ERRATIC GOVERNOR OPERATION

Means of Detection	Corrective Action
3.1 Measure DC voltage at battery positive and battery negative on controller. Nominal battery voltage should be indicated.	If nominal voltage is present, wiring is correct.
3.2 Battery voltage must be 80% or greater for governor to operate.	Check battery and charging system.
3.3 RFI noise due to incorrect shielding.	Correct wiring per applicable wiring diagram.
3.4 RFI noise fed through power supply leads.	Connect twisted pair power leads direct to the battery.

4. PROBLEM: SLOW, SMALL AMPLITUDE, HUNTING OF SPEED OR FREQUENCY

Means of Detection	Corrective Action
4.1 Sticking or very loose linkage.	Correct linkage.
4.2 Improper linkage arrangement. (Stroke too short or improper.)	See installation information.

5. PROBLEM: FAST OSCILLATION OF GOVERNOR LINKAGE

Means of Detection	Corrective Action
5.1 Verify calibration settings of the controller.	Readjust settings.

6. PROBLEM: ENGINE WILL NOT START — ACTUATOR AT FULL STROKE DURING CRANKING

Means of Detection	Corrective Action
6.1 Make sure fuel is available. Air may be trapped in fuel line. Try to operate engine manually.	Check fuel to engine and check for correct wiring to shut downs.

GENERAL MOTORS ENGINE MANUAL

FOR GS25 (20KW RATED & 25KW RATED) STANDBY GENERATORS WITH GM 3.0L GAS ENGINES

OPERATING INSTRUCTIONS

ENGINE WARM-UP

When the engine is below normal operating temperatures, allow the engine to idle for approximately five (5) minutes to allow it to warm up before applying a load.

STOPPING THE ENGINE

1. Decrease the engine speed back to the normal idle speed. Disengage the load from the engine.
2. Allow the engine to idle for four (4) to five (5) minutes at no load. This allows the engine to cool down. After four or five minutes, stop the engine by turning the key to the OFF position.

ENGINE OPERATING SYSTEM MAINTENANCE

A WORD ABOUT MAINTENANCE

We, at Industrial Engine Systems, want to help you keep the I.E.S. engine in good operating condition. Because of all the different ways people operate the engines, maintenance needs will vary. You may need more frequent checks and replacements than you find in this booklet. If you have questions on how to keep the engine in good condition, contact your I.E.S. Distributor or Dealer. It is a good idea to keep your maintenance receipts as they may be needed to qualify your vehicle for warranty repairs.

SELECTING YOUR ENGINE'S MAINTENANCE SERVICES

To find the proper maintenance schedule for the engine, you must

⚠ WARNING

Performing maintenance work on an engine can be dangerous. In trying to do some jobs, you can be seriously injured. Do your own maintenance work only if you have the required know-how and the proper tools and equipment for the job. If you have any doubt, have a qualified technician do the work.

know the type of engine and how it will be used. The engine type and operating conditions will tell you which schedule to follow. The chart is found later in this manual.

ENGINE SYSTEMS

COOLING SYSTEM GENERAL INFORMATION

The following explains the various cooling systems and how to add coolant when it is low.

The proper coolant for your engine will:

- Give freezing protection down to -29°C (-20°F).
- Give boiling protection up to 125°C (258°F).
- Protect against rust and corrosion.
- Help keep the proper engine temperature.
- Let the warning lights/gauges work as they should.

What to Use:

Use a mixture of **clean water** (preferably distilled) and antifreeze that meets "GM Specification 6038M" which will not damage aluminum parts. Also use GM Coolant Supplement (sealer). If you use these, you do not need to use anything else.

If you have to add coolant more than four times a year, or if the coolant is dirty or discolored, Have your Dealer check the cooling system.

NOTE: If you use an improper mix, your engine could overheat

⚠ WARNING

Adding plain water to your cooling system can be dangerous. Plain water or some other liquid, like alcohol, can boil before the proper coolant mix will. Your engine's coolant warning system is set for the proper coolant mix. With plain water or the wrong mix, your engine could get too hot but the overheat warning may not operate. Your engine could catch fire and you or others could get burned. Use a 56144 mix of clean water and a proper antifreeze.

and be badly damaged. The repair cost wouldn't be covered by your warranty. Too much water in the mix can result in freezing and cracking the engine, radiator/heat exchanger, heater core and other related cooling system parts. Some conditions, such as trapped air in the cooling system, can affect the coolant level. Check the coolant when the engine is cold and use the appropriate procedures found later in this section.

NOTE: If you use the proper coolant, you don't have to use extra inhibitors or additives which claim to improve the system. These can be harmful.

RADIATOR TYPE COOLING SYSTEMS

To Check Coolant:

When your engine is cold, the coolant should be at the COLD

> ⚠ WARNING
>
> **You can be burned if you spill coolant on hot engine parts. Coolant contains ethylene glycol and will burn if the engine parts are hot enough. Don't spill coolant on a hot engine**

mark (or a little higher) on the coolant recovery tank. When your engine is warm, the level should be up to HOT, or a little higher.

To Add coolant:

If you need more coolant, add the proper mix at the coolant recovery tank (if equipped). If not equipped with a coolant recovery tank, add the proper mix at the radiator opening ONLY when the engine is cold.

Radiator Pressure Cap

> ⚠ WARNING
>
> **Turning the coolant pressure cap while the engine and radiator are hot can allow steam and scalding liquids to blow out and burn you badly. With the coolant recovery tank, you almost never have to never add coolant at the radiator. Never turn the pressure cap, even a little, when the engine and radiator are hot.**

NOTE: Your radiator pressure cap is a 105 kPa (15 psi) pressure-type cap and must be tightly installed to prevent coolant loss and possible engine damage from overheating.

HEAT EXCHANGER - EXPANSION TANK SYSTEMS

To check coolant:

> ⚠ **WARNING**
>
> **Turning the coolant pressure cap while the engine and heat exchanger expansion tank are hot can allow steam and scalding liquids to blow out and burn you badly. Never turn the pressure cap, even a little, when the engine and heat exchanger-expansion tank are hot.**

When your engine is cold, remove the coolant pressure cap. The coolant level should be one inch (1") below the top of the expansion tank.

To Add coolant:

If you need more coolant, add the proper mix to the expansion tank when cold.

Coolant Pressure Cap

NOTE: Your coolant pressure cap is a 50 kPa (7 psi) pressure-type cap and must be tightly installed to prevent coolant loss and possible engine damage from overheating.

THERMOSTAT

Engine coolant temperature is controlled by the thermostat(s) in the engine coolant system. The thermostat(s) stop the flow of coolant through the radiator until the coolant reaches a preset temperature.

ENGINE OIL REQUIREMENT

It is a good idea to check the engine oil every time you refuel.

Turn off the engine and allow a few minutes for the oil to drain back into the oil pan. If you don't, the oil indicator gauge might not show the actual level.

What Kind of Oil to Use

ALWAYS USE "SH" QUALITY ENERGY CONSERVING II OILS OF PROPER VISCOSITY.

The "SH" designation may be shown alone or in combination with other designations such as SH/CD, SH/SG, etc. These letters show American Petroleum Institute (API) levels of quality.

NOTE: If you use oils that don't have the proper designation, you can cause engine damage not covered by your warranty.

Engine Oil Additives:

Do not add anything to your oil. Your dealer is ready to advise you if you think something should be added.

Synthetic Oils:

IMPCO Engine Systems neither disapproves nor recommends the use of synthetic engine oils. Synthetics may offer advantages in cold temperature pumpability and high temperature oxidation resistance. However, synthetic oils have not been proven to provide operational or economic benefits over conventional petroleum-based oils in IMPCO engines. Their use does not permit the extension of oil change intervals.

⚠ WARNING

Operating the engine with the air cleaner off can cause you or others to be burned. The air cleaner not only cleans the air, it stops flame if the engine backfires. If it isn't there, and the engine backfires, you could be burned. Be careful working on the engine with the air cleaner off.

⚠ CAUTION

If the air cleaner is off, a backfire can cause a damaging engine fire. In addition, dirt can easily get into the engine, which will damage it. Always have the air cleaner in place when operating the engine.

AIR CLEANER SERVICE

See the maintenance schedule to find out how often to inspect and/or replace the air filter and crankcase breather on your engine.

The dry-type air cleaner consists of a removable cover attached to the lower air cleaner body. The body contains a replaceable paper filter cartridge. The air passes through the paper filter element and enters the engine. Some air cleaners may be equipped with a restriction indicator which aids in determining the servicing intervals.

NOTE: Most dry-type air cleaners must be discarded and replaced at specific intervals. Before attempting to clean reuse a dry-type element, follow the manufacturer's recommendations regarding reuse and follow their prescribed cleaning and inspection guidelines. Information regarding replacement air filter elements will be found on an information label attached to the air cleaner body.

Changing Filter Element

To remove the air filter on naturally aspirated engine models, turn the wingnut counterclockwise. Remove the cover, change the filter, and reinstall cover and wingnut.

3.0L INSTALLATION SETUP DATA

The following information lists the changes required when operating engines on different fuels. All engines shipped from Crusader are setup to operate on natural gas fuel. If the engine is going to be operated on propane fuel, the engine setup must be changed (as noted below) to prevent premature engine failure.

NATURAL GAS (NG) OPERATION (3.0L)

The following in formation on this page reflects the engine setup as shipped from the factory.

Mixer Assembly .... IMPCO Model FB125M

Fuel Regulator* .... IMPCO Model IMP-53

*Recommended regulators - not supplied with engine (dealer option).

Fuel Inlet Pressure to Mixer.................. 139.70 mm Wg ± 12.7 mm
(+5.5 in. WC ± 0.5 in. at idle)

Base Timing .... 16° BTDC at 700 RPM

Maximum Total Timing Advance ....36° BTDC at 2600 RPM

Air / Fuel Mixture .... 2% O_2 (Exhaust) at Rated Speed and Power

Fuel Supply Inlet Pressure (Ng):

Inlet fuel pressure (natural gas) to the regulator must be maintained between 177-356 mm Wg (7-14" WC) during full power operation. The low pressure regulator (LPR) is designed to supply the correct gas pressure to the mixer. Regulators MUST NOT be mounted further than 18 in. from mixer for best operation.

All fuel system installations must meet all federal, state, and local codes I along with applicable NFPA regulations.
Specifications revised 3/28/95

PROPANE GAS (LPG) OPERATION (3.0L)

Mixer Assembly .... IMPCO Model CA100M
(Air Valve CV1-16-2)

Fuel Regulator*

Vapor Fuel .... IMPCO Model IMP53

Liquid Fuel: .... IMPCO Model EB or JB
w/VFF3O Vacuum Fuelock Filter

*Recommended regulators not supplied with engine (dealer option).

NOTE: A balance line should be installed between the gas mixer and the regulator when operating this engine in a dusty or dirty environment.

Fuel Inlet Pressure to Mixer .... -50.8 ± 12.7 mm Wg
(-2.0 ± 0.5in. WC at idle)

Base Timing .... 12° BTDC at 700 RPM

Maximum Total Timing Advance .... 30° BTDC at 2600 RPM

Air / Fuel Mixture .... 0.5 to 1.5% CO (Exhaust)
at Rated Speed and Power

Fuel Supply Inlet Pressure (LPG):

• With engines operating on **LPG Vapor,** the fuel pressure at the regulator inlet must be maintained between 177-356 mm WG (7-14" WC) during full power operation. The low pressure regulator (LPR) is designed to supply the correct gas pressure to the mixer. Regulators must not be mounted further than 18 in. from the mixer for best operation.

• With engines operating on **Liquid LPG,** require full tank pressure to both the VFF3O Fuel Lockoff Valve and EB model regulator during full power operation

All fuel system installations must meet all federal, state, and local codes I along with applicable NFPA regulations.
Specifications revised 3/28/95

3.0L GENERAL SPECIFICATIONS

Engine

Type .... Spark Ignition, Gaseous Fuel L4

Rating .... 55 Hp @ 2600 RPM

Displacement .... 3.0 Liter (181 c.i.d.)

Bore .... 101.6 mm (4.00 in.)

Stroke .... 91.44 mm (3.48 in.)

Compression Ratio .... 8.2:1 or 9.25:1

Ignition System .... Delco EST

Timing .... 12° BTDC (LPG)

16° BTDC (Nat Gas)

Spark Plugs .... AC R42T 0.037 in. gap

Firing Order 1-3-4-2

Idle .... 700 RPM

3600 Intermittant

2600 Continuous Duty

Lubrication System

Oil Pressure .... 207-414kPa (30-60 PSI) at 2000 RPM

.... 28 kPa (4 PSI) at Idle Minimum

Oil Type ....SAE 10w30 SG/SH All Temperatures
SAE 30 SG/SH below 5°-27° C (40°-80° F)
SAE 40 SG/SH above 27° C (80° F)
SAE 15w40 SG/SH above -18° (0° F)

Oil Filter ....AC-PF25 (1 Qt.) or PF932 (2 Qt.)

Oil Capacity *w/o* Filter .... 4.7L (5 Qts.) (small pan)
26.50L (28 Qts.) (large pan)
Add 0.95L (1 QT.) w/ small filter

Fill to dipstick FULL Mark

Fuel System

Gas Mixer

Propane: ....IMPCO CA100M

Natural Gas: .... IMPCO FB125 W/AVI-1447 Air Valve

Air Induction System

Air Filter Element

Irrigation .... CRU 80487

Industrial .... CRU 80481

Crankcase Oil Separator .... CRU 80008

PCV Valve .... AC CV736C

Cooling System

Thermostat

71°C (160°F) .... CRU 80215

(as required) 82°C (180°F) .... CRU 80216

Starting System

Type .... 12 volt negative ground

Delco SD300 (12.75" Flywheel)

Delco PG260 (14.00" Flywheel)

Battery Requirement .... 485 CCA Minimum

Starter .... Delco

Charging System

Alternator .... Mando 12 volt

Rating .... 51 Amps

PRESSURE CONVERSION CHART

1 IN. WATER = 0.0735 IN. MERCURY
1 IN. WATER = 0.0361 PSI
1 IN. MERCURY = 13.6000 IN. WATER
1 IN. MERCURY = 0.4910 PSI
1 PSI = 27.7000 IN. WATER
1 PSI = 2.0360 IN. MERCURY
1 PSI = 6.895 kPa
1 kPa = 0.145 PSI

TAYLOR

POWER SYSTEMS

GS25

STANDBY GENERATORS WITH
GENERAL MOTORS 3.0L GAS ENGINES
PARTS MANUAL
20KW RATED & 25KW RATED

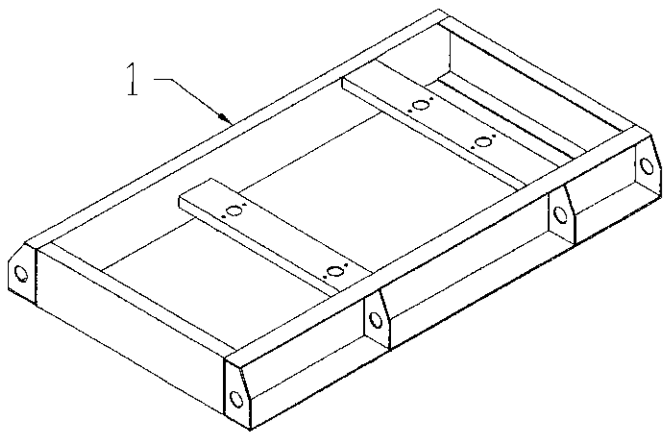
TAYLOR POWER SYSTEMS
461 HIGHWAY 49 SOUTH
RICHLAND, MS. 39218
PHONE (610) 932-5674
FAX (601) 932-4028

TAYLOR POWER SYSTEMS

VT082225

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20	

SKID BASE



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT082225	SKID BASE	1

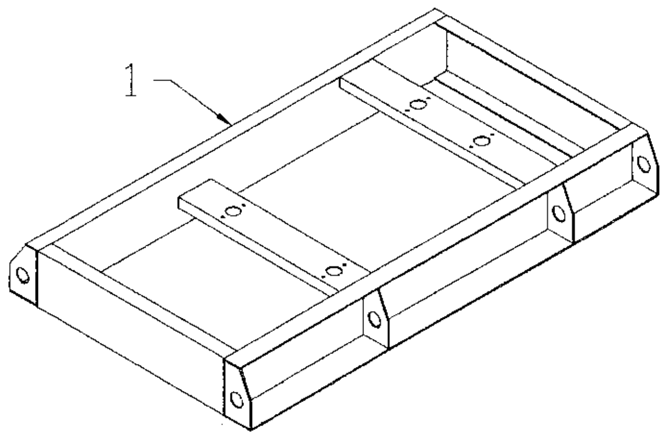
7-17-00

TAYLOR
POWER SYSTEMS

VT082223

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS25	

SKID BASE



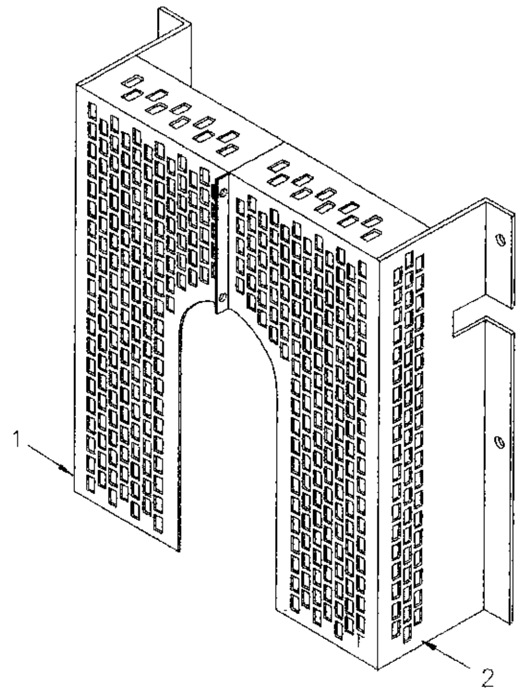
ITEM	PART NO.	DESCRIPTION	QTY.
1	VT082223	SKID BASE	1

7-17-00

TAYLOR
POWER SYSTEMS

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20/GS25	

FAN GUARD



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT060434	LEFT SIDE FAN GUARD	1
2	VT060433	RIGHT SIDE FAN GUARD	1

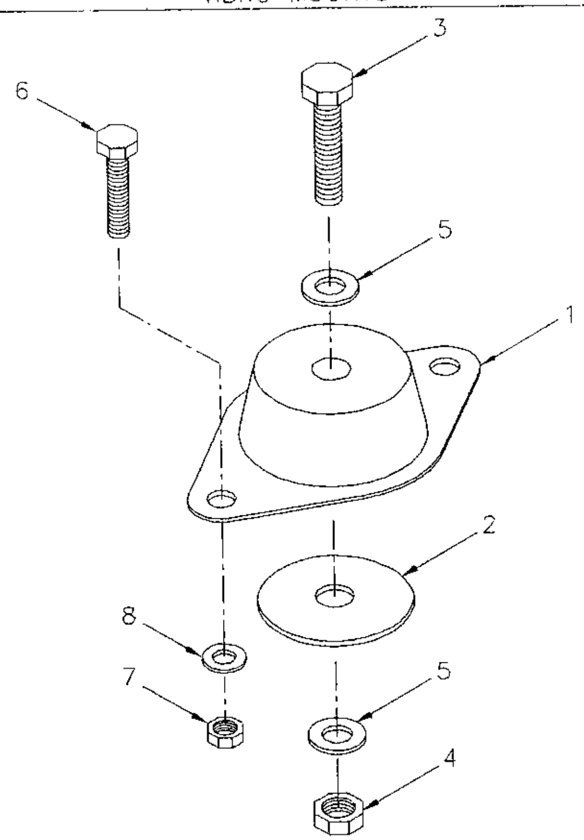
7-17-00

TAYLOR POWER SYSTEMS

VTGRU01032

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL DS20/GS20/GS25	

VIBRO MOUNTS



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT2S6416	VIBRO MOUNTS	4
2	VT981014502	SNUBBING WASHER	4
3	VT37C250CSZ	3/8 X 2 1/2 BOLT	4
4	VT37CCNEZBU	3/8 LOCKNUT	4
5	VT37NWUSZBU	3/8 FLATWASHER	8
6	VT31C100CSZ	5/16 X 1 BOLT	8
7	VT31CCNEZ	5/16 LOCKNUTS	8
8	VT31NWUSZBU	5/16 FLATWASHER	8

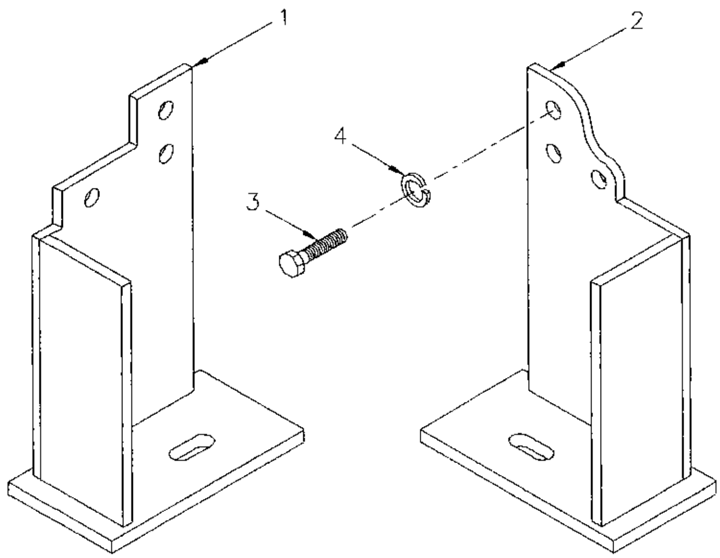
7-17-00

TAYLOR
POWER SYSTEMS

VTGRU01038

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20/GS25	

MOUNTING FEET



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT082231	LEFT FRONT MOUNT	1
2	VT082232	RIGHT FRONT MOUNT	1
3	VT37C100CSZ	3/8 X 1 BOLT	6
4	VT37NLOCZ	3/8 LOCKWASHER	6

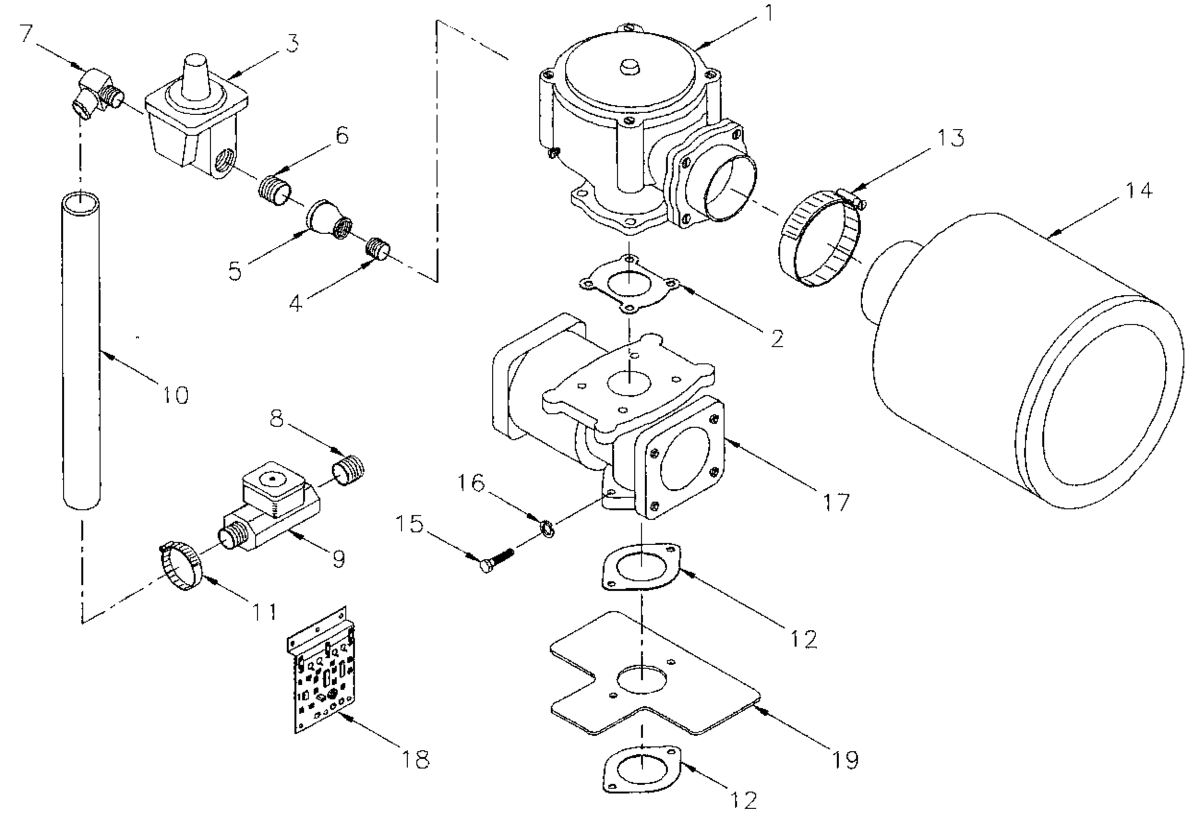
7-17-00

TAYLOR POWER SYSTEMS

VTGRU03078

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20/GS25	

FUEL SYSTEM



ITEM	PART NO.	DESCRIPTION	QTY.
1	VTN000803A	CARBURETOR MIXER	1
2	VTN006708A	CARBURETOR ADAPTER	1
3	VT1MP52	3/4" REGULATOR	1
4	VT1/2CLSNIP	1/2" CLOSE NIPPLE	1
5	VT1/2X3/4BR	1/2" X 3//4" BELL REDUCER	1
6	VT3/4XCLOSE	3/4" CLOSE NIPPLE	2
7	VT86EN	3/4" X 1" ELBOW	1
8	VT86SN	3/4" X 1" STRAIGHT FITTING	1
9	VTSNC3/4	VALVE 12VDC 3/4"	1
10	VTVAPOR	1" VAPOR HOSE	4 ft.
11	VT7051060	1" HOSE CLAMP	2
12	VTG119	GASKETS	2
13	VT7051108	2" HOSE CLAMP	1
14	VTECC065002	AIR CLEANER	1
15	VT37C100CSZ	3/8 X 1 BOLT	2
16	VT37NLOCZ	3/8 LOCKWASHER	2
17	VTDYNC60020	ACTUATOR	1
18	VTDYN110744	CONTROLLER (INSIDE CONTROL PANEL BOX)	1
19	VT082235	HEAT SHIELD	1

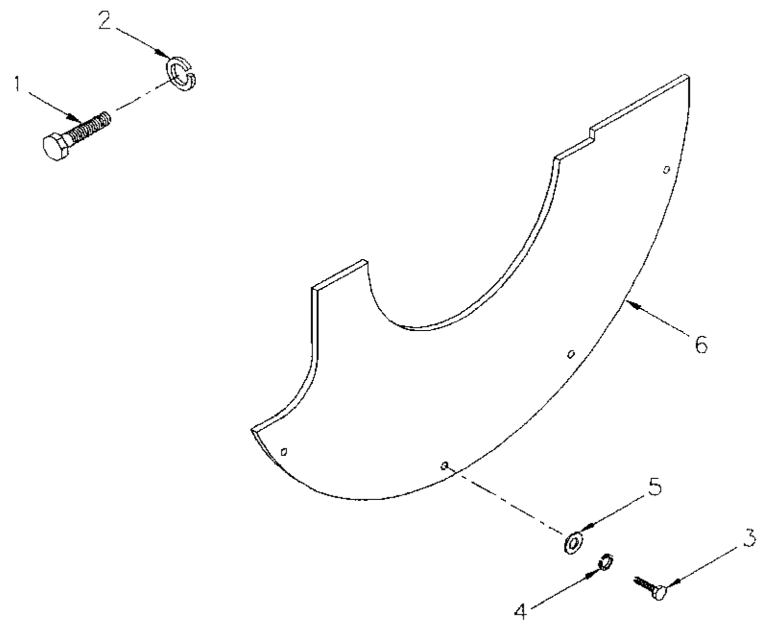
7-17-00

TAYLOR POWER SYSTEMS

VTGRU05018

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20/GS25	

NEWAGE GENERATOR TO ENGINE BOLTS



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT37C150CSZ	3/8 X 1 1/2 BOLT (SECURE GENERATOR TO ENGINE)	12
2	VT37NLOCZ	LOCKWASHER (SECURE GENERATOR TO ENGINE)	12
3	VT25C75CCSS	1/4 X 3/4 BOLT	4
4	VT25NLOCS	1/4 LOCKWASHER	4
5	VT25N62WSSS	1/4 FLATWASHER	4
6	VT082239	FLYWHEEL COVER	1

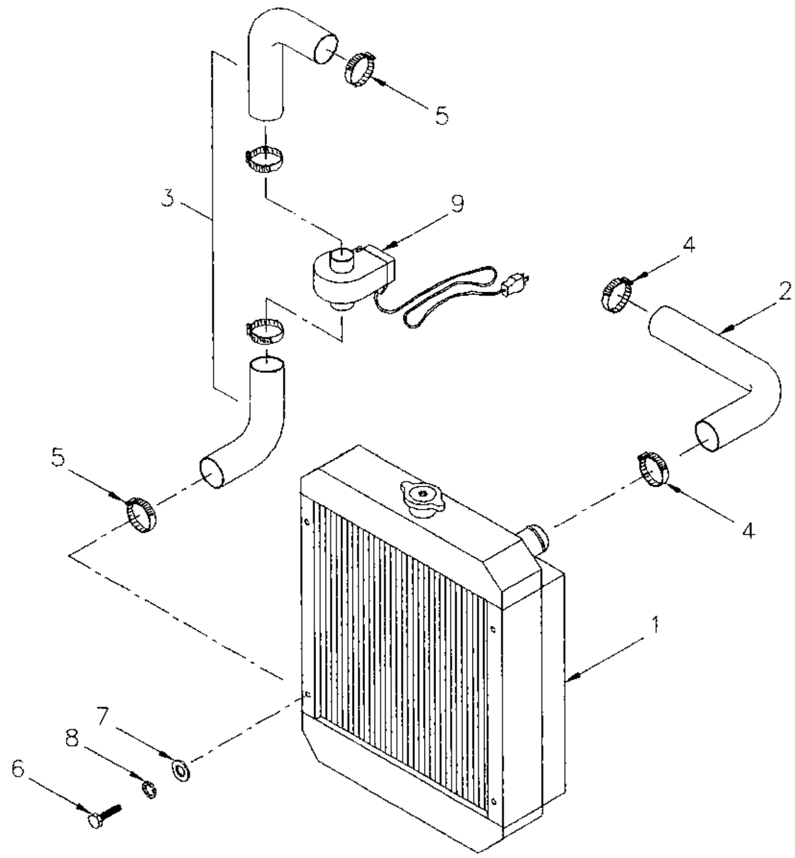
7-17-00

TAYLOR
POWER SYSTEMS

VTGRU06045

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20/GS25	

COOLING SYSTEM



ITEM	PART NO.	DESCRIPTION	QTY.
1	VTRS4352	RADIATOR	1
2	VT715	RADIATOR HOSE	1
3	VT7133	RADIATOR HOSE	1
4	VT7051105	CLAMP #20	2
5	VT7051107	CLAMP #28	2
6	VT31C75CCSS	5/16 X 3/4 BOLT	4
7	VT31N75WSSS	5/16 FLATWASHER	4
8	VT31NLOCS	5/16 LOCKWASHER	4
9	VT3200004	BLOCKHEATER (INCLUDES TWO HOSE CLAMPS)	1

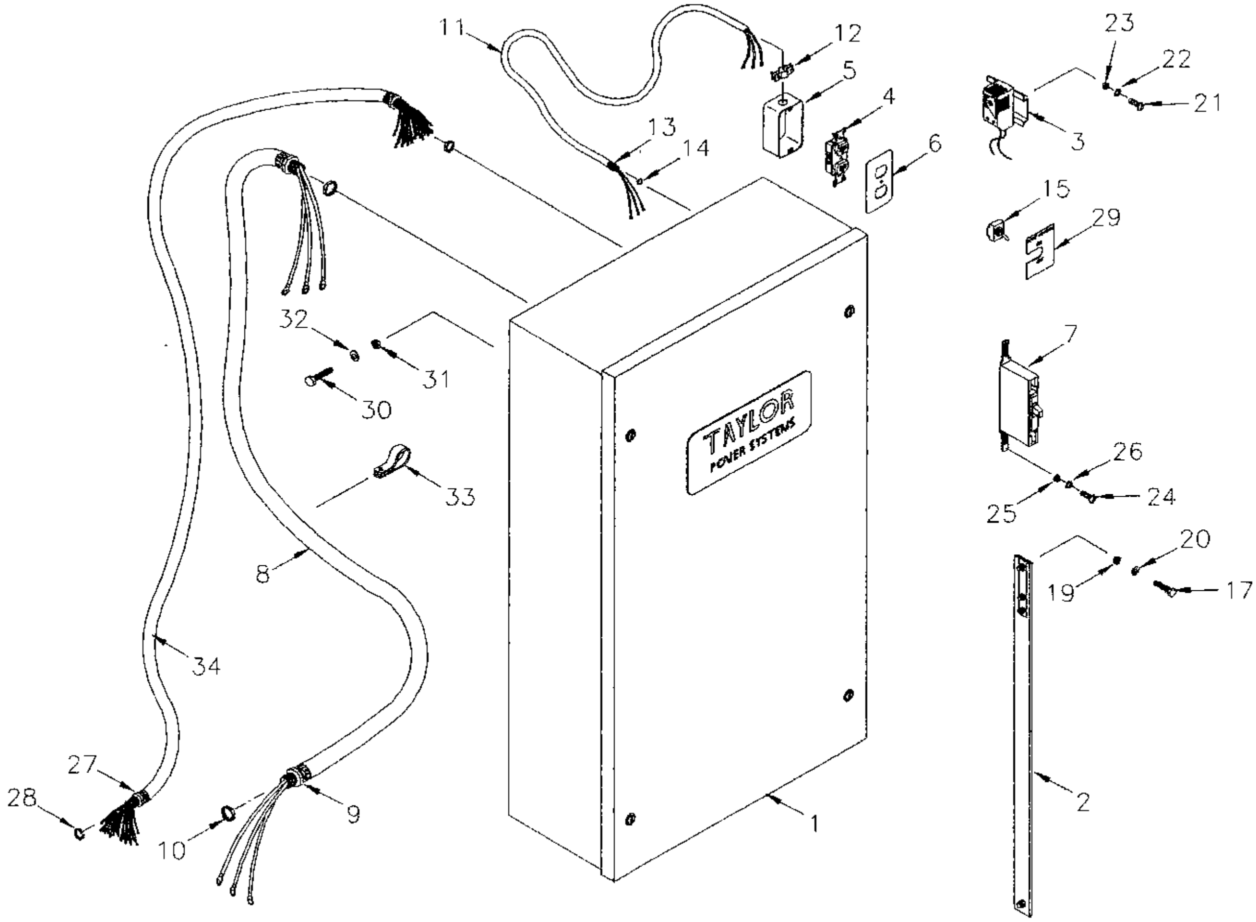
7-17-00

TAYLOR
POWER SYSTEMS

VTGRU07150

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL DS20/GS20/GS25/DS25	

TRANSFORMER & POWER DISTRIBUTION



ITEM	PART NO.	DESCRIPTION	QTY.
1	VTRTHMFDA20	200A AUTOMATIC TRANSFER SWITCH	1
2	VTS1J17RU1	STRIP HEATER (MOUNTED INSIDE TRANSFER SWITCH)	1
3	VTATEMNC	THERMOSTAT (MOUNTED INSIDE TRANSFER SWITCH)	1
4	VTCR15BBU	DUPLEX RECEPTACLE (MOUNTED ON SKID)	1
5	VT660	HANDY BOX (MOUNTED ON SKID)	1
6	VT2510	RECEPTACLE COVER (MOUNTED ON SKID)	1
7	VTQOU115	BREAKER (MOUNTED INSIDE TRANSFER SWITCH)	1
8	VT071069	2/3 POWER CORD	1
9	VTCG112125	1 1/4 CORD GRIP	2
10	VT804	1 1/4 LOCKNUT	2
11	VT071070	POWER CORD FOR DUPLEX RECEPTACLE	1
12	VT6623	1/2 ROMEX CONNECTOR	1
13	VTCG5050	1/2 CORD GRIP	1
14	VT801	1/2 LOCKNUT	1
15	VTSS2011BG	TOGGLE SWITCH (MOUNTED INSIDE TRANSFER SWITCH)	1
16	VT25C75CCSS	1/4 X 3/4 BOLT	2

8-8-00

TAYLOR POWER SYSTEMS

VTGRU07150

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL DS20/GS20/GS25/DS25	

TRANSFORMER & POWER DISTRIBUTION

ITEM	PART NO.	DESCRIPTION	QTY.
17	VT25C100CCSS	1/4" X 1" BOLT	2
18	VT25CCFHS	1/4" NUTS	2
19	VT25CCNES	1/4" LOCKNUTS	4
20	VT25N62WSSS	1/4" FLATWASHER	8
21	VT10C50MSRS	#10 X 1/2" SCREW	2
22	VT10N37WSSS	#10 FLATWASHER	4
23	VT10CCNMS	#10 LOCKNUT	2
24	VT8C50MSRS	#8 X 1/2" SCREW	2
25	VT8CCNMSS	#8 LOCKNUT	2
26	VT8NWSSS	#8 FLATWASHER	4
27	VTCG75100	1" X 3/4" CORD GRIP	2
28	VT803	1" LOCKNUTS	2
29	VTSK0240	DECAL PLANT EXERCISER (AROUND TOGGLE SWITCH)	1
30	VT37C100CSZ	3/8" X 1" BOLT	4
31	VT37CCNEZBU	3/8" LOCKNUT	4
32	VT37NWUSZBU	3/8" FLATWASHER	8
33	VT25716	CLAMP	1
34	VT071091	DRY CONTACT CABLE	1

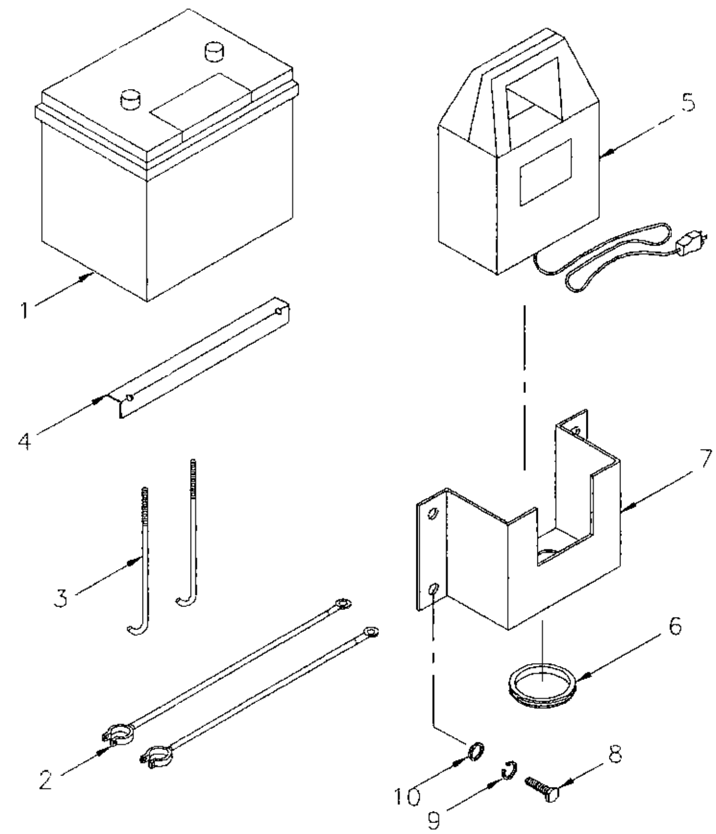
8-8-00

TAYLOR POWER SYSTEMS

VTGRU07152

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20/GS25	

BATTERY GROUP



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT6026	BATTERY	1
2	VT711931	BATTERY CABLE	2
3	VTHD18	J BOLT	2
4	VT082194	BATTERY HOLD DOWN	1
5	VT85315	BATTERY CHARGER	1
6	VT1070	GROMMET	1
7	VT082202	BATTERY CHARGER MOUNT	1
8	VT25C75CCSS	1/4 X 3/4 BOLT	4
9	VT25CCNES	1/4 LOCKWASHER	4
10	VT25N62WSSS	1/4 FLATWASHER	8

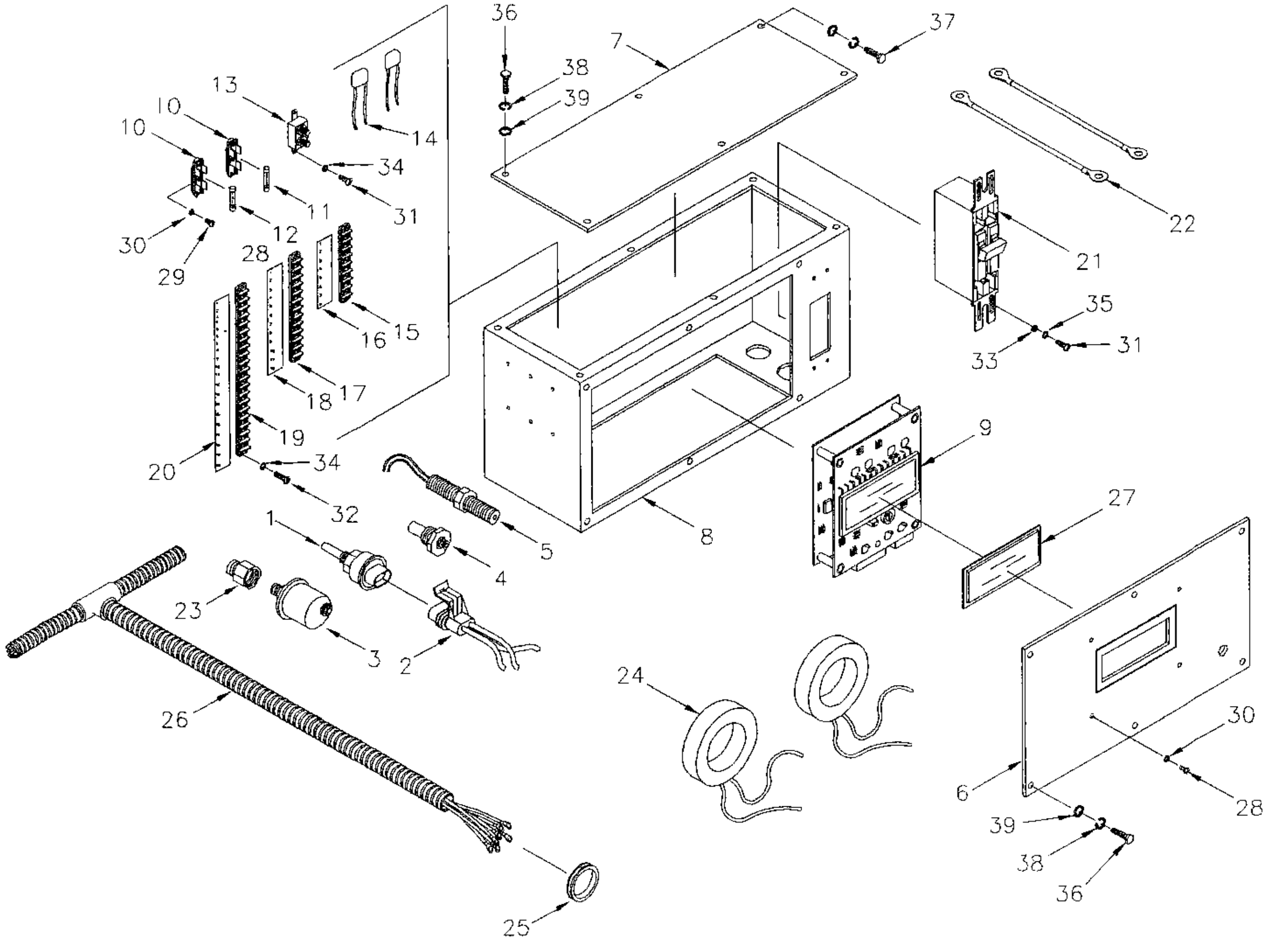
7-17-00

TAYLOR
POWER SYSTEMS

VTGRU07153

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20/GS25	

CONTROL PANEL



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT813NLU000	LOW COOLANT SWITCH	1
2	VT086432A	CONNECTOR	1
3	VTSD0006	PRESSURE SENDER	1
4	VTTS4042	TEMPERATURE SENDER	1
5	VTMSP6730	MAG PICK--UP	1
6	VT071076	CONTROL PANEL PLATE	1
7	VT071042	CONTROL PANEL TOP COVER	1
8	VT071068	CONTROL BOX	1
9	VTDCMTRITEL	DIGITAL CONTROL MODULE	1
10	VT47065	FUSE HOLDER	2
11	VT46110	10A FUSE	1
12	VT46115	15A FUSE	1

8--8--00

TAYLOR
POWER SYSTEMS

VTGRU07153

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20/GS25	

CONTROL PANEL

ITEM	PART NO.	DESCRIPTION	QTY.
13	VT46531	30A BREAKER	1
14	VT65010082	DIODE	2
15	VT47308	8 TERMINAL STRIP	1
16	VT8141MS	8 TERMINAL STRIP MARKER	1
17	VT12141	12 TERMINAL STRIP	1
18	VT12141MS	12 TERMINAL STRIP MARKER	1
19	VT20141	20 TERMINAL STRIP	1
20	VT20141MS	20 TERMINAL MARKER STRIP	1
21	VTQOU2100	100A BREAKER	1
22	VT071071	#6 SRML & 34001 TERMINAL & #6 BREAKER WIRES	2
23	VT3200X2	ADAPTER	1
24	VT100/5 CTS	CTS	2
25	VT1044	GROMMET	1
26	VT071093	ENGINE HARNESS	1
27	VT071090	WINDOW	1
28	VT6C25PSMSS	SCREWS	4
29	VT6C37MSRS	#6 SCREW	2
30	VT6NLOCS	#6 LOCKWASHER	6
31	VT8C50MSRS	#8 X 1/2" SCREW	6
32	VT8C75MSRS	#8 X 3/4" SCREW	6
33	VT8CCNMSS	#8 LOCKNUT	4
34	VT8NLOCS	#8 LOCKWASHER	8
35	VT8NWSSS	#8 FLATWASHER	8
36	VT25C50CCSS	1/4" X 1/2" BOLT	11
37	VT25C75CCSS	1/4" X 3/4" BOLT	1
38	VT25NLOCS	1/4" LOCKWASHER	12
39	VT25N62WSSS	1/4" FLATWASHER	12

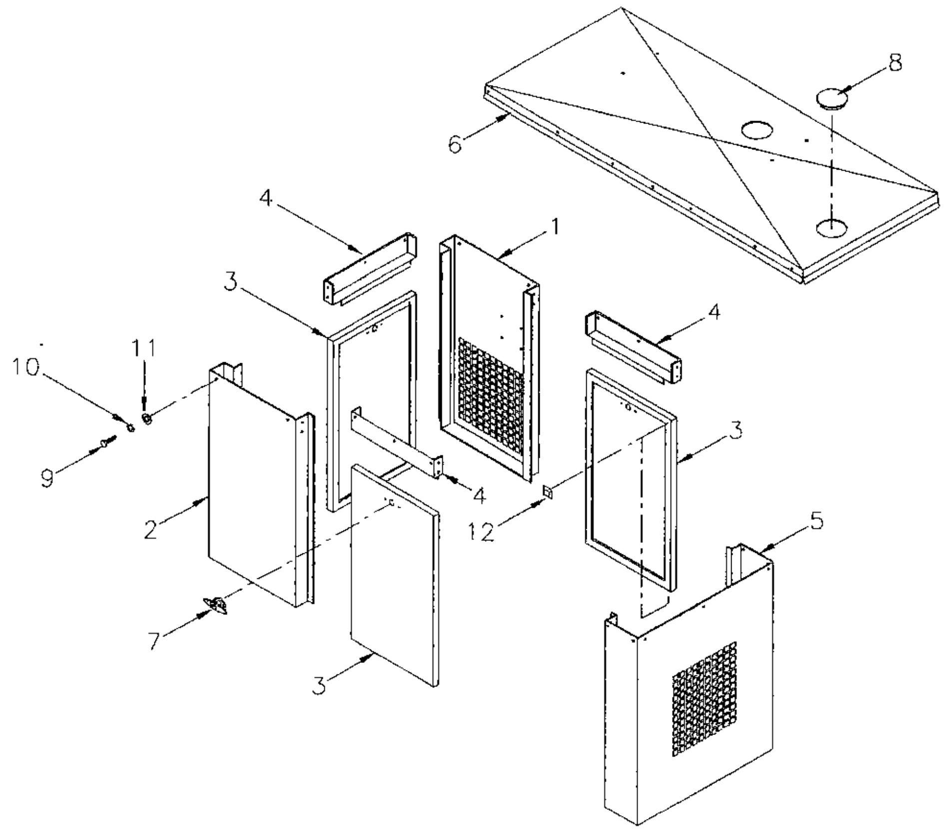
8-8-00

TAYLOR POWER SYSTEMS

VTGRU08132

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS20	

ENCLOSURE



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT082236	LEFT REAR CORNER	1
2	VT082237	RIGHT REAR CORNER	1
3	VT082197	DOOR	3
4	VT082198	DOOR MULL	3
5	VT082226	FRONT COVER	1
6	VT082224	TOP COVER	1
7	VT9221531	LATCH	3
8	VT9750K67	FINISHING PLUG	1
9	VT25C75CCSS	BOLT	40
10	VT25CCNES	LOCKWASHER	40
11	VT25N62WSSS	FLATWASHER	80
12	VT97006	RUBBER BUMPER	12

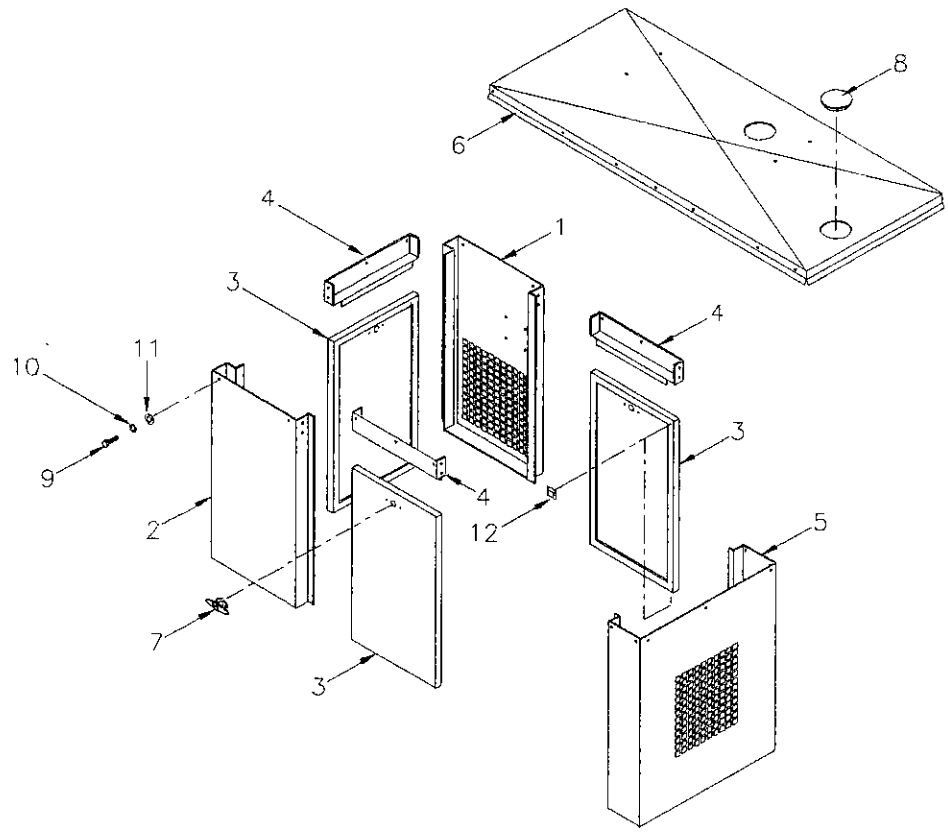
7-17-00

TAYLOR POWER SYSTEMS

VTGRU08135

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL GS25	

ENCLOSURE



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT082212	LEFT REAR CORNER	1
2	VT082213	RIGHT REAR CORNER	1
3	VT082197	DOOR	3
4	VT082198	DOOR MULL	3
5	VT082221	FRONT COVER	1
6	VT082222	TOP COVER	1
7	VT9221531	LATCH	3
8	VT9750K67	FINISHING PLUG	1
9	VT25C75CCSS	BOLT	40
10	VT25CCNES	LOCKWASHER	40
11	VT25N62WSSS	FLATWASHER	80
12	VT97006	RUBBER BUMPER	12

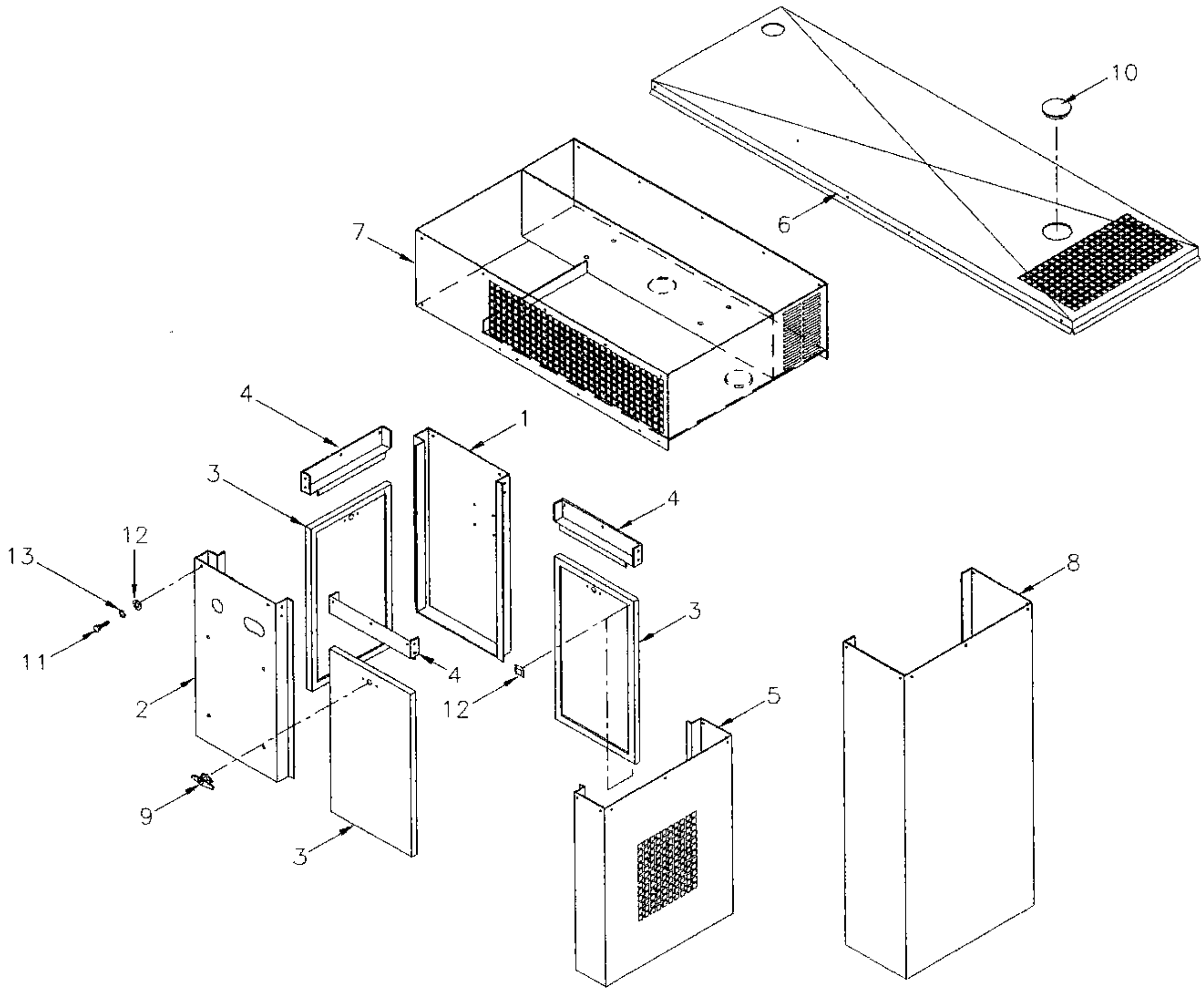
7-17-00

TAYLOR POWER SYSTEMS

VTGRU08134

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL	

SOUND ATTENUATED ENCLOSURE page 1 of 2



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT082238	LEFT REAR CORNER	1
2	VT082237	RIGHT REAR CORNER	1
3	VT082197	DOOR	3
4	VT082198	DOOR MULL	3
5	VT082226	FRONT COVER	1
6	VT082230	TOP COVER	1
7	VT082229	TOP SOUND BOX	1
8	VT082204	FRONT SOUND BOX	1
9	VT9221531	LATCH	3
10	VT9750K67	FINISHING PLUG	1
11	VT25C75CCSS	BOLT	50
12	VT25CCNES	LOCKWASHER	50
13	VT25N62WSSS	FLATWASHER	100

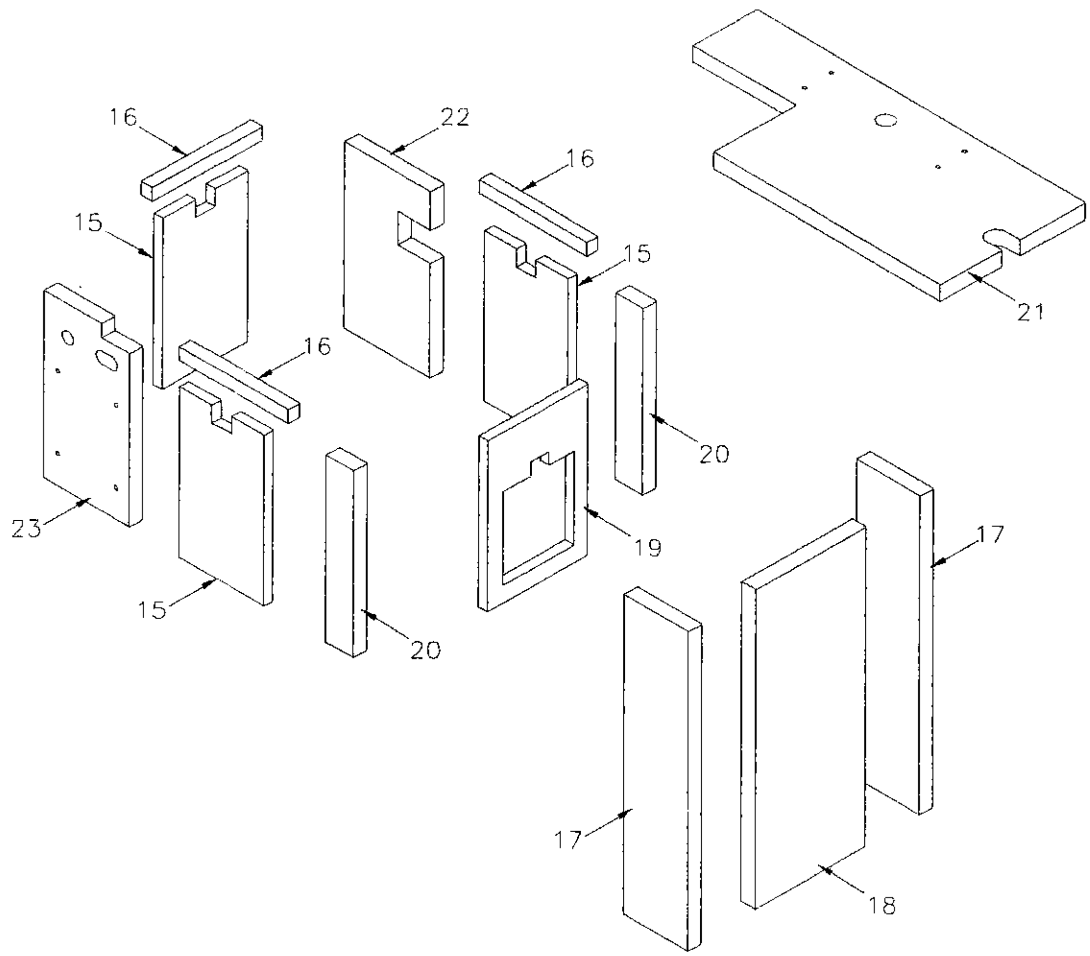
7-17-00

TAYLOR
POWER SYSTEMS

VTGRU08134

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL	

SOUND ATTENUATED ENCLOSURE page 2 of 2



ITEM	PART NO.	DESCRIPTION	QTY.
14	VT7701856	WEATHER STRIP (AROUND DOORS)	4 ROLLS
15	VT082247	DOOR FOAM	3
16	VT082248	DOOR MULL FOAM	3
17	VT082258	L & R FRONT SOUND BOX FOAM	2
18	VT082261	FRONT BOX FOAM	1
19	VT082260	FRONT COVER FOAM	1
20	VT082256	L & R FRONT CORNER FOAM	2
21	VT082263	TOP BOX FOAM	1
22	VT082251	LEFT REAR CORNER FOAM	1
23	VT082252	RIGHT REAR CORNER FOAM	1

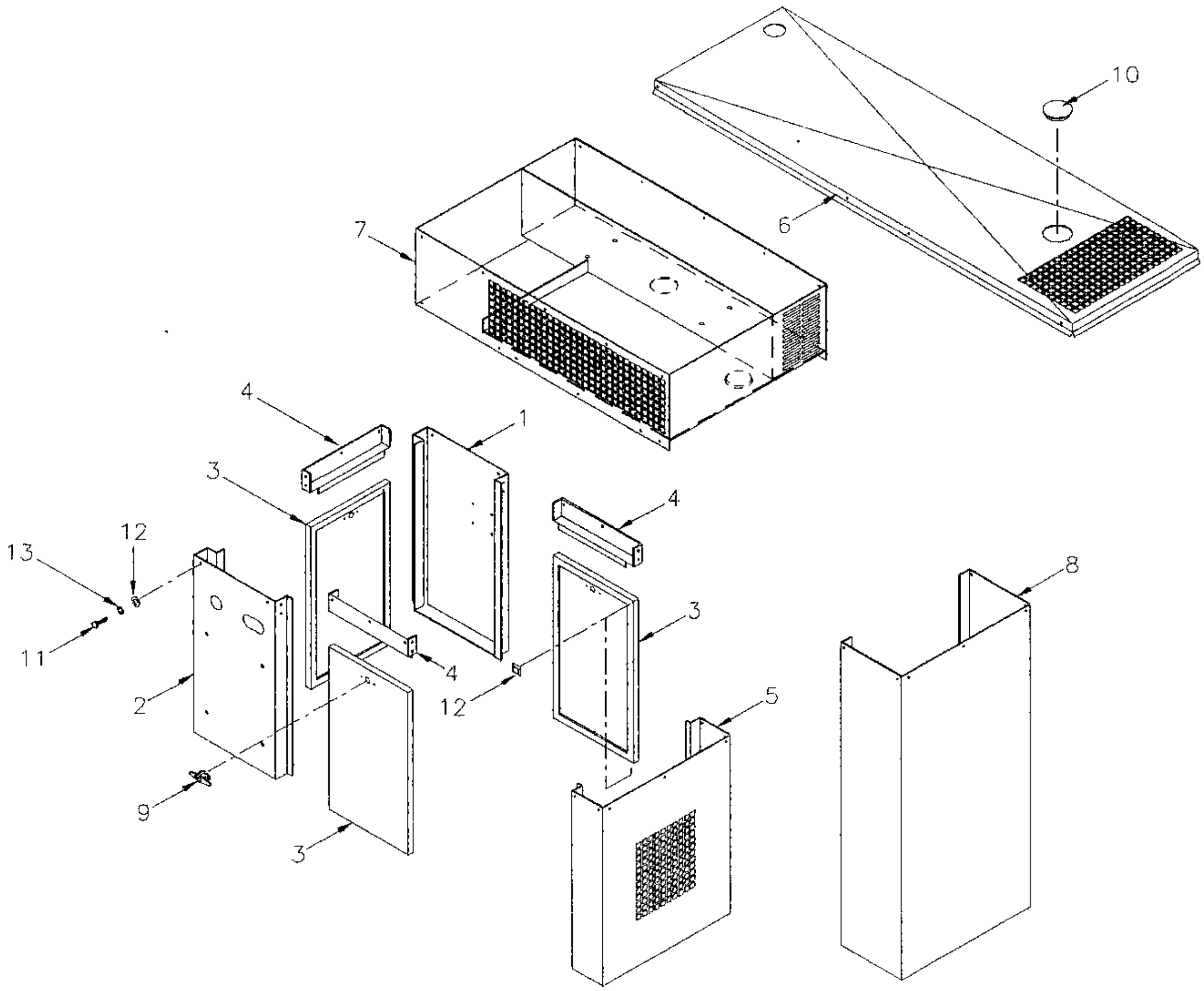
7-17-00

TAYLOR POWER SYSTEMS

VTGRU08136

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL	

SOUND ATTENUATED ENCLOSURE page 1 of 2



ITEM	PART NO.	DESCRIPTION	QTY.
1	VT082217	LEFT REAR CORNER	1
2	VT082213	RIGHT REAR CORNER	1
3	VT082197	DOOR	3
4	VT082198	DOOR MULL	3
5	VT082221	FRONT COVER	1
6	VT082228	TOP COVER	1
7	VT082227	TOP SOUND BOX	1
8	VT082204	FRONT SOUND BOX	1
9	VT9221531	LATCH	3
10	VT9750K67	FINISHING PLUG	1
11	VT25C75CCSS	BOLT	50
12	VT25CCNES	LOCKWASHER	50
13	VT25N62WSSS	FLATWASHER	100

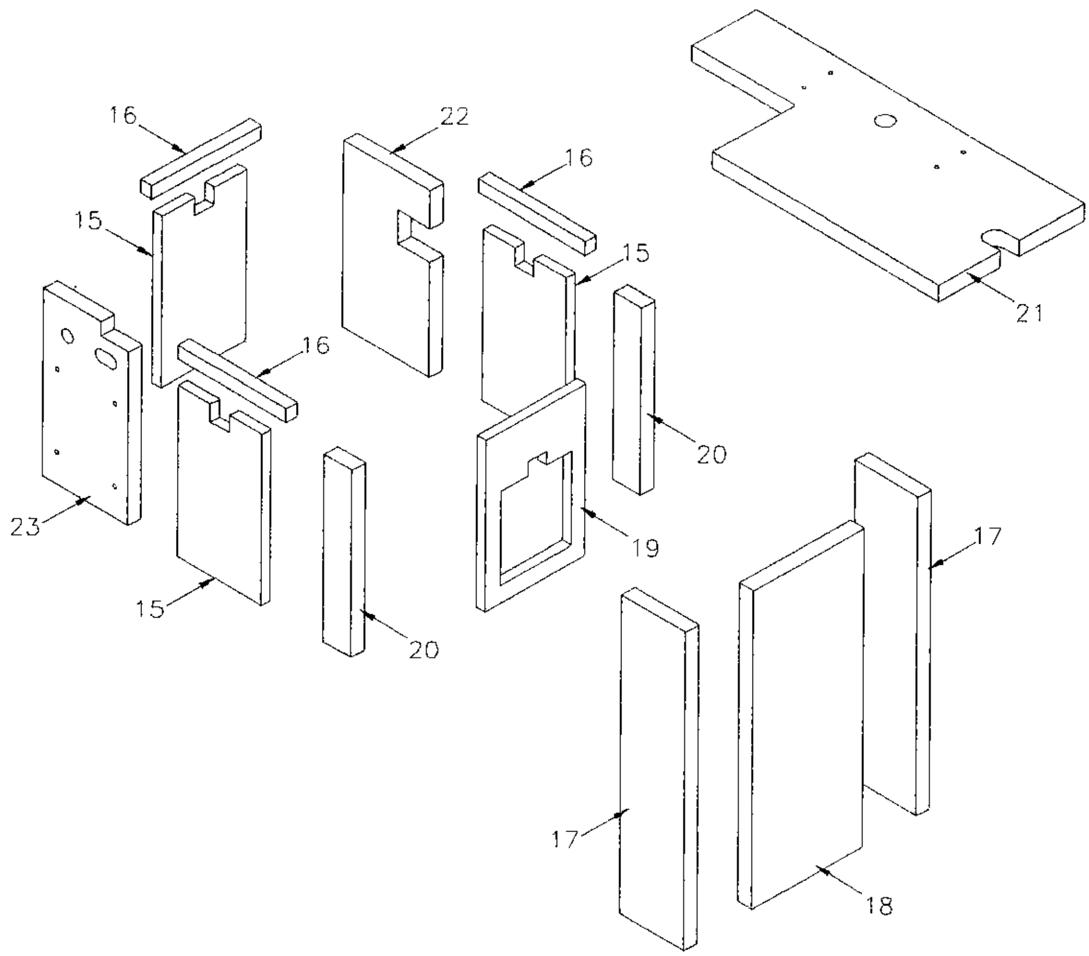
7-17-00

TAYLOR POWER SYSTEMS

VTGRU08136

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL	

SOUND ATTENUATED ENCLOSURE page 2 of 2



ITEM	PART NO.	DESCRIPTION	QTY.
14	VT7701856	WEATHER STRIP (AROUND DOORS)	4 ROLLS
15	VT082247	DOOR FOAM	3
16	VT082248	DOOR MULL FOAM	3
17	VT082258	L & R FRONT SOUND BOX FOAM	2
18	VT082261	FRONT BOX FOAM	1
19	VT082260	FRONT COVER FOAM	1
20	VT082257	L & R FRONT CORNER FOAM	2
21	VT082264	TOP BOX FOAM	1
22	VT082253	LEFT REAR CORNER FOAM	1
23	VT082254	RIGHT REAR CORNER FOAM	1

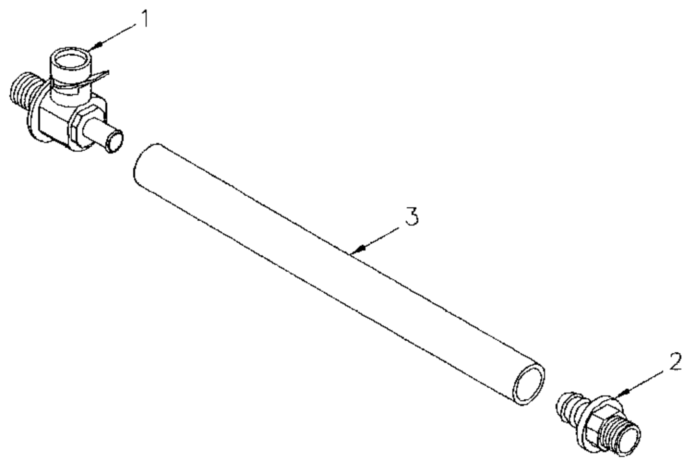
7-17-00

TAYLOR POWER SYSTEMS

VTGRU09019

MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL	

OIL DRAIN



ITEM	PART NO.	DESCRIPTION	QTY.
1	VTF101N	DRAIN VALVE	1
2	VT3018266B	FITTING	1
3	VT8366	HOSE	2 FT.

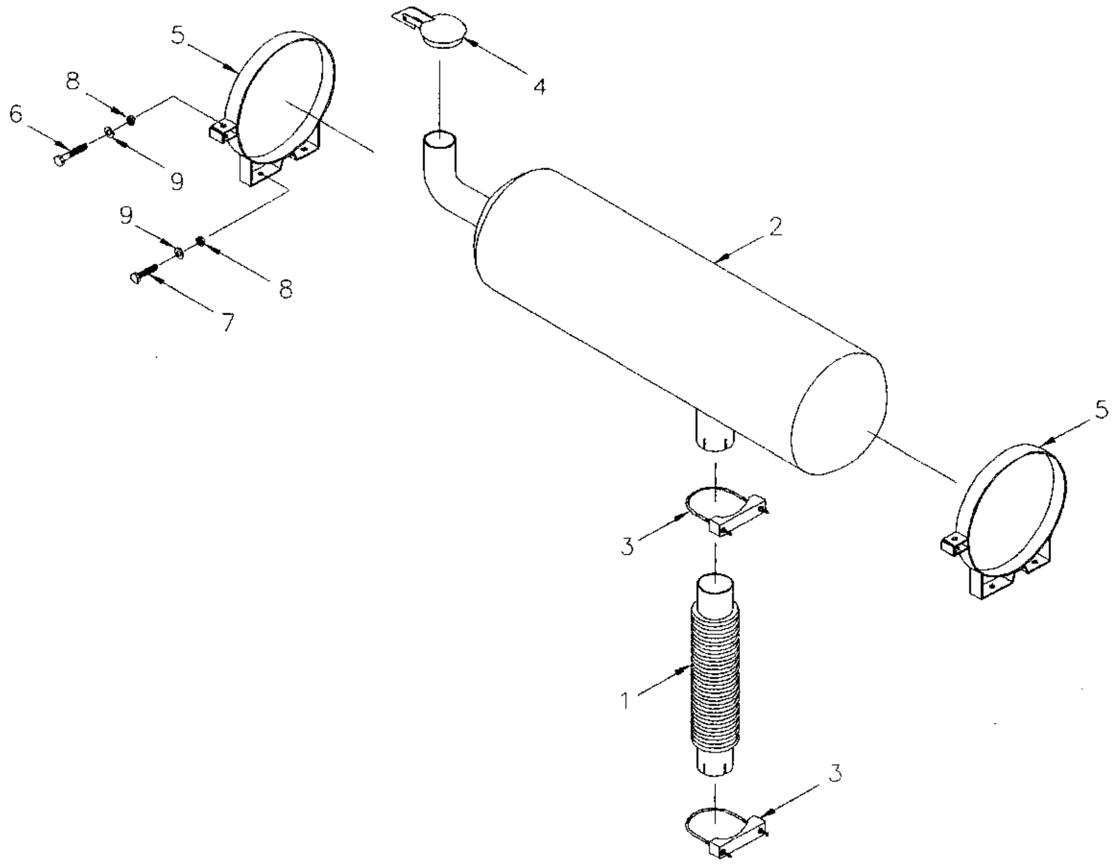
7-17-00

TAYLOR POWER SYSTEMS

VTGRU10049

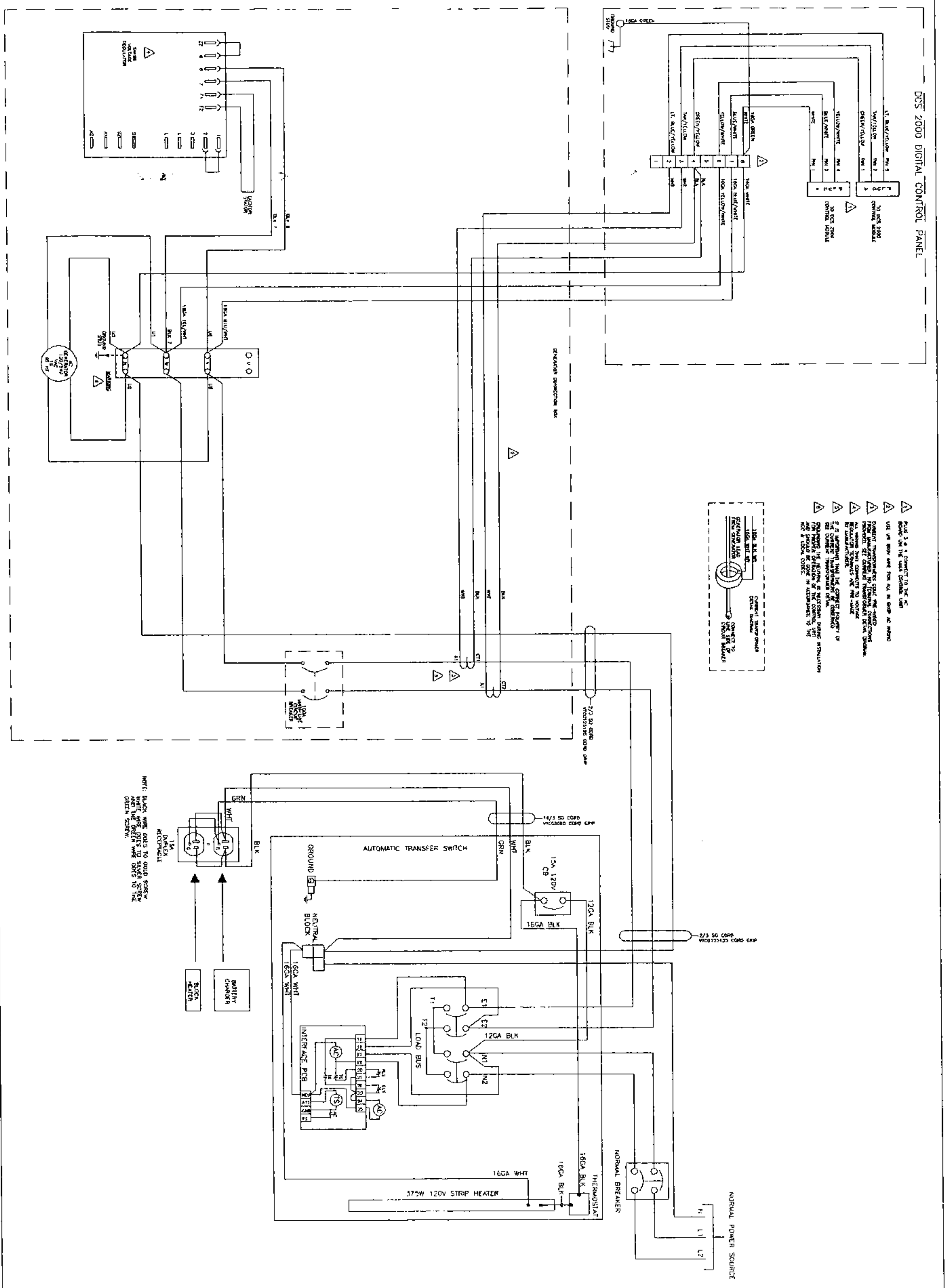
MODEL OR SERIES	COMPONENT OR ASSEMBLY NO.
TRITEL	

CRITICAL SILENCER

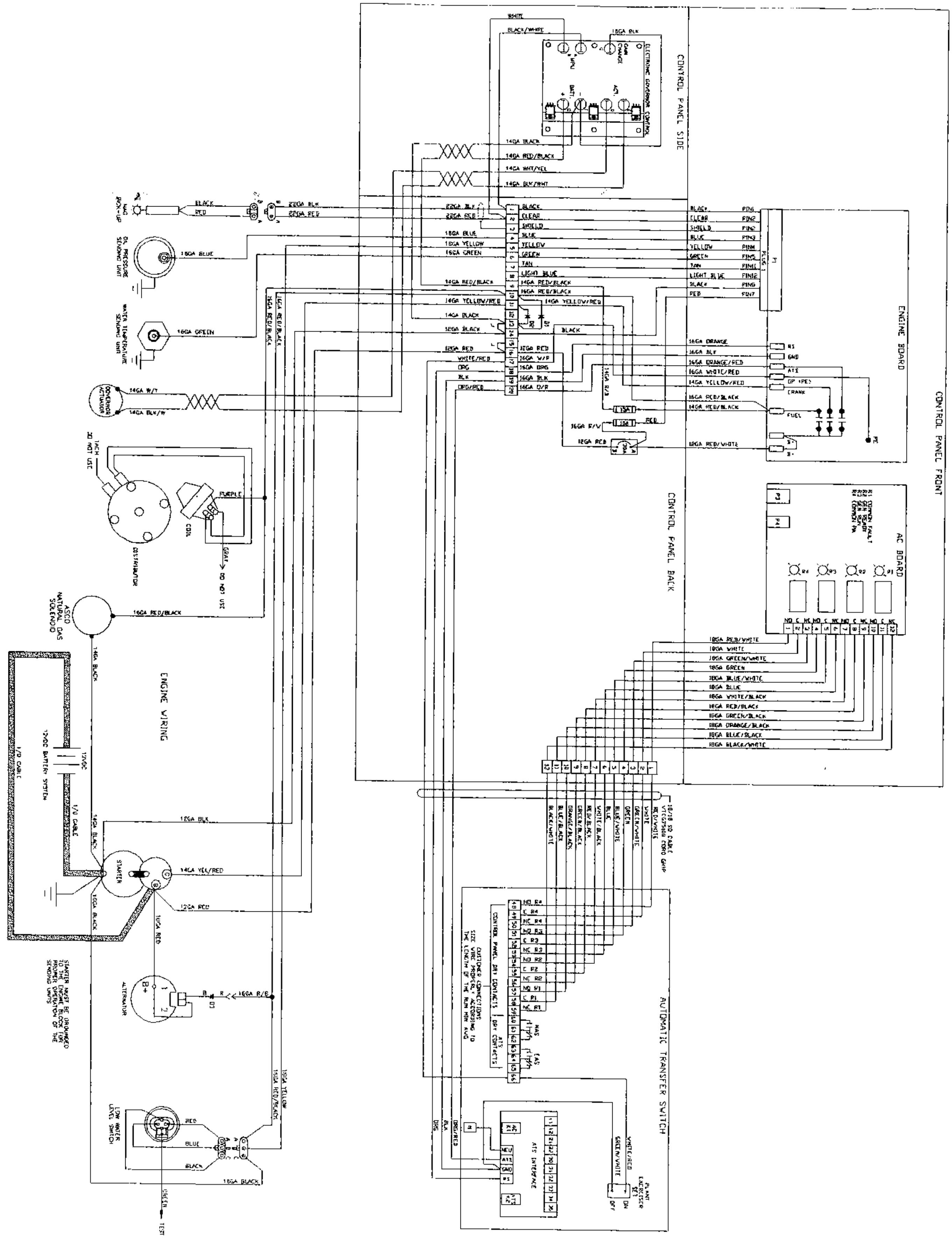


ITEM	PART NO.	DESCRIPTION	QTY.
1	VT100172	FLEX EXHAUST	1
2	VT100171	MUFFLER	1
3	VT35335	2" EXHAUST CLAMP	2
4	VT7031502	2" RAIN CAP	1
5	VT100114	MUFFLER MOUNTING BAND	2
6	VT37C225CSZ	3/8 X 2 1/4 BOLT	2
7	VT37C100CCS	3/8 X 1 BOLT	4
8	VT37CCNES	3/8 LOCKNUT	6
9	VT37N100WSSS	3/8 FLATWASHER	4

7-17-00



TAYLOR POWER SYSTEMS	SCALE: NTS DATE: 6-7-00	DRAWN BY JWM REVISED
PART NAME WITH A NEWAGE 4 LEAD GENERATOR (120/240 SINGLE PHASE) AC WIRING DIAGRAM (WITH DIGITAL CONTROL PANEL)		APPROVED BY
DRAWING NUMBER VT071080	MODEL	CUSTOMER TRITEL



TAYLOR POWER SYSTEMS	SCALE:	DRAWN BY JWM
	DATE: 6-6-00	REVISED 9-26-00
PART NAME DC WIRING DIAGRAM		APPROVED BY
DRAWING NUMBER VT071079	MODEL GS20/GS25	CUSTOMER TRITEL