Hull Vibration

When the vibration frequency of a boat's machinery or propeller synchronizes with the natural vibration frequency of the hull, or some portion of the hull, it can reach a very objectionable sound and motion level.

If the disturbance can be attributed to an engine or generator set, the most effective way to eliminate the trouble is to physically isolate the offending equipment by the use of vibration mounts. When using vibration mounts on main engines, it is usually mandatory to use a flexible coupling on the driveshafts.

A boat has many vibration forces other than those caused by the engine. In checking for causes of vibration, the following sources should be investigated:

1. Misalignment between engine and propeller shaft or improperly machined propeller coupling.
2. Bent propeller shaft.
3. Hull appendages such as struts, sternpost and rudder, if not properly faired into flow stream.
4. Too much power for boat design.
5. Propeller disturbances.
   a. Wheel clearance (sternpost and hull)
   b. Cavitation
   c. Worn stern bearing
   d. Improperly pitched propeller
   e. Propeller not dynamically balanced

If an undesirable vibration is still noticeable after these potential causes have been checked, it is possible that the impulses are induced by the propeller blades passing the sternpost. This may be eliminated by modifying the shaft-propeller system to alter its natural frequency and/or changing the number of propeller blades. These modifications will move the objectionable vibratory frequency out of the operating range of the engine. The system frequency may also be modified by changing the mass of the propeller, the diameter of the shaft, or relocating the shaft bearing supports.

Special Type Hulls

Tugs and Tow Boats:

Special consideration is given to the power ratio of this type of vessel because of its unique operating requirements. It is first desirable to know the load requirements, number of barges, displacement of each for average run, the towing or pushing speed required, and current is also a factor.

Towing speed should be 25% to 30% below the natural speed of the hull. Vessels of this type tend to bury their bow in their own waves when running free. In square ended "pusher" boats, this may occur at speed length ratios close to 1.0.

Propeller slippage on most towing vessels is approximately 45% to 50%. Low speed propellers having maximum diameter and a 'moderate' pitch are the most desirable.

Fishing Boats:

Vessels in this classification that fish by means of nets drawn through the water offer a special problem. For example, a shrimp boat may travel as far as 500 miles or more to the fishing grounds. Owners usually want to cut this travel time as much as possible. However, when fishing, the boat has to tow large doors and heavy nets at slow speeds. The broad variation in performance requirements calls for a compromise in the propeller selection and reduction ratio to obtain the maximum usable power under both operating conditions.

Repowering

The two major reasons for repowering a boat are to restore worn out equipment to its original efficiency or to improve upon the original performance. In most instances, it has been found that owners will request additional horsepower whenever a change is made. However, the length of a displacement type craft limits its speed. The power required to drive the boat faster than a speed length ratio of 1.34 will be found to be greatly out of proportion to the results obtained. This should be given very careful consideration before complying with a request for additional power. By recalling the previously discussed formula,

$$\frac{V}{\sqrt{LWL}} = \text{Speed/Length Ratio,}$$

this factor can be easily checked.

One of the most important steps to be taken in repowering a boat is to obtain all the information possible on the boat in its present condition; i.e., type of hull, condition of hull, SHP of old engine as is, loaded waterline length measurements, gear reduction, engine room size, maximum speed with the present engine, fuel consumption, etc. All this information should be carefully recorded and presented along with a repower request.

There are numerous forms and methods of tabulating the information that supports a successful marine engine installation. Detroit Diesel employs a "Marine Engine Application Data Inquiry Sheet" and an "End Product Questionnaire." The data inquiry sheet is designed to document pertinent marine application information which must be considered in recommending the proper marine engine for a particular application. The "EPQ" offers the Distributor the opportunity to solicit the guidance and recommendations of Detroit Diesel Allison in the installation of a marine engine.

One of the most important repowering considerations is to establish the vessel's speed and propeller efficiency *before* an engine change. If it cannot be done on a measured mile, it should be approximated by noting elapsed time of operation between points of known distances. Fuel consumption should also be checked.

With a known speed, checking the nomograph in Fig. 2 to obtain a speed-length ratio of the hull will result in a closer estimated speed with the new power plant.

Boat Drawings

Major plans of boats drawn by boatbuilders usually include the following:

1. Inboard profile—section through boat structure if it were cut in half lengthwise.
2. Outboard profile—side view showing all of vessel above waterlne as it might appear in a photograph.
3. Deck plans—that view of section through vessel at various heights above keel.
4. Line drawings—set of imaginary outlines used to indicate the shape of the hull.
5. Miscellaneous detail drawings—engine room layout, etc.

There are other calculated data, such as displacement curves and stability curves, which are usually not made up for the size vessel being discussed.

Important Elements of Marine Propulsion

1. Initial Cost—gasoline versus diesel:

- The initial cost of a diesel engine is approximately twice that of a gasoline engine.
- *The true* cost of a marine engine can be clearly seen only by comparing SHP and cruising speed.

Because of their automotive-type ratings, gasoline engines must sacrifice as much as 50% of their SHP output for an acceptable level of engine durability.

Detroit Diesel engines, however, can be run at full rated output and still maintain their high level of diesel durability. If the maximum in durability is desired, it can be achieved with less than a 10% drop in engine SHP output.

Under these conditions, a 130 hp Detroit Diesel engine will compare very favorably with a gasoline engine in the 180-210 hp range, both from the standpoint of cost and boat cruising speed.

2. Maintenance Cost—gasoline versus diesel:

- Out-of-pocket expenses are lower with a diesel engine since fuel costs run 25% to 50% less than gasoline. In addition, it is possible for a diesel to travel 1½ to 2 times as far as a gasoline engine, using the same horsepower.

Gasoline—100 gals. @ 46¢ ($46) and cruise 1 mile/gal. = 100 miles or 2.2 miles per dollar.

Diesel—100 gals. @ 36¢ ($36) and cruise 1½ miles/gal. = 150 miles or 4.2 miles per dollar.

- Diesel engines are precision built and designed for a much greater life expectancy. Diesel maintenance is far less per year, in terms of both time *and* money. Gasoline engines generally need overhaul in 500 to 1000 hours, while diesels in pleasure boats normally go from 2500 to 5000 hours before overhaul.

- The inherent safety and dependability of a diesel engine is added assurance that a diesel powered boat will return to shore safely. Diesel fuel accounts for part of this extra security factor because it is naturally less volatile than gasoline and safer to run. This feature is an ingredient that simply cannot be measured in dollars and cents.

3. Residual Value—gasoline versus diesel:

- There is little doubt that a diesel powered boat provides its owner with a much better return on investment than a gasoline powered boat at the time of resale. Diesels are not only less hazardous to operate but they are in greater demand.

- Banks are willing to finance a larger portion of the purchase price of a diesel powered boat because they *do* have a higher residual value and *are* in such demand.

Conclusion

The information on the previous pages of this manual was provided as basic groundwork in the area of marine propulsion. Its only intent was to provide a brief insight into the various factors involved in an actual marine installation.

Again, the services of a naval architect or a Detroit Diesel engine specialist are strongly recommended to obtain the most precise performance information and technical advice.

With a basic knowledge that permits intelligent application of an expert's experience, more satisfactory installations are sure to follow.

Detroit Diesel Allison
Division of General Motors Corporation

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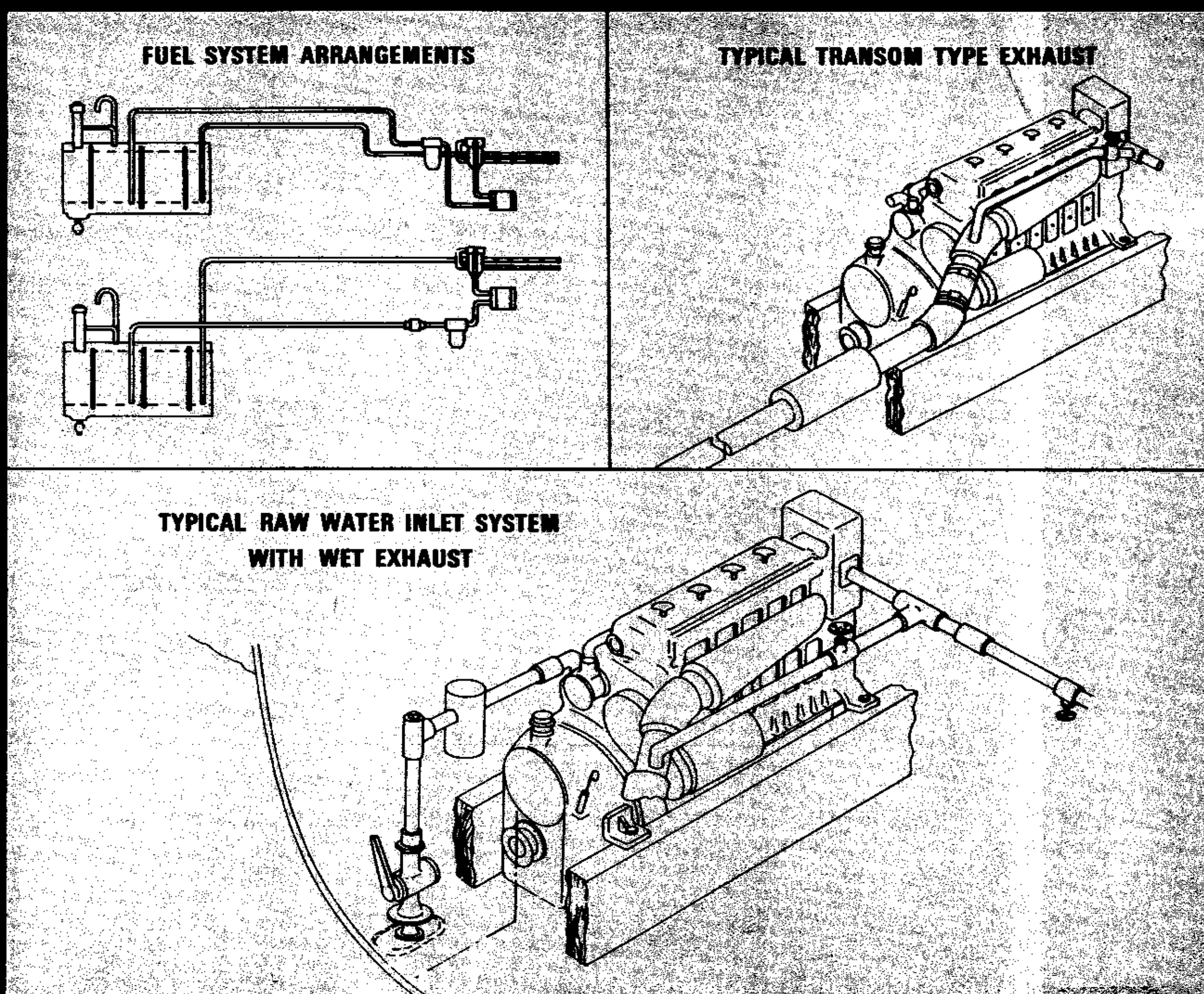
Detroit Diesel Allison

MARINE ENGINE INSTALLATION GUIDE



FOREWORD

This booklet approaches the subject of Marine Engine Installations by offering a number of practical guidelines for the marine novice and expert alike.

The information presented includes brief descriptions of the basic parameters to be followed to achieve sound marine engine installations. To help the reader appreciate why adhering to recommended installation guidelines "pays off" in the long run, detailed descriptions of individual Detroit Diesel marine engine systems with appropriate illustrations, charts, and sample problems are offered in support of these guidelines.

In addition, installation data for every Detroit Diesel marine engine appears on each engine installation drawing located in Section III of the binder. Information including engine room vent area, installation angles, physical dimensions and pipe sizes for fuel, cooling and exhaust systems is listed on these drawings.

It should be noted, however, that a more detailed technical investigation of marine installation data than offered here must also await the test of experience before performance results can be assured. Consequently, any conclusions made from this booklet can only be general in nature.

The services of a naval architect or a Detroit Diesel Allison marine sales engineer are recommended for obtaining more precise engine installation information.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

I INSTALLATION PARAMETERS

ENGINE ROOM LAYOUT

When designing a new boat, or when repowering an old one, there are several factors to consider regarding the power plant, which require pre-planning in order to insure a good engine installation. Proper planning will avoid costly revision work which may arise later when troubleshooting, maintenance, and repairs occur. The following is offered as a checklist of points to consider for planning purposes:

Clearance

a. To allow the engine and all accessories to fit in the hull.

b. For accessibility to perform minor maintenance.

c. For ventilation between engine and hull or adjacent equipment.

d. To allow for future removal and installation of the engines by providing removable hatches or adequate clearance in the entrance hatches.

Inclination and Trim of the Vessel

a. Effect of engine weight and its location.

b. Effect of storage tanks for fuel, lube oil, and water.

c. Location of battery packs and other heavy accessory equipment.

Engine Bed Structure

a. Should have strength to support the engine weight.

b. Should have rigidity under the torque and thrust loads of the propeller and boat movements.

c. Should allow for engine accessory locations and oil pan removal.

d. See Part 'B' of this section, "Engine Foundations."

Location and Routing of Services

a. Lube oil filters, fuel filters, engine water filters, and sea strainers must be readily accessible for maintenance and inspection.

b. Piping runs should be direct but as neat appearing as possible. Use a minimum number of elbows and other fittings to avoid flow restrictions and reduce installation costs.

Ventilation

a. Determine capacity required for engine room cooling and air consumption by main engines and auxiliaries.

b. Determine flow path of ventilating air to do the most efficient job.

Fuel Systems

a. Adequate tank capacity considering vessel operations and availability of fuel.

b. Proper tank location in the vessel, and fuel level with respect to the engine fuel pump.

c. Proper line sizing, routing, and material.

d. Possibilities of future leaks and fire hazards involved.

e. Proper isolating valves where needed.

f. See II . . . "Fuel Systems."

Cooling Systems

a. Consider whether it should be a heat exchanger or keel cooled system, taking into consideration the boat operation and average sea temperatures.

b. Consider need for and location of sea strainers.

c. Consider hull fitting locations and piping paths to them to avoid excessive flow restriction.

d. See IV . . . "Cooling Systems."

Exhaust System

a. Determine whether it should be a wet or a dry-stack system.

b. Determine most direct piping runs.

c. Determine mufflers to be used and locations.

d. Provide for preventing rain water or sea water from entering the engine.

e. Eliminate fire hazards due to hot-spots in the system.

f. See VI . . . "Exhaust Systems."

Starting System

a. Determine whether it should be air, electrical, or hydraulic.

b. Determine whether it should be remote or engine room starting.

c. Consider air pressures or voltages available and required.

d. Consider wire sizes, routing, and exposure of connections.

e. See VIII . . . "Starting Systems."

Controls

a. Whether mechanical, pneumatic, hydraulic, or electrical controls should be used depending on the availability of the air or electricity for control and on the vessel operation.

b. Establish location of the operator's controls and ease of cable versus pipe or electric wiring runs.

c. Consider experience and ability of the operator.

d. See IX . . . "Control Systems."

Vibration and Noise Isolation

a. Decide on method of mounting engine to engine foundations. Use of isolation mounts depends on whether the vessel hull transmits or dampens vibration and whether the vessel is for commercial or pleasure use.

b. Determine possibility of engine room insulation against noise.

c. Use flexible hose and fixtures for all fuel, water, exhaust and other connections between the engine and the hull.

d. The engine related mechanical noise is attributed to the combustion and rotating and reciprocating mechanical components of the basic engine and is radiating from the vibrating surface of the engine. Anything attached to the engine such as reverse and reduction gears, front PTO's, accessory drives, or application structural frame and components become radiating surfaces due to the mechanical vibration transmitted from the engine. The most significant and economical noise reduction is by acoustical treatment of the engine room. A discussion of acoustical and vibration control materials, resilient mounts and engine room treatments is available in Detroit Diesel Engineering Bulletin #36.

Legal Requirements

a. Check all local, state, and federal requirements regarding marine inspection of commercial and pleasure vessels and adhere to them.

ENGINE FOUNDATIONS

The overall engine bed is usually twice the length of the engine and is physically tied into the construction of the boat so that it will strengthen and stiffen the boat in the vicinity of the engine.

The support of the engine involves not only the weight of the engines, but the thrust of the propeller, the torque of the propeller rotation and the torque resulting from the rolling and pitching of the boat. The actual support of the engine weight is, therefore, only a small part of the engine bed function.

The angle of the engine bed should preferably be the same as the propeller shaft angle, but if this is not possible, the difference can be compensated for through the use of shims placed under the engine mounts. The angle of the engine should not exceed that given on the manufacturer's engine specification sheet.

The height of the engine bed in relation to the shaft line will depend on the model of the reverse and reduction gear used and the vertical difference between the mounting flanges and centerline of the engine propeller shaft coupling. The various engine model installation drawings,give the location of the mounting flange in relation to the coupling center. The engine bed should be constructed so that approximately ½" shims will be required in aligning the engine. This permits corrections up or down in case the boat changes its shape due to hull strain.

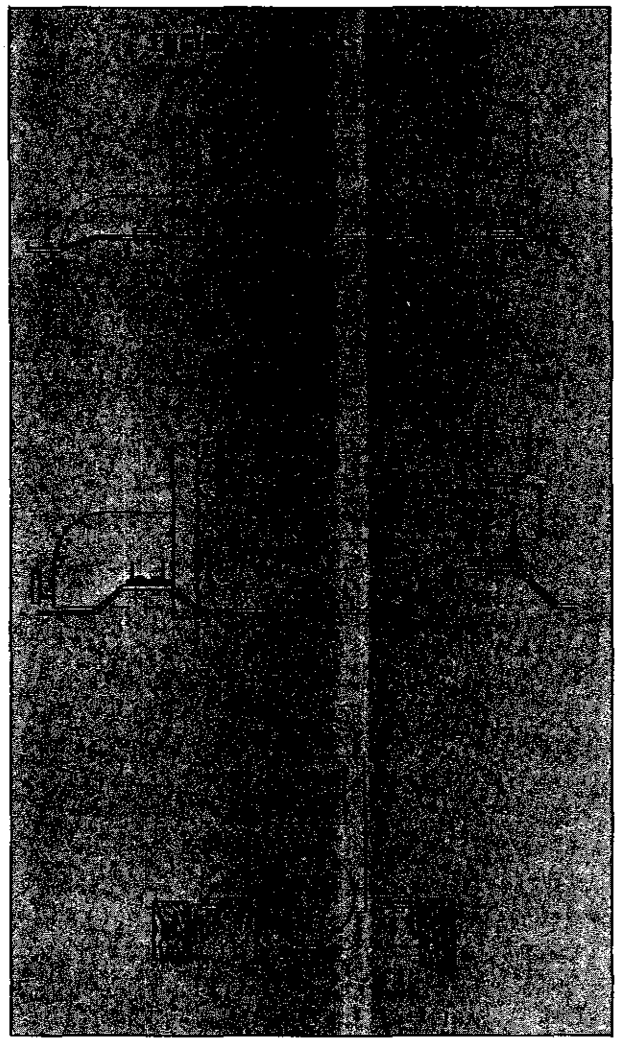


figure 1

Figure 1-A shows a conventional engine bed with clearance allowed for ½" hardwood or steel shims. These shims should cover the width of the bed timber and be about 8" long so that a large surface area is against the bed. This construction unfortunately makes it very difficult to properly service the engine, because the presence of the bed makes it almost impossible to remove the oil pan. After the oil pan is removed, it would still be very difficult to perform any repair work.

A possible solution to the problem of oil pan removal would be to lower the engine bed elevation between the front and rear mounting pads (Figure 1-B). It should be 6" to 8" lower than the mounting bracket positions and extend as closely as possible without weakening the bed. Since shims are still necessary, sturdy spacers of hardwood, case iron or welded steel should be prepared and fitted between the engine flanges and the bed.

Figure 1-C shows angle irons bolted to the bed. This construction serves the purpose of spacing the engine bed timbers further apart and permitting easier access to the oil pan. Reduced bed elevation between mounting pads, in addition to angle irons, will permit even better results. Angle iron, not less than 4 x 4 x ⅝, should be used along with at least two ⅝" bolts for each engine flange. The bolt fit should be tight to prevent movement of the angle iron. As in the other cases, shims are necessary.

The holes in the foundation for the engine mounting bolts should not be drilled until the engine is in position and accurately aligned. The bolts used should be long enough to extend through all shims and spacers and into the foundation proper. If special slotted castings or welded steel forms are used, they should be bolted to the bed and the engine is bolted to the spacer. Side clearance must be left so that the engine can be moved slightly from side to side in securing the final alignment. Bolts and nuts should be bronze or galvanized iron.

Engine Foundations in Wooden and Fiberglass Hulls

In general, the timber supporting a single Detroit Diesel engine should not be less than 3" x 6" cross section. The bed itself must tie into the keel and frames of the boat, either through keelsons or floor timbers; bolts holding the engine bed should be numerous and on a minimum of 18" centers. Chocks should be placed on either side of the bed timbers at each floor timber. The bed must be absolutely rigid.

The material of the engine bed should be hardwood so that the engine mount flanges will not press into the wood and cause misalignment. Oak is a popular material, but other hardwoods such as maple, ash and birch are equally good. If a satisfactory wood is not available for engine bed construction or if the surface of the bed is to be protected, a thin hardwood spacer or ¼" sheet steel shim can be laid on top of the bed timbers.

In a heavy boat, the engine bed is built directly on top of the sister keelsons. In lighter boats, the engine bed timbers are put on top of the closely spaced floor timbers, being notched and bolted to the floor timbers so that the boat strength is increased.

In fiberglass hulls, the bed is usually made of hardwood timbers, welded aluminum or steel; and then fiberglassed directly into the hull bottom. These beds, or stringers, as they are called, should extend from the transom to one of the main forward bulkheads. In any case, the ends of the stringers should fasten to a transverse member with adequate strength to transmit propeller thrust to the hull without a danger of hull damage.

Engine Foundations in Steel and Aluminum Hulls

The problems of a foundation in a metal boat are very much the same as those encountered in wooden boat construction. The engine bed is built up of metal I-Beams which are firmly secured to the keel and hull. These beams add materially to the strength and rigidity of the hull in the vicinity of the engines.

Often the double bottom tanks in a steel boat are used for fuel storage and the engine is mounted over these. In this case, it is important to have steel girders constructed within the tanks, to support the engine beams above.

ENGINE MOUNTS

Detroit Diesel engines are relatively vibration free. In a boat, however, there are many added variables that can result in vibration. Thus, vibration is often a topic of chronic complaint.

Noise and vibration telegraph very easily through the hull of a boat, especially steel hulls, and may reach an objectionable level. Some type of insulating material such as wood, cork or rubber should be inserted between the engine mount and the bed to reduce the vibration.

A resilient mount of the rubber-in-shear type is recommended for the best job of vibration elimination. The mounts used must be able to support the engine torque due to the rotating shaft and the rolling of the vessel. They must also support the weight of the engines statically and the thrust of the propeller pushing the vessel. Mounts of this nature allow for a certain amount of engine movement, and therefore require a good flexible coupling. This combination will reduce wear on shaft bearings and assure that the shaft is isolated from the engine.

When rubber mounts and couplings are used, all other engine-to-hull connections must also be made flexible. Water pipes, fuel lines, and exhaust piping should have flexible hose connectors at the engine and be made of ample material specification to handle their respective fluids. A solid connection will transmit vibration and will eventually fatigue and break.

ALIGNMENT

Proper alignment of an engine is critical . . . both during the initial installation and at frequent intervals during the life of the boat. It is rather common for a boat to change its form under various loads and with age. A bend is actually formed in the keel which changes the original engine and shaft alignment. The following steps may be taken to secure proper engine alignment:

Propeller Shaft Installation

a. A wire is run through the shaft log and secured to a brace near the engine bed, giving the wire a position equivalent to the shaft centerline.

b. The stern bearing and stuffing box are installed and bolted into position with the wire passing through each in the exact center of the bore.

c. The propeller shaft is installed in its proper position.

d. If an intermediate shaft is used, it is blocked into position and its coupling is aligned with the propeller shaft coupling (see the following paragraph —"Engine Alignment"). If there is an intermediate bearing in the line, this is installed and positioned with shims during the alignment process.

Engine Alignment to Propeller Shaft

The face run-out of the couplings should be checked before the engine is placed in the boat. It is important to align the engine only when the boat is afloat and *not* in dry-dock. During this alignment period, it is also advisable to fill the fuel tanks and add any other ballast that will be used when the boat is in service.

With the engine in position on the engine bed, arrangements must be made to have a controlled lifting or lowering of each of the four corners of the engine. This can be accomplished with jacking screws. In this case, a threaded hole is provided in each of the engine mounts. By inserting screws in these holes, the engine can be raised by screwing down or lowered by backing off the desired amount. Steel plates must be inserted under the jacking screws so that the bolts will not damage the engine bed. Lifting can also be accomplished by the use of chain hoists or properly placed jacks. Adjustable shims also are available and can simplify the whole problem, particularly for future realignment.

It will also be necessary to move the engine from one side or the other on the bed to secure horizontal alignment. This can be done with a jack placed horizontally between the engine and the foundation.

As the engine then comes into its aligned position, it will be possible to match the male and female halves of the propeller coupling, and prepare for bolting together. Care should be taken not to burr or mar this connection because the fit is very critical.

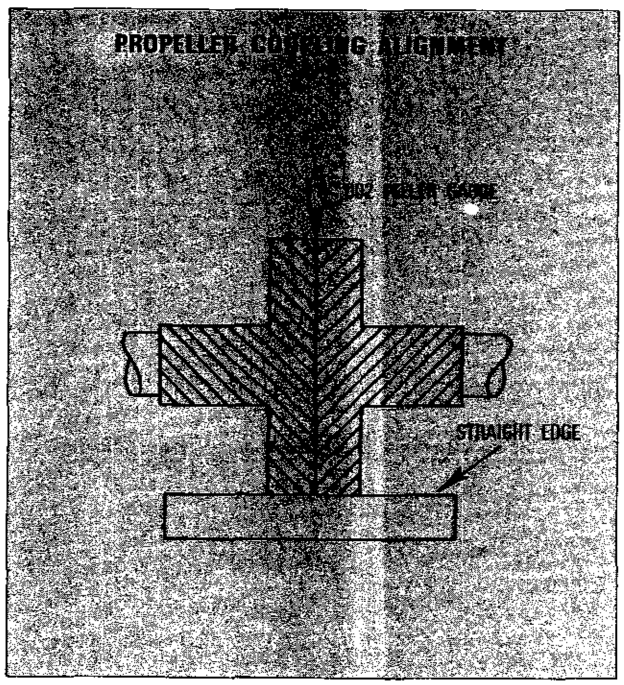
A .002 feeler gauge is inserted between the flanges of the coupling at the same time a straight edge is laid across the edges of the flanges at the top and sides to check the parallel alignment of the coupling edges (See figure 2). The feeler gauge is run completely around the coupling.

Then the engine coupling is rotated 90°, 180° and 270°, with the feeler being run around the flange again in each successive position. If the alignment is correct, the feeler gauge fits snugly with the same tension all around the coupling. The straight edge should continually show the edges to be parallel.

If the alignment varies during rotation, then further alignment is necessary or the engine and shaft couplings should be checked for improper face run-out. Face run-out on the engine coupling can usually be corrected, by repositioning the coupling on its spline. Shaft coupling run-out is usually due to inaccuracy of taper fit or key interference.

Some boats are not structurally rigid and some carry their load in such a way that they will "hog"

figure 2



or go out of normal shape with every loading and unloading. Where this condition exists, it may be necessary to make a compromise between the top and bottom coupling clearance by leaving a greater clearance at the bottom of the engine and propeller couplings. This clearance might be .005 to .007, while the top would maintain the standard .002.

During the process of securing final alignment, it may be necessary to shift the engine many times. When it becomes apparent that the alignment is reasonably close, the holes for the lag studs are marked and drilled. Then with final alignment secured, the necessary steel or hardwood shims are made up and the engine is fastened in place. The alignment is then rechecked, and if satisfactory, the coupling is bolted together and rechecked again.

Although it is not as necessary to align a flexible coupling as accurately as a solid coupling, the closer it is in the initial alignment, the more vibration-free it will be. The most accurate method of alignment is to align the shaft on to the engine with flexible coupling out of the system. This can be done with a spacer the same size as the coupling but not flexible in nature. Flexible couplings are used only for noise and vibration dampening . . . not to correct inadequate alignment.

When a heavy boat is dry-docked, it naturally undergoes some bending. Therefore, it is always good practice to unbolt the engine coupling and prevent bending of the shaft.

II DIESEL FUEL SYSTEM

The requirements of a marine fuel system are to store and supply an ample quantity of clean, water-free fuel to the engine with as little restriction of the pump as possible.

This section will be concerned only with the external fuel system, such as tanks, lines, and filters.

TANKS

The size and shape of a tank is governed largely by its location in the hull. Often, tanks are constructed to fit compartments which are relatively inaccessible and generally unfit for other purposes. For this reason, they must be constructed to last and be relatively service free.

One of the most important factors in tank selection is the material of which the tank is made. Black iron, sheet steel, or monel are acceptable materials, as are some molded plastics, but galvanized materials should *not* be used under any circumstances. Zinc in a galvanized coating reacts with the sulfur in the fuel oil to form a white zinc sulfate which will quickly plug filters and ruin pumps and fuel injectors.

The tank should, of course, be firmly mounted and secured in all directions of potential motion. It must also be protected from rubbing action by insulating with rubber or some other friction absorbing substance. And, the tank should be electrically grounded to the ship's common grounding system.

It is especially important to construct baffles in all fuel tanks for marine applications, because fuel shifting in rough seas can make a ship very difficult to handle. It also causes additional stress on the tank supports. The baffles should sit vertically, two to three feet apart, and stand the entire height of the tank. The baffles should be drilled with several holes and fit in the tank with a two inch gap left at the top and bottom. They should be of the same material as the tank and securely welded in place.

Tank vents must be installed at the highest point of the tank and should be made of not less than ½ inch tubing. Extending both the vent and the filler a short distance into the tank assures that expansion area will be left after filling. The vent should be extended above deck and protected so that water and dirt cannot enter the system.

Each tank should have a drain plug located in a readily accessible spot by which the tank can be drained dry. There should also be a hand hole near the top of the tank for cleaning purposes. The plug should be at least ⅜ inch diameter and the hand hole large enough to permit adequate cleaning. Typical fuel tank construction is shown in Fig. #3, page 10.

In applications where more than one tank is used, a crossover line with a gate valve connecting the tanks near their low points will allow equal draining of all tanks and maintain the vessel's inclination and trim. These valves can also be used to isolate any one tank in case of trouble, such as contamination.

In systems with very large tanks, a day tank is commonly used. This tank holds enough fuel for a full day's running and is used as a settling tank to rid the fuel supply of any water accumulation. This system will require a method of transferring fuel from the storage to the day tank.

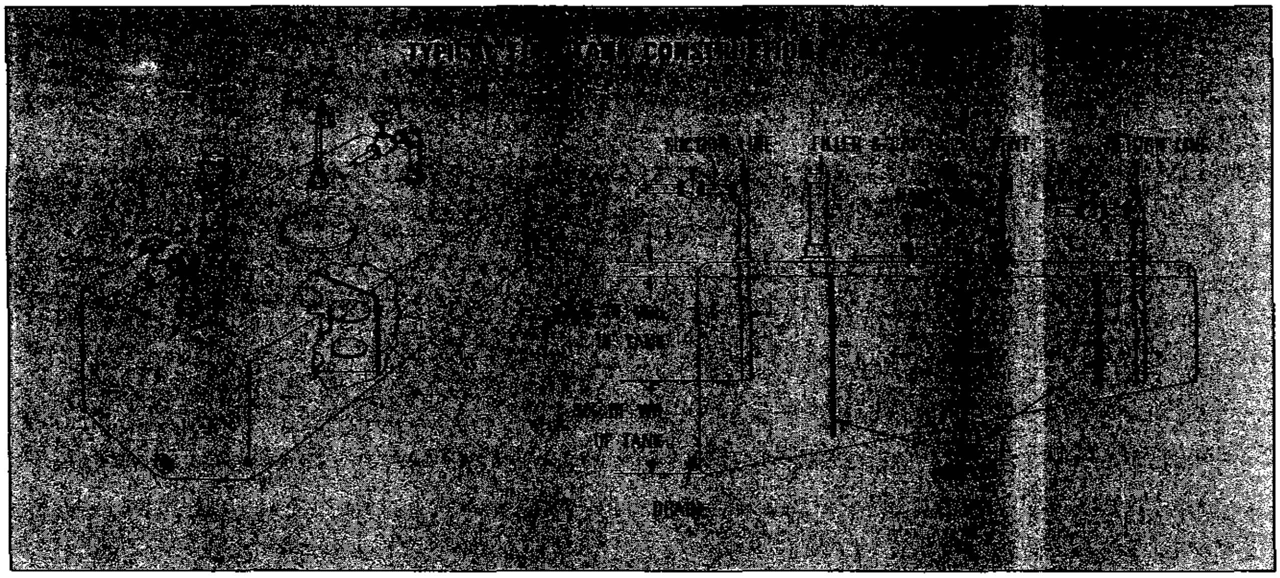


figure 3

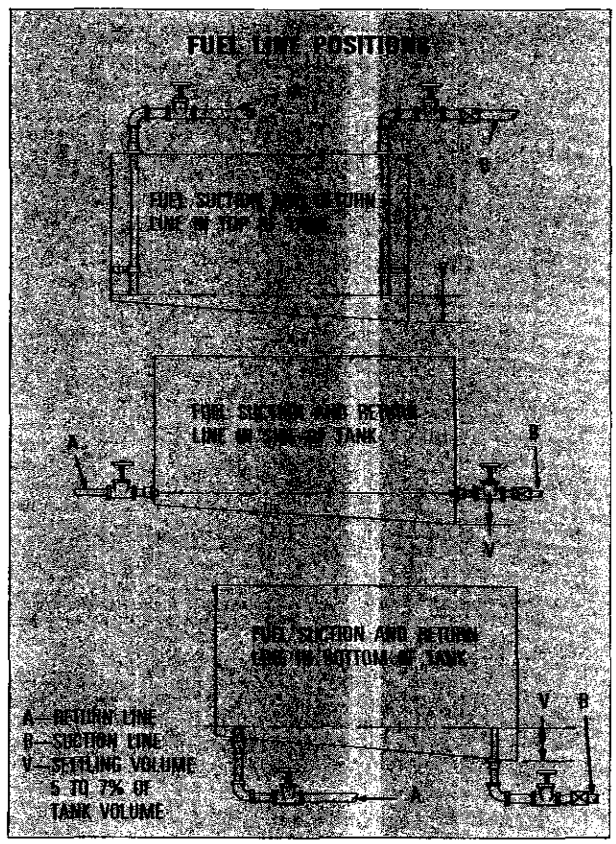
LINES

The suction and return lines should be no smaller than specified in the manufacturer's specification sheet and should take the most direct route from tanks to the engine fuel pump. Under no conditions should the pump suction exceed 12 inches of mercury with the engine operating at rated R.P.M.

The suction and return lines should extend into the tank at the same elevation but as far apart as possible. This allows the same fuel head to be used on both lines and reduces the possibility of air or hot fuel from the return line discharging directly into the suction line. The line openings should end at a level which allows five to seven percent of the tank volume to be below them and permit the settling of sediment and water.

The most satisfactory situation, as far as fuel suction is concerned, is to have the center of the tank at the same level as the engine injectors and the low point of the tank at, or a little below, the pump. When the tank is considerably below the pump, additional pumping power is required from the engine fuel pump. In *no* case should the suction point be located more than 48" below the pump level. When the tank is above the pump, the fuel flows by gravity to the pump and shut-off valves or solenoid valves must be provided, enabling the fuel flow to be stopped when the engine is not in use. If this is not done, a broken or disconnected line can let large quantities of fuel escape from the tank. Even worse, the tank head could conceivably leak into a cylinder through an unseated injector, leaving the possibility of a hydrostatic lock upon start up. The very least that will happen with leaking injectors is lube oil dilution. Typical fuel line arrangements are shown in Figure 4, page 10 and Figure 5, page 11.

figure 4



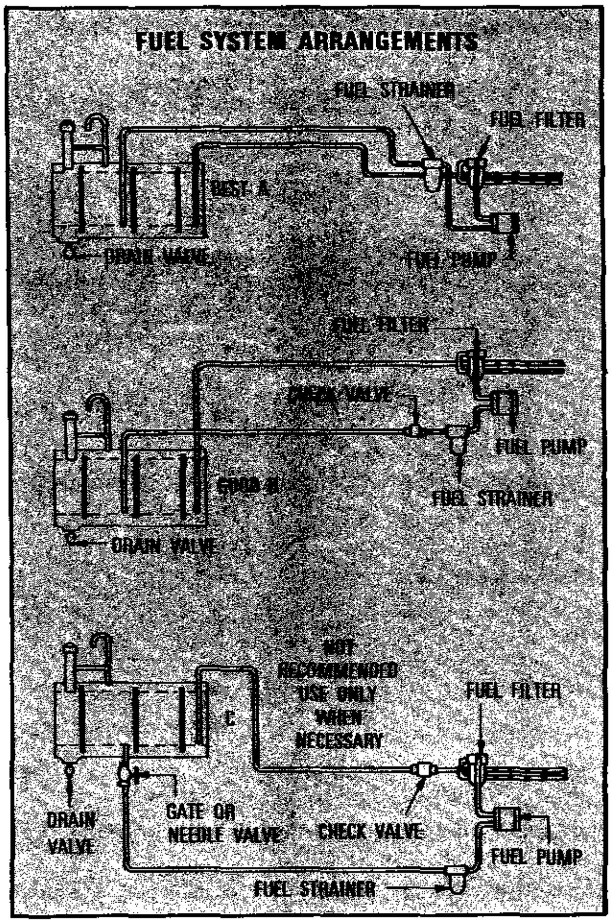


figure 5

In applications with fuel tanks below the pump, a check valve in the suction line at the tank will keep fuel oil from running back into the tank when the engine is stopped, greatly aiding engine start up.

Material for fuel lines can be either black iron, steel, or brass, but copper and galvanized material should not be used because they form harmful by-products that ruin pumps and injectors. All lines should be supported with fasteners at frequent intervals to check vibration. The connection with these fuel lines at the engine should be through flexible hoses which meet material specifications for fuel under pressure.

The following recommendations will help minimize fuel suction restrictions:

1. Run fuel lines as directly as safety and neatness will allow.
2. For unusually long runs, use a size larger line than specified by the manufacturer.
3. Keep the number of tees, els, and other fittings to a minimum, but do not sacrifice ease of maintenance by the elimination of necessary fittings. Street elbows are *not* recommended for safety reasons.
4. Use gate valves, as opposed to glove type valves.

Specific fuel system data for individual Detroit Diesel marine models is included on the installation drawing for each engine model. Fuel system information on the installation drawing includes maximum inlet restriction at the pump and suggested pipe size.

Tables 7, 8, and 9 on page 28 for computing more exact fuel system restrictions are in the Appendix.

FUEL FILTERS

Primary Fuel Strainer

The primary fuel strainers are used in the suction line just ahead of the engine fuel pump. Strainers supplied by the engine manufacturer will provide more than adequate pump protection under normal fuel conditions, and are the only strainers recommended.

It may be necessary to use additional strainers in series and to change elements much more frequently if operating in areas where unusually dirty fuel is the only type readily available. Any number of strainers may be used as long as the total restriction of the fuel supply line does not, under *any* conditions, exceed twelve (12) inches of mercury at the suction pump while the engine is running at rated speed. When this maximum limit is reached, with clean strainers, it will be necessary to revise the suction piping by placing additional strainers in parallel and reducing unnecessary restrictions. Each strainer supplied by Detroit Diesel will offer from four to six inches of mercury drop when clean.

When possible, strainers are to be located below the level of the fuel tanks. However, it is far more important for a strainer to be readily accessible for its daily maintenance. It is essential that both the strainer and absorption filters be drained often to eliminate water and impurities that may collect in the bowls.

Secondary Filter

Secondary filters are located in the system after the pump and just before the injectors. They have a much finer filtering capacity than the primary strainers and are essential for the protection of injector parts. For this reason, fuel filter change periods recommended by the manufacturer must be strictly adhered to. If the fuel used is known to be dirty, then even more frequent filter changes are called for.

Water Trap

A good commercial water trap should be inserted in the system between the fuel tank and the primary

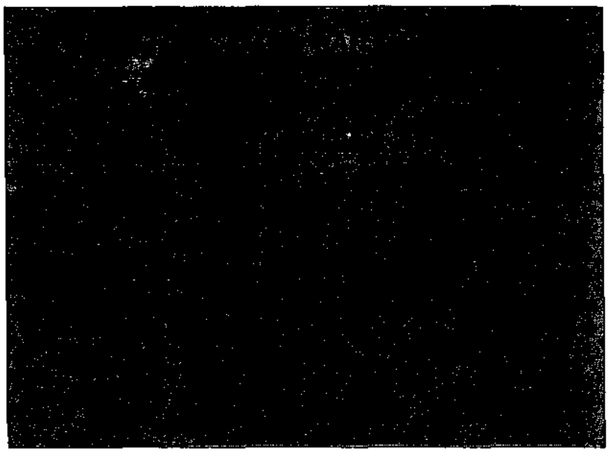


figure 6

filter or strainer. It should be in a position to permit convenient draining and is generally constructed as shown in Fig. 6, above.

Fuel Coolers

Fuel coolers are becoming increasingly popular on boats with low capacity fuel tanks. This popularity is brought about by the fact that in small tanks, the spill fuel heats the entire contents of the tank to an excessively high temperature, and the increase in temperature has a direct effect on engine power output. (2% loss per every 20°F. increase above 90°F.)

The cooler is usually plate type, and cooled by raw water or a jacket installed around the raw water pipe into the heat exchanger.

These coolers have been proven to lower the fuel temperature in the tanks by as much as 20°F.

III LUBRICATING SYSTEMS

The parts of the lube system discussed in this section are those external to the engine and which require periodic servicing.

All Detroit Diesel engines use the full flow oil filter system. Some may also employ additional by-pass filters, depending on the engine and its application.

The three prime requirements of the engine lube system are:

1. Use an oil of good quality and weight as recommended by the engine manufacturer.
2. Change the oil at frequent enough intervals to maintain that quality.
3. Change the oil filters as recommended to maintain their effectiveness.

Reverse gears, gear boxes and "V" drives have their own lubricating oil systems which operate independently of the engine oil systems. There are many varied types of systems and the details of each must be found in the manual supplied with the gear. The oil specifications and oil system service requirements for the gear will be provided by the gear manufacturer. However, the same good maintenance practices should be followed for gear as those recommended for the engine oil system.

If any filters are to be remote mounted, they must be mounted in a location that will allow easy servicing. They must also be connected with flex lines capable of withstanding the pressures and temperatures of the system. These flex lines must be protected from possible damage by a sturdy guard.

Drip pans, easily installed beneath each engine installation, can be of immeasurable later value in maintaining bilge cleanliness. These pans should extend aft of the propeller shaft coupling and forward of any equipment mounted on the front of the engine. The bottom of the pans should pitch forward or aft to allow for easy cleaning. They should be made of copper and should be anchored in such a manner to eliminate vibration.

The method of removing oil from the sump pan for oil changes must also be considered before installation of the engines so that access to the sump plug is not made impossible. Use of a small, thin tube inserted into the dipstick hole and connected to a hand or power driven pump is one common method of overcoming inaccessibility of the sump plug.

Oil Quality

There are hundreds of commercial crankcase oils marketed today. Lubricants marketed for heavy duty diesel service consist of refined crude oil to which compounded additives have been added to meet the desired engine performance levels. Oil additive selection is based on evaluations conducted by the oil supplier; therefore, satisfactory oil quality is the responsibility of the oil supplier. (The term oil supplier is applicable to refiners, blenders and rebranders of petroleum products, and does not include distributors of such products.) Experience has shown that oil performance in commercial heavy duty diesel service applications varies from brand to brand.

Obviously engine manufacturers or users cannot completely evaluate the hundreds of commercial oils; therefore, the selection of a suitable lubricant in consultation with a reliable oil supplier, strict observance of his oil change recommendations (used oil sample analysis can be of value), and proper filter maintenance will provide your best assurance of satisfactory oil performance.

Detroit Diesel lubricant recommendations are based on general experience with current lubricants of various types and give consideration to the commercial lubricants presently available.

Recommendation

MIL-L-2104B Lubricants

Detroit Diesel engines have given optimum performance and experienced the longest service life with the MIL-L-2104B, SAE-30 oils evaluated by Detroit Diesel. MIL-L-2104B oils have superseded the older MIL-L-2104A and Supplement 1 oils MIL-L-2104B, SAE-30 oils should be used during run-in prior to initial oil drain and are recommended for continued use thereafter. Contact a reliable oil supplier and obtain his assurance that his product has been tested and given good performance in Detroit Diesel engines. You may wish to request the oil supplier to show the performance results of his product in *Detroit Diesel engines.* An SAE-30 oil of MIL-L-2104B performance level is recommended for year-round use. The use of lower viscosity oils or multigrade products will usually result in less than nominal engine life.

MIL-L-45199 (Series 3) Lubricants

The use of *Low Ash Series 3 oils* (sulfated ash less than 1.85 percent by weight—A.S.T.M. designation D-874) may be necessary if the continued use of high sulfur fuel is unavoidable. Low ash Series 3 oils are premium priced products and may be desired by the user in preference to MIL-L-2104B oils. Consult a reliable oil supplier, obtain assurance that his products have been tested in *Detroit Diesel engines,* and select the best performer for optimum engine life.

Low ash Series 3 oils do NOT have to meet any specific military low temperature performance requirements; therefore, they may NOT perform as well as MIL-L-2104B lubricants in cold climates.

The older high ash Series 3 oils should NOT be used in Detroit Diesel engines as they tend to deposit heavy ash on valve faces and head inserts resulting in channelling, guttering, and short engine life.

Supplement 1 Lubricating Oils

Supplement 1 lubricating oils have been superseded by MIL-L-2104B lubricants and S-1 oils are gradually becoming unavailable. However, where a history of satisfactory performance of a specific S-1 oil has been experienced, it can still be used.

MIL-L-2104A Lubricating Oils

This military specification is obsolete.

Multigrade Lubricating Oils

Multigrade oils are NOT recommended. The use of an SAE-30 grade is desirable for year-round use when cold starting can be accomplished. Multigrade oils should be considered only as the "last resort" to facilitate starting when prolonged exposure to temperatures below freezing is unavoidable and adequate starting aids are unavailable.

Experience clearly indicates that multigrade oils are NOT comparable to SAE-30 lubricants for heavy duty diesel service. Cylinder liner scuffing, liner port and ring groove deposit levels are all greater using multigrade lubricants. This results in shortened engine life.

Cold Weather Operation

Cold weather starting will be facilitated when immersion type electrical coolant heaters can be used. Other practical considerations, such as the use of batteries, cables and connectors of adequate size, generators or alternators of ample capacity, proper setting of voltage regulators, ether starting aids, oil and coolant heater systems, and proper fuel selection will accomplish starting with the use of SAE-30 oil. For complete cold weather starting information, consult an Authorized Detroit Diesel Service Outlet.

Oil Changes

It is recommended that new engines be started with 100 hour oil change periods. The drain interval may then be gradually increased, or decreased with experience on a specific lubricant while also considering the recommendations of the oil supplier (analysis of the drained oil can be helpful here) until the most practical oil change period for the particular service has been established.

Solvents should not be used as flushing oils in running engines. Dilution of the fresh refill oil supply can occur which may be detrimental.

Oil Filtration

Heavy sludge deposits found on the oil filter elements at the time of an oil change must be taken as an indication that the detergency of the oil has been exhausted. When this occurs, the oil drain interval should be shortened. Since abrasive dust, metal particles and carbon material accumulate in the lubricating oil during engine operation, the oil filter elements must be replaced each time the oil is changed.

NOTE: The manufacturer's warranty applicable to Detroit Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's lubricating recommendations indicated above may not be within the coverage of the warranty.

IV COOLING SYSTEMS

Unlike an automotive engine, which fans air through a radiator to accomplish cooling, marine engines use the sea for heat rejection. There are two types of marine cooling systems to consider:

1) Raw water (heat exchanger) cooling.
2) Keel cooling.

RAW WATER HEAT EXCHANGER SYSTEM

This system utilizes two water pumps which are usually engine mounted. One pump circulates water from the sea suction through the engine mounted heat exchanger, and then overboard. The other is used for circulating fresh water through the engine and heat exchanger elements. On a *wet* exhaust system, some of the raw water is dumped directly into the exhaust pipe, and the rest passes through the overboard discharge line. (See section VI . . . "Exhaust Systems" and Figure 7, page 15.)

The raw water system intake employs an intake scoop outside the hull near the keel, a seacock or skin valve inside at the through-hull fitting, and a sea strainer. Piping and fittings should be of adequate size to keep intake restrictions down.

When raw water heat exchanger cooling is used, the raw water system must be carefully designed to avoid excessive restriction at the pump. Excessive restriction results in reduced raw water flow and overheating. Minimum outside diameter for water connections are shown in Table 2, Page 26. Larger pipe will be required where unusually long runs of pipe or a number of elbows or fittings are required. Street elbows or globe valves should not be used in raw water systems.

Tubing may be used providing proper size is selected to give an inside diameter equal to or greater than the recommended pipe size. Flexible rubber connections in both inlet and outlet and discharge lines should be provided as close to the engine as possible. Refer to page 24 for a sample computation of restrictions.

The inside diameter of the through hull fittings and seacock should be the same as that of the inlet piping. The inlet scoop should be carefully selected to provide an opening area at least twice that of the inlet pipe and so located to take advantage of the raw effect when underway. The strainers should have a clear plastic body and must be easily accessible for frequent inspection and cleaning. A dirty strainer will cause flow restrictions and subsequent engine overheating. Commercial strainers usually have inlet and outlet markings on the strainer assembly. These naturally must be adhered to when piping up. Normally, the inlet is directed to the outer part of the strainer basket and the pump outlet to the inner part of the strainer basket. When duplex strainers are used, it is recommended one size larger strainers be used than that specified for single strainers to compensate for the added restriction of the control valve.

The heat exchanger is on the discharge side of the raw water pump and can be either tube type or a cooling cell type. Cell type elements are removable and an access must be left for their removal and inspection. Because of the corrosive effects of sea water, zinc plugs for anodic protection will be found at the raw water pump suction and at the heat exchanger. As an additional protection against corrosion due to electrolysis, material used in the raw water piping system should be consistent for all parts. Brass, stainless steel, monel or copper are the preferred materials (see page 16 of this section . . . "Electrolysis"). Piping connections between the engine and the hull are made flexible by using a length of rubber hose and clamps. Drain plugs must be provided at the low points in the system to permit a complete draining for repair and storage.

When water is injected into the exhaust, a means of controlling the amount of water may be necessary in order not to exceed the maximum limit of exhaust back pressure. In these installations the water must be split, with part of the water injected into the exhaust for cooling the exhaust gases, and part of the water led overboard to some point above the water line. By installing a gate valve in each line (see figure 7) it is possible to restrict the flow of water into the exhaust or increase it as required. The set-

table 1

TUBE O.D./LENGTH RELATIONSHIP									
Tube O.D.	1⅛"	1"	⅞"	¾"	⅝"	½"	⅜"	5/16"	¼"
Tube Length Per Engine H.P.	6"	6¾"	7¾"	9"	10¾"	13½"	18"	21½"	27"

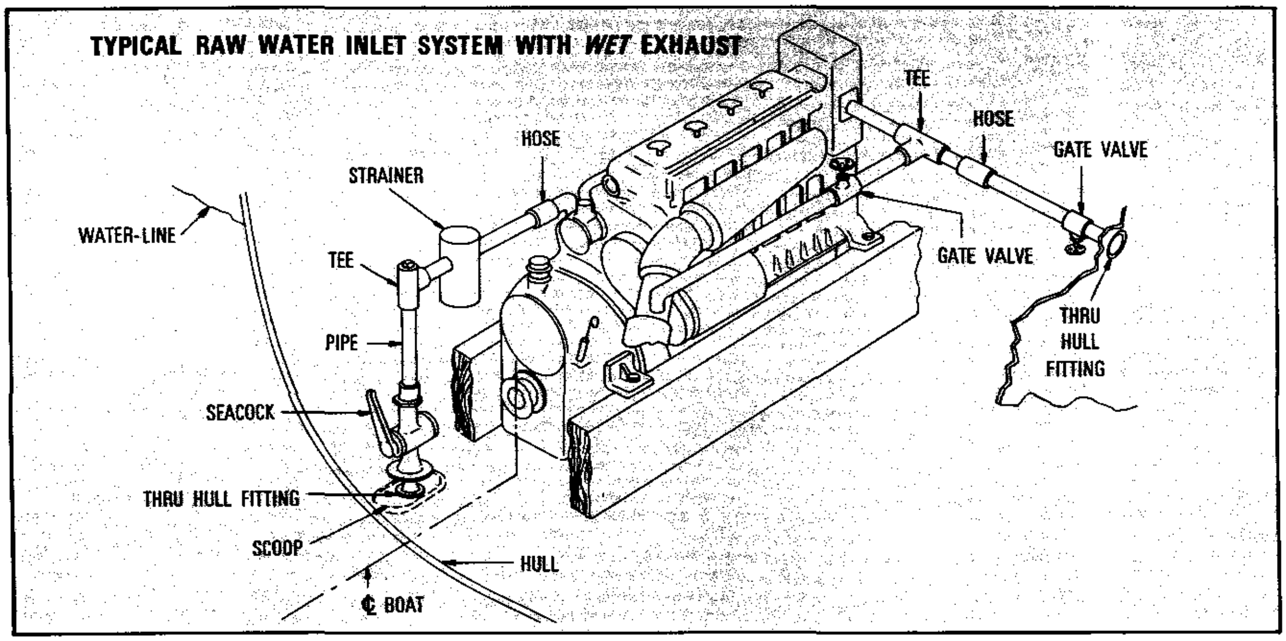


figure 7

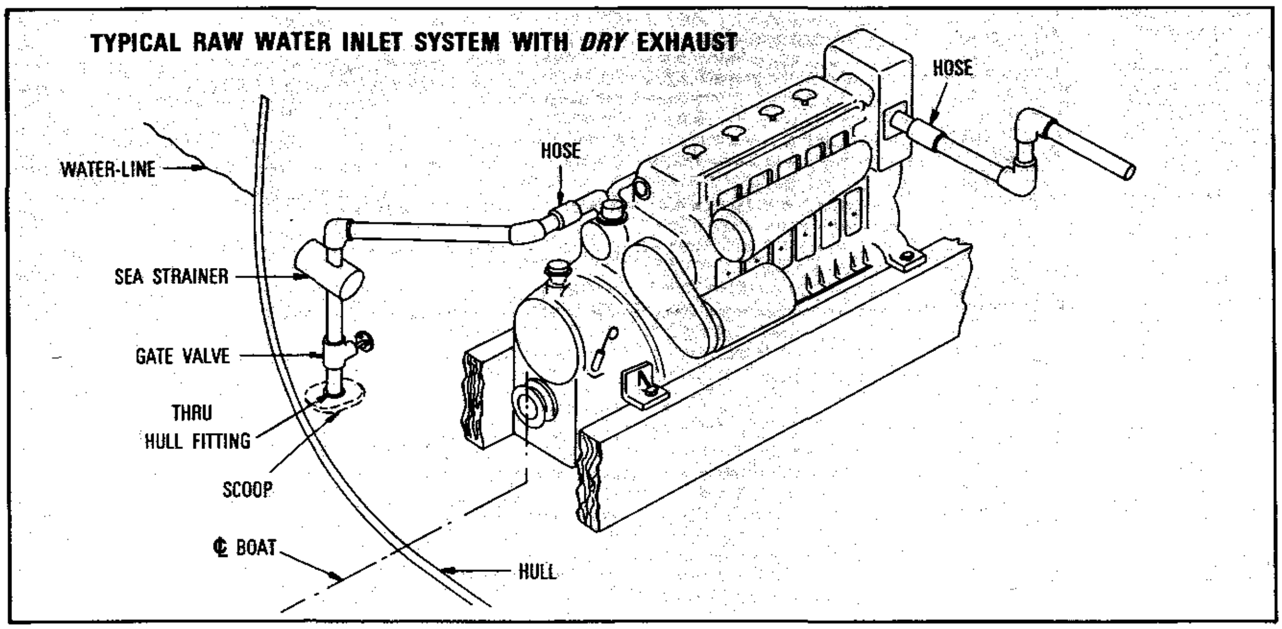


figure 8

tings of the valves can be determined by test, after which the valve handles are wired or locked in a fixed position to prevent them from being changed.

Individual engines in multiple units should have separate raw water inlet systems where possible.

Keel cooling is a system which uses a heat exchanger that is mounted externally on the hull below the water line. This system eliminates the need for a raw water pump or raw water piping, but increases the complexity of the fresh water piping.

The primary considerations when installing this type of system are: 1) Cooling capacity of the coils or tubes, and 2) Flow resistance due to frictional losses in the tubing.

The cooling capacity is determined by the amount of tubing surface area which is used effectively. Table 1 shows the relationship between the outside tube diameter (O.D.) and tube length per engine horsepower that is necessary to maintain adequate cooling under normal operating conditions.

Frictional losses in tubing can be controlled by any of several different means. Some of these are: 1) varying tube O.D., 2) varying the flow quantity, and 3) varying the piping layout; i.e., using several short tubes in parallel rather than one long tube.

In the design and selection of a keel cooling system, flow and pressure drop through the system must be in accord with the engine manufacturers recommendations to assure proper circulation of coolant through the engine. An additional expansion tank must be used to provide a reservoir for the added water in the keel cooler and its piping. The added tank capacity should be approximately 4% of the additional water in the keel cooling system.

Commercial keel coolers are generally purchased as assemblies and their resistance to flow characteristics should be investigated and compared with water pump discharge head limitations prior to an actual purchase or installation.

ELECTROLYSIS

Electrolysis is the term applied to the decomposition of metals caused by the action of small electrical currents.

These tiny electrical currents originate from two primary sources, which are:

1. Two dissimilar metals in contact with one another in the presence of an electrolyte (in this case, sea water).
2. Two dissimilar metals not in contact with one another and not connected to a common ground but in contact with an electrolyte (sea water).

When these conditions exist, a reaction very similar to that which occurs in a storage battery will take place. The most chemically active metal of the union will decompose.

The union of dissimilar metals can be eliminated by using a single, standard material for piping or by separating dissimilar materials with an insulator such as rubber hose.

Electrolysis that is caused by two dissimilar metals not in contact with one another, but in contact with an electrolyte, can be eliminated by providing a common ground throughout the boat and connecting every exposed metallic component to the ground.

As an added protection, Detroit Diesel engines are equipped with zinc electrodes in marine heat exchangers and raw water pumps. If electrolysis persists after the above precautions have been taken, these plugs will decompose instead of a vital part of the boat's equipment. These plugs can be replaced easily at small cost and should be checked often.

Specific cooling system data for individual Detroit Diesel marine models is included on the installation drawing for each engine model. Cooling system information on the installation drawing includes:

- Fresh water flow (to keel cooler).
- Raw water flow.
- Maximum inlet restriction at pump.
- Suggested pipe size.
- Suggested sea strainer size (single).
- Suggested sea strainer size (duplex).

In addition, general information to aid in the design and installation of a proper cooling system is included in the Appendix.

V AIR INLET SYSTEMS

For a proper engine air inlet system, it is important to consider such factors as engine room ventilation area, air cleaners and silencers, air inlet restriction and crankcase ventilation.

VENTILATION

In a closed engine room, there must be a blower or ventilation fan, and possibly an exhaust fan, with enough capacity to supply the air requirements for engine consumption and for ventilation. If blowers aren't installed, a permanent opening to the outside must exist or the engine room will soon be in a low pressure condition. When this occurs, loss of engine power will result. The required amount of ventilation area is shown on the manufacturer's specification sheet. This area must, of course, be great enough to supply all engines in the compartment. Dependence upon hatchways or engine room entrances for air is not recommended. They will inevitably be closed at times by the operating personnel or passengers.

One method of overcoming the problem is to pipe air from the atmosphere directly to the engine intake. If this is done, care must be taken to assure that no sea spray, rain, or any other foreign matter can enter the intake. Louvers or mushroom vents will usually stop rain and the spray of sea water.

AIR CLEANERS

To be assured that foreign matter will not enter the intakes, an approved air cleaner is required. Oil bath or dry type air cleaners recommended by the engine manufacturer will be effective in removing even the most minute particles which could score moving parts and cause a reduction in engine life.

INLET SILENCERS

Only when the atmosphere is clean will the mounting of intake silencers suffice in place of air cleaners. There is no cleaning effect derived from the silencers, so a thorough examination of possible future operating conditions must be considered. One must account for the possibility of dust from shore-side factories and sand barges, or paint chips and dust from the boat itself. Some intake silencers, such as the ones used on Detroit Diesel Series 53 engines, will accommodate an open cell polyeurethane cleaner pad. This pad is good to accomplish coarse particle removal.

AIR INLET RESTRICTION

When silencers, cleaners, piping and engine room air inlets are inadequate, the engine air intake restriction is increased. To keep the restriction within specifications, the proper size equipment must be installed and maintained. Just as in the fuel, water and lubrication systems, the air intake system should have a minimum of pipe length, bends and obstructions. For design purposes, the intake piping and fittings can be converted to equivalent pipe lengths, as shown in Table 13, page 31. The maximum equivalent pipe length for various engines is shown in Table 14, page 32. After an installation is completed, a manometer connected to the air inlet housing will give the actual installed value of restriction. Then, a check with the manufacturer's recommendation should be made to be sure the installation is within the specified restriction.

NOISE SUPPRESSION

Air intake noise is the easiest of the engine related noise sources to reduce. Recommended air cleaners with built-in silencing elements or separate silencers can effectively reduce the air intake noise. The silencer should be installed as close to the engine as possible and is generally satisfactory provided the complete engine is totally enclosed.

Due to the high frequencies of the air intake system noise and the need for an airtight system, special attention should be given to the intake piping. Heavy wall, round piping with as few rubber sections as possible is recommended.

CRANKCASE VENTILATION

The vent line from the crankcase breather is usually directed to the engine air intake so that blow-by gases and vapors will not be dumped into the engine room.

If a dry type cleaner is used, or if the air intake is quite distant from the engine, then the vent should be led to the above deck atmosphere. If the vent is led above deck, care must be taken to prevent sea or rain water from being able to enter the pipe.

If the first two methods are impossible and there is no other alternative, it may be dumped into the engine room.

VI EXHAUST SYSTEMS

More care must be taken to properly install a marine exhaust system than is required of most other exhaust system installations. Noise, odor, back pressure, heat, and protection from sea and rain water are criteria which must be treated with individual concern.

Basically, there are two types of marine exhaust systems: 1) Vertical stack type, 2) Horizontal through-hull or transom type.

VERTICAL STACK

Figures 9-A and 9-B, below, show two typical stack arrangements in which the exhaust lines from each engine are led vertically above the engine to release the exhaust to the atmosphere. Note that the noise problem is reduced by employing a muffler or silencer.

figure 9-A

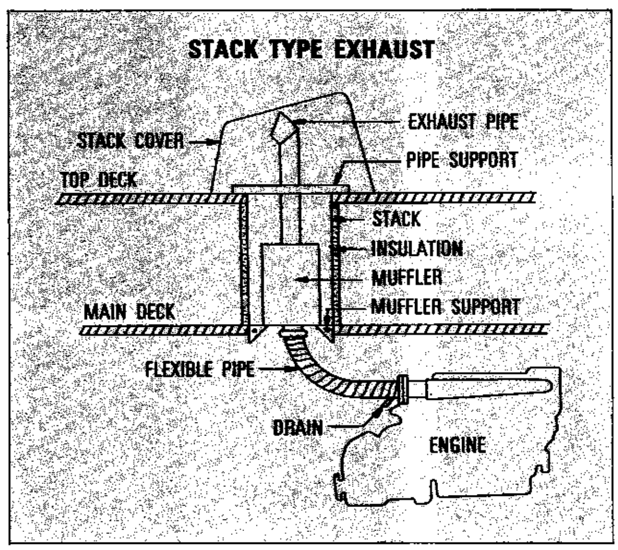
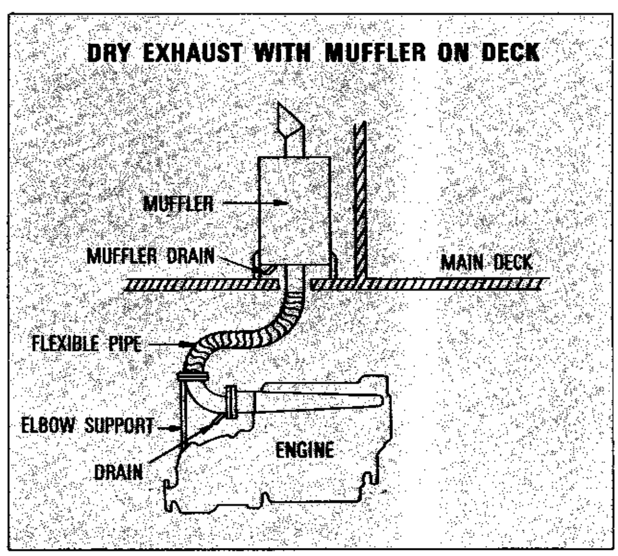


figure 9-B



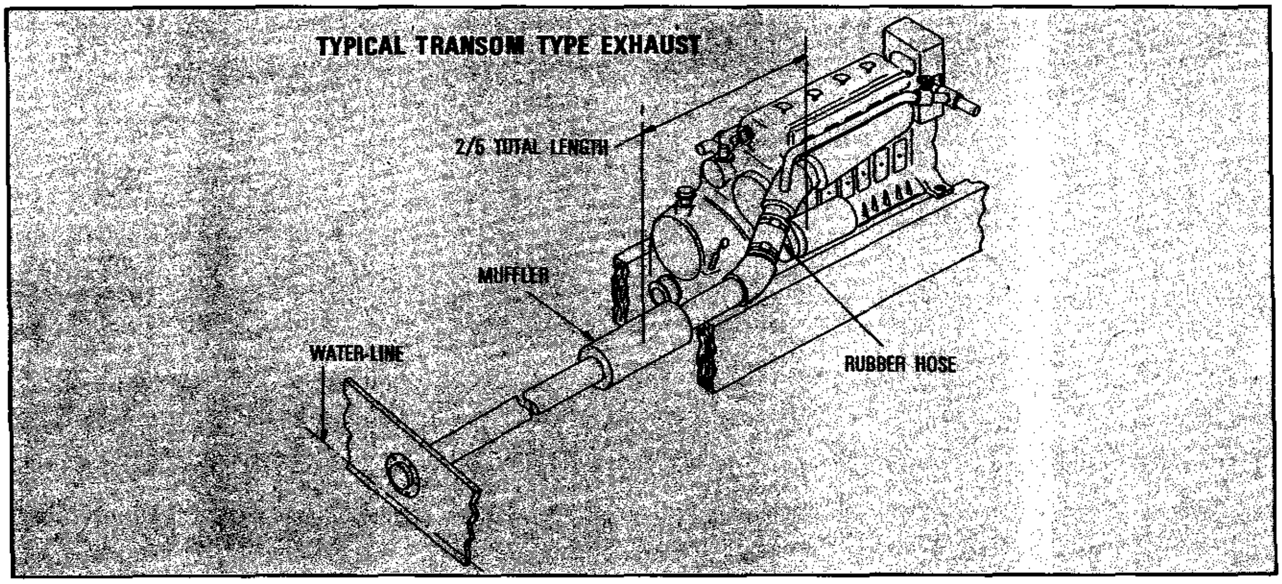


figure 10

Since exhaust gases may reach temperatures approaching 1000°F, protection of wooden structures and exposed areas is achieved through asbestos piping insulation and by leaving air spaces between the pipes and the surrounding stack cover. The stack cover and passages may also be insulated. The bend of the outlet pipe directs the gas flow up and aft as well as protecting against the possible entrance of falling rain. Should a driving rain force water into the system, it will collect in the muffler where a plug should be installed to drain it off.

A balanced rain cap may be used in place of the pipe bend. As in other engine piping systems, the connection between the exhaust manifold outlet and the piping secured to the hull must be flexible. This is done only with high temperature material such as flexible metal pipe; its purpose being to relieve any heat or mechanical stress and vibration on the system. The flex pipe may also be insulated.

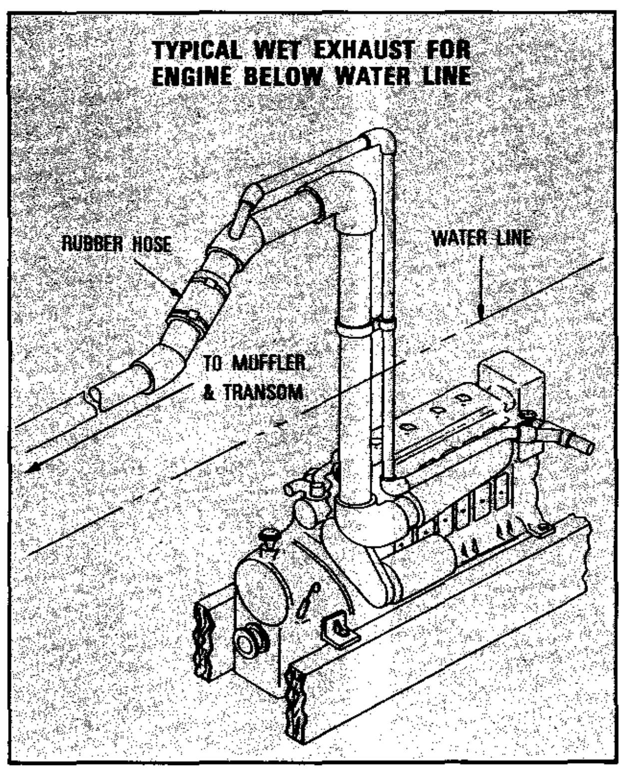
HORIZONTAL THROUGH-HULL

Figure 10, above, and Figure 11, right, show a typical transom exhaust system with its many advantages over the stack type. This system allows the noise from the open pipe to be directed aft of the boat and away from a direct contact with passengers' ears.

As a further noise reduction technique, this system allows for a 'wet type' exhaust in which water is injected directly into the exhaust gas stream. Raw water is injected after it has circulated through the engine heat exchanger and through the exhaust manifold jacket. Note that this has the added advantage of protecting against heat and fire hazard, and that insulating material is unnecessary on the water cooled exhaust lines.

Since only a part of the raw water may be injected into the exhaust system, while the rest is ejected through the raw water overboard discharge, an adjustment of the water distribution must be available. This requirement is met with an

figure 11



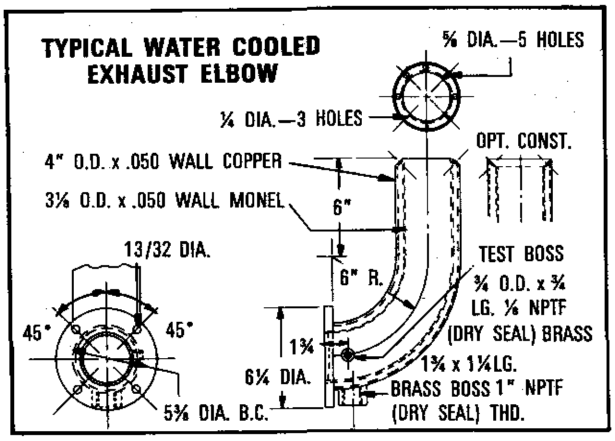


figure 12

overboard discharge valve at the hull connection. This valve is adjusted while observing both the exhaust back pressure and the raw water pump pressure so that neither exceeds its maximum value as shown on the manufacturer's specification sheet. The valve handle is then lashed in place to prevent vibration from changing the setting.

Mufflers may still be placed in the system as shown in Figure 10, page 18. Flexible connections such as rubber hose and clamps may be used as long as they are at a portion of the line where the exhaust is wet.

As a precaution against the backwash of sea water, a riser is placed in the exhaust line with the peak of the riser high enough above the normal water line of the hull to prevent backwash under any circumstances. See Figures 11 and 12.

A wet type exhaust system is usually preferred on small boats because it is water cooled and does not require expensive jacketing or insulation. The wet type exhaust system, however, must employ material capable of withstanding both corrosion and erosion brought about not only by the hot salt water, but also from the exhaust gas components.

Sulphorous acid, for example, formed by cooling water and the sulphur content in the average diesel fuel, is often sufficiently concentrated to create excessive corrosion unless it is diluted by a proper amount of cooling water through the exhaust line.

The most suitable materials for use in a wet exhaust system are cast gray iron, copper, copper nickel, monel and specially enameled steel. In addition, a suitable type rubber is considered excellent material for water cooled exhaust lines, and is now in popular use. The common grades of stainless steel are too readily pitted in salt water while the better grades of stainless, Inconel, Hasteloy C and other materials of this type, although excellent from a corrosion standpoint, are generally impractical because of their high cost.

Special consideration must be given to the exhaust system for turbo-charged engines.

The externally applied load at the turbocharger outlet flange must not exceed 400 lb. in. to avoid turbine housing cracking and distortion which could result in premature failure of the high speed rotor shaft bearing. The combined effect of the following must be considered in evaluating an exhaust installation to meet this specification.

—moment of piping rigidly attached to the turbocharger (including an allowance for maximum impact loads anticipated).

—moment due to thermal expansion of hot exhaust piping.

—moment due to load resulting from relative movement of engine with respect to the exhaust pipe.

The piping rigidly attached to the turbo-charger must be supported *from the engine* or fabricated from light gauge (⅛" wall) material with a flexible hose connection as close to the turbocharger as possible. For maximum life, stainless steel is recommended for light gauge fabrications in dry exhaust systems. Monel is recommended for wet or jacketed systems. Hot exhaust pipes should be lagged with lightweight insulation.

Dry exhaust systems are recommended for turbocharged engine installations wherever feasible. Where an overhead stack is used, the outlet must be protected against weather with a condensate drain provided at the low point of the system.

When a wet exhaust system must be used, extreme care must be exercised to prevent water from backing up into the turbocharger under the most extreme conditions. In general, water should be introduced into the exhaust line in a section which drops sharply at approximately 45° (degrees) for a vertical distance of at least twelve (12) inches. The point of water injection should be at least six inches below the high point in the system with water directed downstream to prevent any back-splash from entering the turbocharger. From the lower end of the steeply sloping section, a run-off of at least one-half (½") inch per foot—with no dips or bumps —should be provided to carry the cooling water to the hull outlet above the waterline. In many installations it will be necessary to run a riser pipe at the engine, leading the exhaust upward to provide an adequate run-off from the point of water induction. In long exhaust pipes with marginal run-off, traps with baffle or check valves will be required at the bottom of the steeply sloping section to control wave action on water surging in the exhaust line when operating in heavy seas.

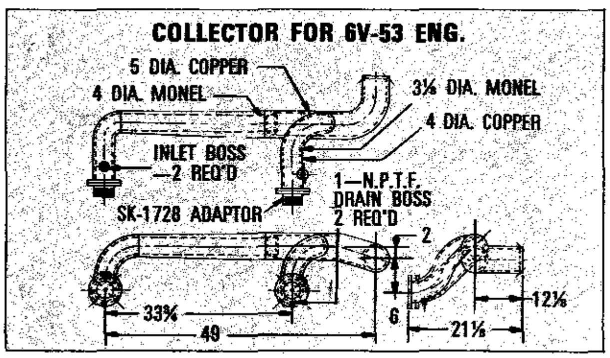
Exhaust back pressure must be held to a minimum for efficient operation of the turbocharger. In no case should the back pressure exceed two and one-half (2½") inches of mercury at rated speed and load. When the length of the exhaust line exceeds thirty (30') feet, or when a number of ninety (90°) degree elbows or fittings are required, the inside diameter of the piping should be increased.

Individual exhaust lines for each engine are recommended for multiple engine units. If individual engine exhausts are piped into a common manifold, pipe sizes become quite large to avoid excessive back pressure. In addition, it becomes necessary to provide a means of closing off the exhaust of each engine to avoid serious damage to an idle engine.

COLLECTORS

Water jacketed collectors or headers are available from various manufacturers to join the manifolds of V-engines. A typical example is shown in Figure 13, which illustrates the use of monel inside and copper outside. If so desired, the component pieces can be purchased for fabricating, but the pipe sizes must remain within the limits listed on the specification sheet. It is quite important to adequately support these collectors or headers to eliminate undue stresses in the exhaust manifolds.

figure 13



MUFFLERS

It is important to obtain a muffler that fits the specific needs of a particular system. This means that the muffler must provide adequate sound reduction, yet be capable of handling the volume of gas expelled by the engines without exceeding its back pressure limit.

The location of the muffler has considerable effect on the noise level of the system. The best locations for a muffler are, in this order: 1) at the manifold, 2) at 2/5 the total length of the system measured from the manifold or, 3) at 4/5 the total length. Mufflers will have the least effect when located at 1/5, 3/5 or 5/5 the total length of the system.

Mufflers used in all systems should have a drain plug at their lowest point so that condensates and trapped cooling water can be drained during extended periods of inoperation.

Since most mufflers turn out to be quite heavy, adequate bracketing is essential. In fabricated mufflers, resonant vibration is sometimes encountered. This can be eliminated by spacing the baffles unevenly on assembly or by a rubber mounting. If unexposed resonance is encountered, it can probably be eliminated with controlled water injection.

The exhaust noise is usually the predominant noise in most diesel marine applications and is one of the more easily suppressed. Mufflers of varying degree of silencing are readily available and the selection of the proper muffler is dependent on the degree of silencing required. A muffler of double wall-thickness —or wrapped to reduce shell noise radiated from the outer surfaces—will aid in minimizing exhaust noise.

The leakage of exhaust system pipes and joints are obvious sources of possible noise which generally increase during engine life due to wear, misalignment or improper repair of the exhaust system. Proper selection and installation of the correct pipes and joints plus good maintenance procedures will obviate unnecessary noise from the above sources.

EXHAUST ODOR

Exhaust odor in the engine room can be reduced by maintaining tight, gasketed connections on the dry systems, and on wet systems by injecting the jacket water as close to the engine as possible. Above deck odors are reduced by directing gases up and aft with pipe bends in a stack system or by use of outboard deflectors in transom exhaust outlets. Increasing the exhaust back pressure to the maximum allowable limit will also help eliminate exhaust odors above deck due to increased velocity of the exhaust gases.

When these methods are ineffective and where odors might be offensive to passengers, a commercial smoke and odor inhibitor may be added to the fuel supply. Vitasul, Almask, and Deodall No. 1 are some examples of these additives.

EXHAUST BACK PRESSURE

Due to the extensive piping and silencing involved in marine applications, careful planning of the piping sizes, lengths, runs, and fittings used is essential to keep back pressures within limits shown on the manufacturer's specification sheets. If this is neglected, the engine power output may be reduced.

Pipe fitting restrictions can be converted to equivalent lengths of straight pipe (Table 11, page 30). The maximum equivalent length of straight pipe to prevent excess back pressure, for a given engine, is shown in Table 15, page 32.

Back pressure will naturally increase with the introduction of water into the exhaust system. How much the pressure will be raised is difficult to predict and must be measured after each installation.

On V-engines, where a water-jacketed collector is sometimes used to join the two banks, the design of this collector should be such that the one pipe is ample to handle the two bank pipes without increasing the back pressure. Figure 13, page 20, shows the recommended single and double pipe sizes for a 6V-53. These specifications are also listed on the engine installation drawings.

Once a system is installed, the actual back pressure under operating conditions should be verified. This is done with a U-tube manometer, using a suitable fitting in the exhaust manifold to pipe flange.

VII STARTING SYSTEMS

Marine starting and electrical systems differ very little from those of trucks and power units or any other engine installation. Basically, there are two separate electrical systems; one issued for starting only while the other supplies power for accessories such as lights and pumps. Choosing the proper starter, batteries and generator to do a satisfactory job is the main concern in a new marine installation.

STARTERS

Electric starters come in three voltages: twelve, twenty-four, and thirty-two volts. The voltage used for a particular engine starter is determined by the size of the engine and by the electrical system used in the boat.

The starter voltage recommendations of Detroit Diesel are shown in Table 16, page 33. This and the other electrical equipment on the boat should be taken into consideration in selecting the starter voltage.

Air starters are used on larger installations where an air pressure system is available. Hydro-Starters are used where air and electricity cannot be depended upon.

BATTERIES

Battery selection must provide enough power to start the engines and to handle the requirements of any electrical equipment that must operate while the engines are not in use. Table 16, page 33 shows the recommended battery rating for starting alone.

Battery location, from the standpoint of cable length, weight distribution and storage space, is quite important. These three items are closely related. A battery must be placed to maintain boat inclination and trim, must not take up too much valuable storage space, and must be kept dry. It must also be placed so as to use a minimum length of cable (Table 17C, page 34).

Battery placement must provide protection from excessive temperatures, spray from leaky pumps and stuffing box seals, sloshing bilge water, leaky fuel lines, and any other potentially damaging mishap.

Most electrical equipment, such as motors, alternators and other auxiliary equipment, are built and wired with a positive lead and a negative ground. Care must be exercised to insure that the electrical installation has the proper ground and that future auxiliaries are installed with this in mind.

GENERATORS AND ALTERNATORS

The alternator, due to its many advantages, is rapidly replacing the D.C. generator as a source of battery charging power. The biggest single advantage in the marine industry is the fact that alternators, or A.C. self-rectifying generators, can be paralleled regardless of the ampere rating. They must, of course, be of the same voltage rating.

The selection of the proper generator size, A.C. or D.C., depends on: 1) the maximum load it will be expected to carry, 2) the speed at which the engine will run when this output is expected, and 3) the output that is necessary to keep the batteries fully charged.

VIII INSTRUMENTATION AND TROUBLE-SHOOTING

For purposes of safety at sea and to protect the engine, it is necessary to monitor the various temperatures, pressures and RPM of the engine during its operation. The important and most common monitors are listed below:

OIL PRESSURE

1. **Engine Oil:** A Bourdon tube mechanical type gauge, electric transducer and gauge, or electric transducer and indicator light may be used to monitor engine oil pressure. The mechanical type is the recommended method of monitoring for the greatest accuracy and dependability. Pressure is usually taken from the main oil gallery at a threaded hole in the side of the block. Low pressure may be an indication of dirty filters or intake screen, pump malfunction, worn bearings, hot oil, an open pressure regulator, or a leak. A surging pressure may indicate air in the system due to low oil level.

2. **Gear Oil:** Gear oil may be monitored in the same manner as engine oil and is usually measured at the gear oil pump outlet or at the clutch inlet. Low pressure can be attributed to pump, clutch, and other seal leakages, suction restriction, hot oil, or strainer and filter clogging. Clutch slippage and excessive gear wear will result if the trouble is not rectified.

WATER TEMPERATURE

Capillary tubes or electric transducers may be used to monitor water temperature. Measurement is usually taken at the fresh water manifold outlet to the heat exchanger and should range from 160°F to 185°F during load conditions. High temperature is a result of overheating caused by poor heat exchanger cooling, a sticking thermostat, engine overloading, or sea temperatures that are too warm. Too low an engine temperature may often be traced to an open thermostat with sea temperatures that are too cold or operation at low load.

[illegible]

A boat operator depends on accurate engine RPM indicators for safe, economical operation. A tachometer adapter is usually mounted on one of the engine accessory drives to which a mechanical or an electrical tachometer may be attached.

For the greatest accuracy, the mechanical cable and tach is recommended but an electric transmitter and tach should be used where cable lengths become excessive. Drive ratios of 1:1 and 1:.5 are common for tachometer adaption. In some cases, a shaft RPM indicator is useful, in addition to engine RPM, to detect clutch slippage under load. Low engine RPM's indicate power loss or an excessive propeller loading.

AMMETER

An ammeter is used to detect the condition of the batteries, voltage regulator and alternator. Consistent discharge readings indicate excessive electrical loads on the system, low alternator output, or a voltage regulator malfunction. Consistent high charge readings indicate weak batteries or a voltage regulator malfunction.

[illegible]

The more one knows about his engine's operating parameters, the easier it is to detect malfunctions and to troubleshoot. The following monitors are good additions to have but are generally not considered essential:

1. **Air Cleaner Restriction Indicators:** This monitor is used to detect clogged air cleaners. They are usually mounted on the air cleaner discharge to the engine blower inlet.

2. **Fuel Pressure:** To detect clogged filters and strainers.

3. **Exhaust Stack Temperature:** To detect combustion problems which may occur from faulty injectors.

4. **Oil Sump Temperature:** To detect oil overheating due to excessive friction in the moving engine parts.

5. **Engine Hour Meter:** To schedule engine maintenance.

Monitors should be in an unobstructed view of the operator during engine operation. Dual guages in the engine room should be seriously considered for added convenience. Engine mounting of gauges is not recommended, however, because of vibration.

When a low oil pressure or high water temperature occurs, the situation is serious enough to warrant the installation of contact switches in the monitoring system which will automatically flash a light, sound an alarm or even shut the engine down. Troubleshooting procedures should then begin without operating the engine again until the problem is solved.

If the difficulty is not immediately apparent, always check the accuracy and functioning of the gauges before dismantling engine components. Refer to the appropriate Detroit Diesel Engine Maintenance Manual for precise, detailed troubleshooting procedures.

[illegible]

[illegible]

There are two basic control functions to be performed by a marine engine installation: 1) Direction of rotation of the propeller shaft, and 2) Speed of propeller shaft rotation.

The direction of rotation, clock-wise or right-hand rotating and counter-clock-wise or left-hand rotating, is controlled within the reverse gear.

The speed of rotation of the propeller shaft is a function of the engine speed and the reverse gear reduction ratio. The engine speed is controlled by the governor settings of the fuel control racks.

REVERSE GEAR

Except in the case of high speed planing hulls, most engines run at too high an RPM for the propeller size selected for a given hull. The engine speed then must be converted to a lower speed through the use of gears.

Unlike automotive gears, a given marine gear generally has only one reduction ratio available. This may vary from a 1:1 ratio to a 5 or 6:1 reduction ratio or greater.

Reversing is accomplished through the control of forward or reverse clutches. These clutches are, in most cases, integral with the reverse-reduction gear. Control is accomplished through a selector lever mounted on the gear box which controls hydraulic pressure for engagement of either the forward or the reverse clutch. If neutral is desired, then neither clutch is engaged. Positioning of the selector lever will be explained later in this section under "TYPES OF CONTROLS."

GOVERNORS

To make speed changes to the boat during its operation, the propeller RPM must be changed. This is done by changing the engine RPM which is controlled through the engine mounted governor.

There are two basic types of governors, limiting speed and variable speed. The limiting speed governor will control engine speed to a predetermined setting at idle and at maximum RPM settings. This means that the engine will not stall when the speed control lever is moved to the minimum position nor overspeed when it is moved to the maximum position, regardless of load conditions. For speed settings between these extremes, any change in load will cause speed changes which the operator must compensate for by hand.

The variable speed governor, on the other hand, not only maintains minimum and maximum speed, but will maintain any speed selected between these settings, regardless of changing load conditions. Speed settings are accomplished by the operator's positioning of the governor speed control lever on the governor housing.

STOPPING AND STARTING

Since positioning of the speed control lever at its minimum position will not shut the engine fuel off, another lever, the governor control lever, is mounted on the governor housing. Its purpose is to override the speed control lever by cutting off the fuel to the combustion chamber completely, thereby stopping the engine.

Another method of stopping the engine is to cut the air supply. This is done by a damper in the air inlet housing which can be released to stop engine air intake. The latter method of stopping is used only in emergency, or when the fuel cannot be cut off quickly enough.

Starting is done with common 12, 24, or 32 volt electric starting motors, with air starting motors, or with hydrostarters. Air starters will be found mainly in the larger installations where compressors and air tanks are available. Hydrostarters are starting motors operated by high-pressure hydraulic fluid from a charging cylinder. This cylinder can be charged by an engine driven pump or by a hand pump.

TYPES OF CONTROLS

In summary, the control requirements of most marine engine installations include starting, stopping speed and reversing.

Electric starting can be done by remote push buttons and solenoids. Air starting is usually accomplished by a hand operated, quick-closing valve right at the engine. The hydrostarter also has a quick-closing valve mounted on the starter motor for starting purposes.

Stopping is done with an electric solenoid mounted on the governor housing. When a remote stop button is pushed, the solenoid shoves the governor control lever into the fuel-off position. The air inlet damper is controlled by a cable which is extended to some location outside the engine room, usually the operator's control panel. When the operator pulls on the cable in an emergency, the damper is released from its latch to stop the air flow.

The speed control lever and clutch selector lever on the engine and gear box can be mechanically controlled from the operator's control station. This is done through the use of cables and pulleys attached to the operator's hand control lever. If there is a separate lever for clutch and speed, the operator must exercise care to see that engines are at idle speed during shifting in order to protect the clutches. By using single lever control, the operator cannot make a mistake because shifting cannot take place until the lever is in the idle position.

It is often found that, in larger installations where the vessel has an air compressor, the method of control is through pneumatic means. Piston-type actuators, operated by air pressure, perform the movements required to move the speed and clutch levers.

SHAFT BRAKE

On larger vessels, using engines developing power approaching 1000 HP and high gear ratios, the propellers and shafting are of such size that the rotating moments of inertia are very high.

To relieve the reversing clutches of this extreme loading, a shaft brake is strongly recommended to stop the rotation of the propeller and shaft during shifting operations.

The controls of the shaft brake are always incorporated into the engine controls to eliminate any operator error.

X APPENDIX

DETERMINING OPTIMUM PIPING SYSTEM PERFORMANCE

For optimum piping system performance, considerable care must be devoted to the planning of the system. In all cases, the pump inlet restrictions and discharge heads must never exceed those limits stated on the engine specification sheet. If those limits are exceeded, proper operation of the equipment involved cannot be expected.

The proper combination of piping and components can be determined by trial and error, but this procedure is usually costly in terms of time *and* money. The following pages provide the tables and explanations necessary to calculate flow restrictions of the fuel system and the raw water system. Proper use of these convenient reference tables will eliminate much of the wasted time in piping up a new system.

COMPUTATION OF FRICTION LOSSES IN RAW WATER SYSTEM

To compute friction losses in a piping system, each component (valves, fittings, pipe, strainers, etc.) must be converted to an equivalent length of straight pipe (Table 3, page 26). The friction loss of the equivalent length of pipe is then found in Table 5, page 27. The friction loss of the equivalent length of pipe is then multiplied by a coefficient multiplier which is determined by the type of piping used (Table 6, page 27).

It is important to remember that before multiplying or adding, all units must be alike; i.e., feet of water, inches of mercury, etc. It is a simple operation to convert from feet of water to inches of mercury (multiply feet of water times 0.88 to obtain inches of mercury).

The engine chosen as an example for computing raw water piping restrictions is a 6-71 turbocharged marine engine rated for 300 HP at 2300 RPM. At this RPM the raw water system flows at a rate of 72 GPM (Figure 14, page 25). Assume that the inlet piping system is composed of a 2" scoop, a 90° 2" elbow, two 45° 2" elbows, a 2½" simplex strainer, a 2" gate valve and 5 feet of straight pipe. Also assume that the raw water pump inlet is one foot above the water line and that new brass piping is used.

		Equivalent Length
One 90° Elbow of 2" pipe	=	5.17 feet (page 26)
Two 45° Elbows of 2" pipe	=	4.82 feet (page 26)
Five feet of straight 2" pipe	=	5.00 feet
One 2" gate valve of 2" pipe	=	1.21 feet (page 26)
		16.20 Total

16.20 feet of new brass pipe has a friction loss of $\frac{20.9}{100}$ (Table 5, page 27) x 0.6 (Table 6, page 27) or

		Friction Loss in feet of H_2O
20.9 feet equivalent length of new brass pipe	=	0.1254
1 2½" Simplex Strainer	=	2.75 (Table 4, page 26)
Height of pump above water line	=	1.00
		3.8754
3.8754 feet of water x 0.88	=	3.42 inches Hg.

In this example, the restriction is within limits specified on the engine specification sheet. If it was not, changes such as larger piping, fewer sharp angle bends, etc. would have to be made to correct the system.

This example calculates only the inlet restriction, but the same procedure is used in calculating the discharge head. The only new factor is; to convert from feet of water to psi, multiply feet of water times 0.433.

figure 14

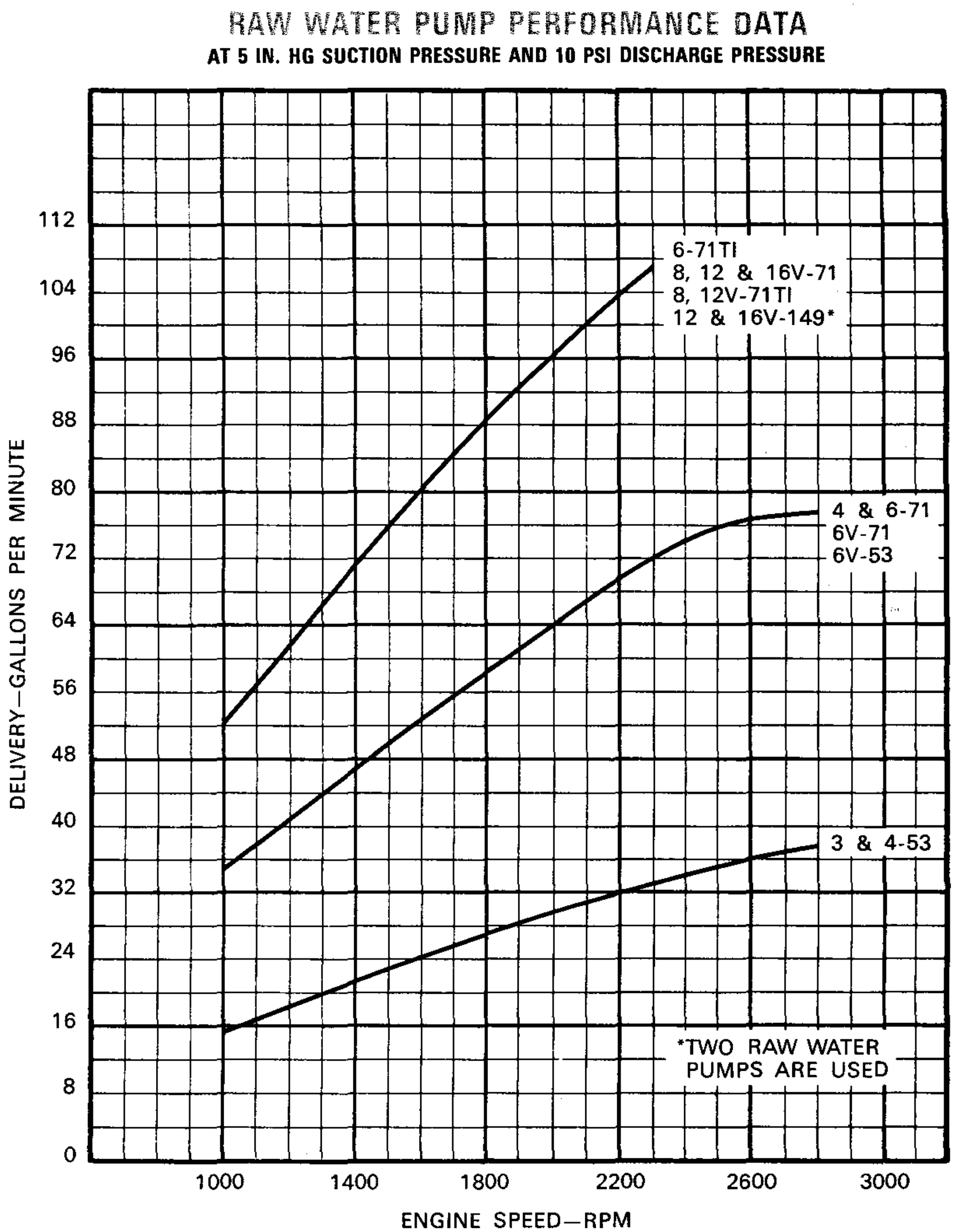

RAW WATER PUMP PERFORMANCE DATA
AT 5 IN. HG SUCTION PRESSURE AND 10 PSI DISCHARGE PRESSURE
DELIVERY—GALLONS PER MINUTE
112
104
96
88
80
72
64
56
48
40
32
24
16
8
0
1000
1400
1800
2200
2600
3000
ENGINE SPEED—RPM
6-71TI
8, 12 & 16V-71
8, 12V-71TI
12 & 16V-149*
4 & 6-71
6V-71
6V-53
3 & 4-53
*TWO RAW WATER PUMPS ARE USED

table 2

Model	Water Inlet Connection	Water Outlet Connection	
		Simplex	Duplex
Series 53			
3 & 4-53	1¼ In.	1½ In.	2 In.
6V-53	2 In.	2½ In.	3 In.
Series 71			
4-71	1½ In.	2 In.	2.5 In.
6-71	2 In.	2½ In.	3 In.
Series V-71			
6V-71	2 In.	2½ In.	3 In.
8V-71	2½ In.	3 In.	4 In.
12V-71	2½ In.	3 In.	4 In.
16V-71	2½ In.	3 In.	4 In.
Series 71-TI			
6-71TI	2 In.	2½ In.	3 In.
8V-71TI	2½ In.	3 In.	4 In.
12V-71TI	2½ In.	3 In.	4 In.
Series 149			
12V-149	2½ In.*	3 In.*	4 In.*
16V-149	2½ In.*	3 In.*	4 In.*

SUGGESTED PIPE SIZE FOR WATER CONNECTIONS

(*Per Pump)

table 3

FRICTION LOSS THROUGH PIPE FITTINGS AND VALVES
LOSS EXPRESSED IN FEET OF LINEAL PIPE

	90° Elbow	45° Elbow	Gate Valve	Globe Valve	Angle Valve	Return Bend
1¼"	3.45	1.61	.81	38.3	19.1	7.66
1½"	4.02	1.88	.94	44.7	22.4	8.95
2"	5.17	2.41	1.21	57.4	28.7	11.5
2½"	6.16	2.88	1.44	68.5	34.3	13.7
3"	7.67	3.58	1.79	85.2	42.6	17.1
4"	10.1	4.70	2.35	112.0	56.0	22.4
5"	12.6	5.88	2.94	140.0	70.0	28.0
6"	15.2	7.07	3.54	168.0	84.1	33.8

table 4

STRAINER PRESSURE DROPS IN FEET OF WATER

	GPM				
	60	70	90	140	180
2" Simplex	2.0	3.7	6.0		
2" Simplex-Reversed Flow (Outside of basket to inside)		2.27			
2" Duplex	2.85	7.4			
2½" Simplex	.57	2.27	4.28		
2½" Simplex—Reversed Flow		1.14	2.85		
2½" Duplex	1.14	4.55	8.55		
3" Simplex	.23	.46	.8	1.7	2.62
3" Simplex—Reversed Flow			.11		
3" Duplex	.57	1.01	1.6	3.41	5.7
4" Simplex	.11	.17	.285	.68	.91
4" Duplex	.23	.34	.57	1.36	1.82
5" Simplex			.11	.285	.46
5" Duplex			.23	.57	.91
6" Simplex				.11	.23
6" Duplex				.23	.45

Inches of mercury (hg.) x 1.14=Feet of water
Feet of Water x 0.88=Inches Hg.

Feet of Water x 0.433=pounds/square inch
Inches of Hg. x 0.491=pounds/square inch

table 5

FRICTION OF WATER IN PIPES
LOSS OF HEAD IN FEET PER 100 FT. LENGTH

RATE OF FLOW IN GALLONS PER MINUTE	Diameter of Pipe 1¼"	1½"	2"	2½"	3"	4"	5"	6"
25	16.6	7.8	2.73					
30	23.5	11.0	3.84	1.29				
35	31.2	14.7	5.1	1.72	.75			
40	40.0	18.8	6.6	2.2	.91	.22		
45	50.0	23.2	8.2	2.8	1.15	.28		
50	60.0	28.4	9.9	3.32	1.38	.34		
75		60.0	20.9	7.1	3.0	.73	.24	
100		102.0	35.8	12.0	4.96	1.22	.41	.17
125			54.0	18.2	7.6	1.86	.64	.27
150			76.0	25.5	10.5	2.62	.88	.36
175			102.0	38.8	14.0	3.44	1.18	.48
200			129.0	43.1	17.8	4.4	1.48	.62
250				66.0	27.2	6.72	2.24	.95
300					38.0	9.3	3.14	1.32

table 6

COEFFICIENT MULTIPLIERS FOR VARIOUS TYPES OF PIPE	
25 Year Old Iron Pipe	1.2
New Brass or Steel Pipe	.6
New Iron Pipe	.7
15 Year Old Iron Pipe	1.0

BREAKDOWN OF INLET SYSTEM BY INDIVIDUAL COMPONENTS			
COMPONENT DESCRIPTION	RESTRICTION (In. Hg.)	TOTAL UNITS	TOTAL RESTRICTION (In. Hg.)
½" steel tubing (.444" I.D.)	.134 in. hg/ft (Figure 15, Page 28)	18 ft.	2.41
137425 90° elbow (½" tube, ⅜" NPTF)	.43 ea. (Figure 16, Page 29)	7	3.01
137409 (½" tube, 38" NPTF)	.03 ea. (Figure 16, Page 29)	2	.06
6435876 Primary strainer (8-½" element)	1.32 (Figure 17, Page 30)	1	1.32 ea.
Fuel Lift (1.0 ft.)			
Total Restriction at Fuel Pump Inlet			7.60 in. hg.
Maximum Allowable Restriction at Fuel Pump Inlet			6.00 in. hg.
Excessive Restriction (unsatisfactory)			1.60 in. hg.

COMPUTATION OF FRICTION LOSSES IN FUEL SYSTEM

The calculated fuel pump inlet restriction for a typical engine application, with the fuel pump located above the fuel tank, would be determined as follows:

Maximum fuel flow (6V-71 engine, Table 8, page 28), 90 gal. per hr.

Maximum fuel pump inlet restriction, 6 in. hg. (See engine specification sheet).

Each foot of fuel lift is equivalent to 0.8 in. hg. restriction.

Minimum recommended fuel inlet line size (Table 7, page 28), ½"

SOLUTION 1 Replace 90° elbows with connectors and additional tube bends.	Remove 5 elbows and decrease restriction 2.15 in. hg. Add 5 connectors and increase restriction .15 in. hg. Add 5 tube bends and increase restriction .20 in. hg. Total decrease in system restriction 1.80 in. hg. Revised total restriction at fuel pump inlet 5.80 in. hg. A restriction of 5.80 in. hg. is satisfactory (below 6 in. hg.)
SOLUTION 2 Increase tubing size to ⅝".	A similar result, but most likely more expensive, could be accomplished by changing to a ⅝" steel tube.

As indicated above, the most significant restrictions are generally due to fittings, valves and piping. Therefore, the maximum restriction of 6 in. hg. can be achieved, in most cases, by varying fittings, pipe sizes, or both.

table 7

MINIMUM FUEL LINE SIZES				
	3 & 4-53, 4-71	6V-53, 6-71 & 71TI, 6V-71 8 & 12V-71 & 71TI	16V-71	12 & 16V-149
Supply Line (Min. Tube Size)	3/8"	1/2"	5/8"	1"
Return Line (Min. Tube Size)	5/16"	5/16"	3/8"	5/8"

table 8

ENGINE FUEL FLOW			
Engine Series	Fuel Return Orifice	Engine Speed (RPM)	Fuel Flow GPM
3 & 4-53	.070"	1600-2800	60
6V-53	.070"	1600-2800	60
4 & 6-71 & 6-71TI	.080"	1600-2300	90
6 & 8V-71	.080"	1600-2300	90
8 & 12V-71TI	.080" or .106"	1600-2300	120
12V-71	.106"	1600-2300	120
16V-71	.070"	1600-2100	120
12 & 16V-149	.136"	1600-1900	250

table 9

Engine Series	Spill Flow @ 2100 rpm U.S. Gal./Min. Minimum		Recommended Spill Orifice Size	
3 & 4-53	.6		.070"	
6V-53	.6		.070"	
4 & 6-71	.8		.080"	
6 & 8V-71	.8		.080"	
6L, 8V & 12V-71TI	.8	1.2	.080"	.106"
12V-71	.8	1.2	.080"	.106"
16V-71	1.2		.070" (2 Orifices)	
12 & 16V-71	2.0		.136"	

figure 15

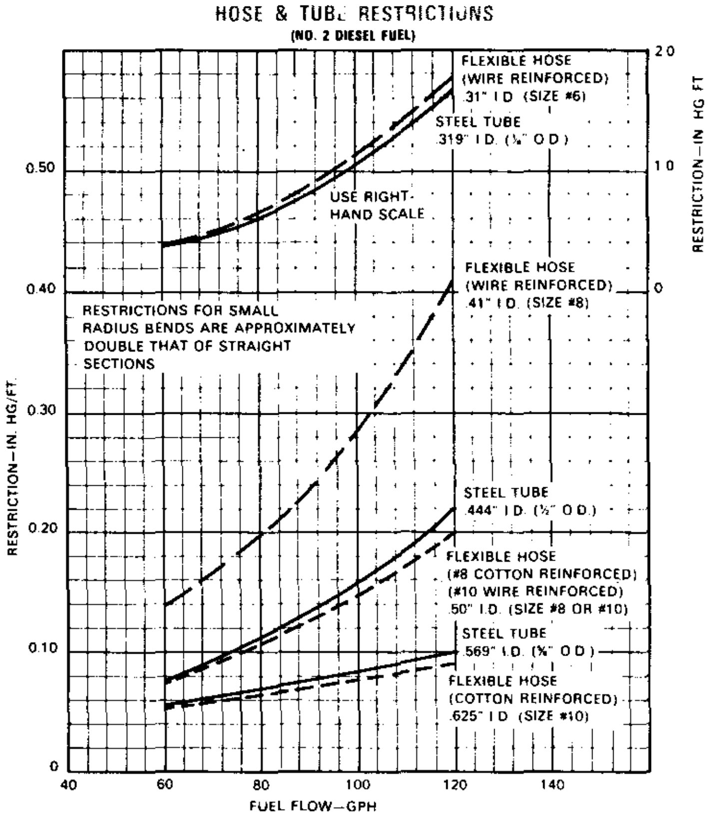


figure 16

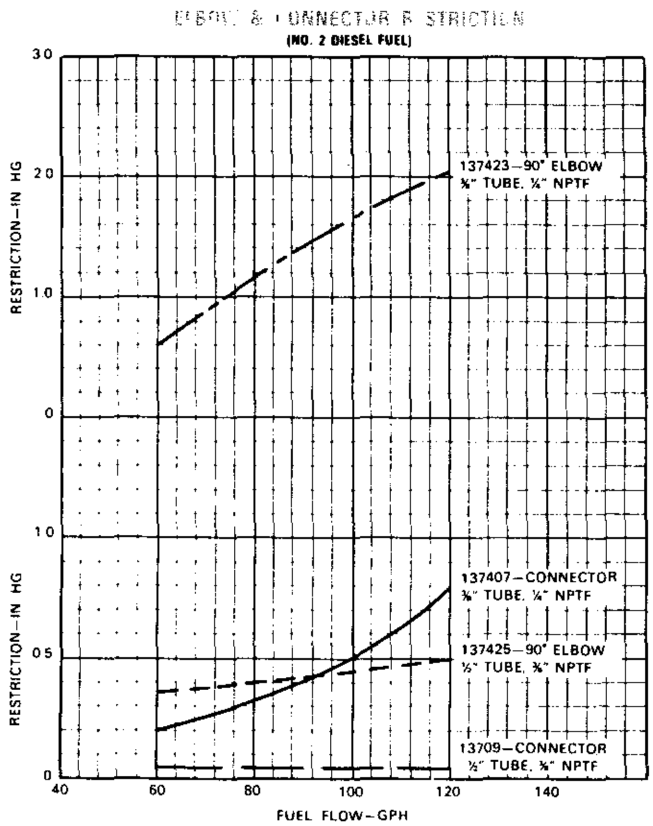


figure 17

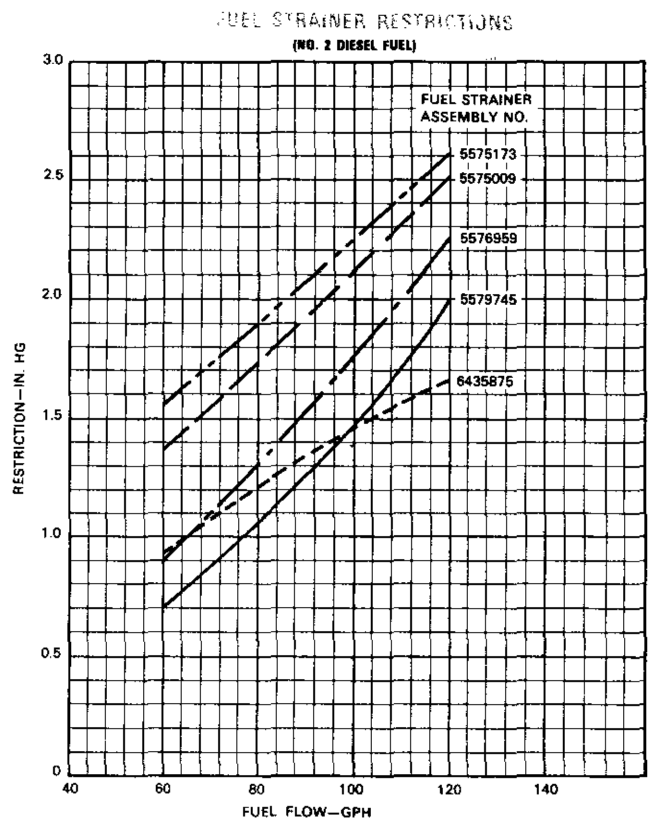


table 10

RECOMMENDED MINIMUM EXHAUST PIPE SIZE

Engine Series	Exhaust Pipe Dia.—In.		Engine Series	Exhaust Pipe Dia.—In.	
	Single	Double		Single	Double
			8V-71	5	3½
3-53	3	—	8V-71T	5	3½
4-53	3½	—	12V-71	6	4
6V-53	4	3	12V-71T	8	5
			16V-71	8	5
4-71	3½	—			
6-71	4	—	12V-149	8	6
6-71T	5	—	16V-149	10	8
6V-71	4	3			

table 11

EQUIVALENT EXHAUST PIPE LENGTH—FT.

Pipe Size In. Dia.	Tee	90° Formed Elb. & Y	45° Formed Elbow	Bends Having Radius Values From 1 Thru 6 Dia.					
				R/D = 1	R/D = 2	R/D = 3	R/D = 4	R/D = 5	R/D = 6
2	10	5	2.5	2.5	1	.5	.25	.75	1.25
2½	12.5	6.25	3.12	3	1.5	1	.75	1.25	1.75
3	15	7.5	3.75	3.5	2.0	1.25	1.0	1.5	2.25
3½	17.5	8.75	4.38	4	2.25	1.5	1.25	1.75	2.5
4	20	10	5	4.5	2.5	1.75	1.5	2	3
5	25	12.5	6.25	5.5	3	2.25	2	2.75	3.75
6	30	15	7.5	6.5	4	2.5	2.25	3	4.5
8	40	20	10	9	5	3.75	3.5	4.5	6
10	50	25	12.5	10.75	6.5	4.75	4.25	5.25	7.5
12	60	30	15	13	8	5.75	5.5	6.5	9
14	70	35	17.5	15	9	6.5	6	7.5	10.5

Based on straight pipe lengths of 12 ft. for exhaust (dry—not water cooled) and 6 feet for air intake. For longer lengths, or if bends, elbows or mufflers are used, size may have to be increased, as shown on Tables 11, 12, and 13.

These exhaust pipe sizes at critical lengths may be affected by pressure waves. Therefore, any system should be checked for recommended back pressure limits.

table 12

MUFFLERS OR COMBINATION MUFFLER MANIFOLDS

PIPE SIZE	EQUIVALENT PIPE LENGTH (FEET) FOR PRESSURE DROP						
	½ In. Hg	1 In. Hg	1½ In. Hg	2 In. Hg	2½ In. Hg	3 In. Hg	3½ In. Hg
2½"	7 ft.	14	21	28	35	—	—
3"	7	13½	20	27	34	40	47
3½"	6½	13	19	26	32	38	45
4"	6	12	18	24	30	36	42
5"	5½	11	16	22	27	32	38
6"	5	10	15	20	25	30	35
8"	4½	9	13	18	22	26	31

An example of back pressure computation might be a 6-71 for intermittent duty at 1800 RPM and with the following fittings in 5" pipe:

2—45° bends—2 (12¾ x ½) feet	=	12¾ feet
1—90° bend	=	12¾ feet
30 feet of 4" pipe	=	30 feet
1—4" muffler at 1½ Hg	=	16 feet
		71½ feet

The total calculated equivalent length is then 71½ feet and below the maximum equivalent length of 75 feet for a 6-71. This, of course, is for a dry exhaust system.

table 13

AIR INTAKE PIPE

PIPE DIA.	45° ELBOW	90° ELBOW & FORMED "Y"	TEE	BEND
2"	2.5'	5'	10'	1.75'
3"	4'	7.5'	15'	2.5'
4"	5'	10'	20'	3'
5"	6'	12.5'	25'	3.75'
6"	7.5'	15'	30'	4.5'
7"	9'	17.5'	35'	5.25'
8"	10'	20'	40'	6'
9"	11'	22.5'	45'	6.75'
10"	12.5'	25'	50'	7.5'
11"	13.75'	27.5'	55'	8.25'
12"	15'	30'	60'	9'
13"	16.25'	32.5'	65'	9.75'
14"	17.5'	35'	70'	10.50'

table 14

MAXIMUM EQUIVALENT LENGTH OF STRAIGHT AIR INTAKE PIPE (FEET)

ENGINE	SINGLE INLET PIPE								DUAL INLET PIPE				
	3″	4″	5″	6″	7″	8″	9″	10″	4″	5″	6″	7″	8″
3-53	16	82											
4-53	4	36											
6V-53		11	52										
4-71		30	112										
6-71		9	46										
6-71TI			5	30	75								
6V-71		9	46										
8V-71			22	70									
8V-71TI				10	37	85				7	47	83	
12V-71				26	66				9	46			
12V-71TI					5	25	50	88			27	68	
16V-71				8	30	71				30	96		
12V-149					11	35	66	127			36	90	
16V-149						11	30	63			15	46	101

table 15

EXHAUST EQUIVALENT PIPE LENGTH—FEET

	SINGLE EXHAUST DIAMETER—IN.									DOUBLE EXHAUST DIAMETER—IN.						
ENGINE	3	3.5	4	5	6	8	10	12	14	3	3.5	4	5	6	8	10
3-53	12	37	86	308												
4-53		14	39	156												
6V-53			9	60	184					12	37	86	308			
4-71		16	44	173												
6-71			13	71	213											
6-71TI				27	100	520										
8V-71				31	110	563					16	44	173	476		
8V-71TI				11	57	333										
12V-71					35	237						13	71	213		
12V-71TI						111	355						27	100	520	
16V-71						123	386						31	110	563	
12V-149						41	170	485						41	261	
16V-149							80	259							135	419

table 16

DDAD—GENERAL BATTERY RECOMMENDATIONS FOR CURRENT MARINE ENGINE MODELS

Engine Series	Cranking Motor Voltage	MARINE 8 Volt Batteries For 24 or 32 Volt Systems			Connect Batteries In
		Qty.	S.A.E. Cold Cranking Amp @ 0°F Amp per Battery	Total S.A.E. Cold Cranking Amp @ 0°F Amp per Bank	
3-53 4-53 Bedford 220	12 V 24 V	— 3	— 600	— 600	Single Series
4-71 6-71 6V-71 6V-53 Bedford 330 & 466	12 V 24 V 32 V	— 3 4	— 600 600	— 600 600	Single Series Series
8V-71	24 V	3	750	750	Series
12V-71	24 V ± 32 V ±	3 4	750 750	750 750	Series Series
16V-71	24 V ± 32 V ±	6 8	750 750	1500 1500	Series/Parallel Series/Parallel
12V-149 16V-149	24 V** 32 V**	— 4 per starter	— 750	— 750	Series Series

± 5-9/16" Frame starters only.

**Two 5-9/16" Frame starters per engine. One starter per engine above 70°F.

NOTE: Bank refers to the combined connected batteries.
(rev. 11-8-73)

table 17-A

RECOMMENDED WIRE SIZES AND LENGTHS FOR ELECTRICAL CIRCUITS OF VARIOUS TYPES AND CAPACITIES

RECOMMENDED WIRE SIZES FOR GENERATOR CIRCUITS										
CAPACITY OF CIRCUIT AMPERES	WIRE SIZE 12 VOLT CIRCUITS									
	14	12	10	8	6	4	2	0	00	
	TOTAL LENGTH OF CIRCUIT FEET									
5	40	64	100							
10	20	32	50	80	127					
15	15	24	37	60	94					
20	10	16	25	40	63	100				
25			21	33	52	83				
40				20	32	50	80	127		
50					25	40	64	102	128	

FOR 24 & 32 VOLT SYSTEMS
DOUBLE THE ABOVE CIRCUIT LENGTHS

table 17-B

RECOMMENDED WIRE SIZES FOR ALTERNATOR CIRCUITS						
CAPACITY OF CIRCUIT AMPERES	WIRE SIZE 12 VOLT CIRCUITS					
	10	8	6	4	2	0
	TOTAL LENGTH OF CIRCUIT IN FEET					
30	34					
45	52	36				
60		58	42			
85			68	48		
105				77	53	
130						80

FOR 24 & 32 VOLT SYSTEMS
DOUBLE THE ABOVE CIRCUIT LENGTHS

table 17-C

DDAD GENERAL STARTING MOTOR WIRE SIZE RECOMMENDATIONS

	Magnetic Switch or Series Parallel Switch Circuit Figure 1 Reference Wires A,B,C		Solenoid Switch Circuit* Figure 2 Reference Wires D & E		Starting Motor Circuit Figure 3 Reference Wires F & G	
	Length in Inches	Wire Size	Length in Inches	Wire Size	Length in Inches	Wire Size
12V System	Less than 125 126-195 196-300	No. 16 No. 14 No. 12	Less than 66 67-107 108-214	No. 10 No. 8 No. 6	Less than 114 115-145 146-187 188-238	No. 0 No. 00 No. 000 No. 0000
24V System	Less than 250 251-400	No. 16 No. 14	Less than 196 197-309 310-490	No. 12 No. 10 No. 8	Less than 199 200-249 250-321 322-410	No. 0 No. 00 No. 000 No. 0000
32V System	Less than 310 311-490	No. 16 No. 14	Less than 449 450-719 720-1120	No. 12 No. 10 No. 8	Less than 199 200-249 250-321 322-410	No. 0 No. 00 No. 000 No. 0000

MAXIMUM CIRCUIT VOLTAGE DROP AND RESISTANCE

	Magnetic Switch and Series Parallel Switch Circuit		Solenoid Switch Circuit*		Starting Motor Circuit	
	Volts	Ohms	Volts	Ohms	Volts	Amps
12V	.50	.048	1.0	.0067	.12	100
24V	1.00	.100	2.0	.030	.20	100
32V	1.25	.124	2.6	.070	.20	100

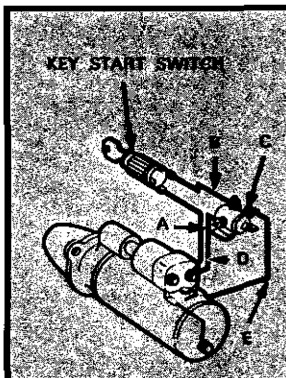


FIGURE 1
Typical magnetic switch circuit. Wire length equals A + B + C.

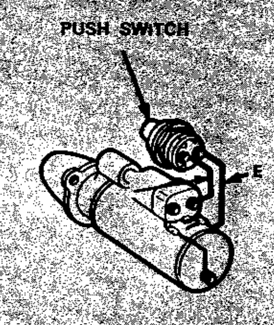


FIGURE 2
Typical solenoid switch circuit. Wire length equals D + E.

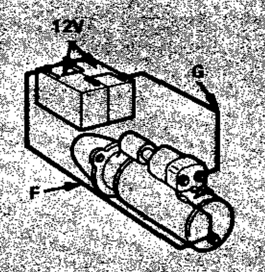


FIGURE 3
Typical starting motor circuit. Wire length equals F + G.

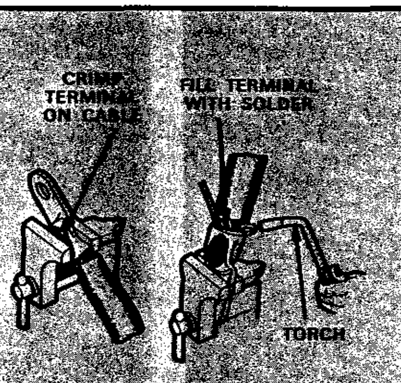


FIGURE 4
Battery cable terminal installation.

Detroit Diesel Allison
Division of General Motors Corporation

13400 West Outer Drive Detroit, Michigan 48228

In Canada: Diesel Division, General Motors of Canada Limited London Ontario

Specifications subject to change without notice.

LITHO IN U

DDA PROPULSION ENGINES APPROVED BY AMERICAN BUREAU OF SHIPPING AND LLOYD'S REGISTER OF SHIPPING

AMERICAN BUREAU OF SHIPPING

Engine	Injector	BHP	Full Load rpm
3-53	N45	86	2800
4-53	N45	128	2800
6V-53	N45	181	2800
4-71N	N55	120	1800
	N70	165	2300
6-71N	N55	180	1800
	N70	265	2300
6-71T	N90	335	2300
8V-71N	N55	240	1800
	N70	335	2300
8V-71TI	N90	435	2300
12V-71N	N55	360	1800
	N70	500	2300
12V-71TI	N90	675	2300
16V-71N	N55	480	1800
	N70	666	2300
12V-149	120	700	1800
	130	800	1900
12V-149TI	150	960	1800
16V-149	120	1205	1800
	130	1060	1900
16V-149TI	150	1280	1800

LLOYD'S REGISTER OF SHIPPING - PROPULSION ENGINES

Engine	Injector	BHP	Full Load rpm
3-53	N45	86	2800
4-53	N45	136	2800
6V-53	N45	181	2800
3-71N	N70	78	1800
4-71N	N70	165	2300
6-71N	N70	265	2300
6-71T	N90	335	2300
12V-71N	N55	360	1800
12V-71N	N70	500	2300
12V-71TI	N90	675	2300
8V-71N	N55	240	1800
	N70	335	2300
8V-71TI	N90	435	2300
16V-71N	N55	480	1800
	N70	666	2300
12V-149	130	700	1800
	130	800	1900
12V-149TI	150	870	1800
	150	960	1900
16V-149	130	930	1800
	130	1060	1900
16V-149TI	150	1160	1800
	150	1280	1900

DDA AUXILIARY ENGINES APPROVED BY AMERICAN BUREAU OF SHIPPING AND LLOYD'S REGISTER OF SHIPPING

AMERICAN BUREAU OF SHIPPING

Engine	Injector	BHP	Full Load rpm
2-71	70	65	2000
3-71	70	110	2300
4-71N	70	110	1500
	70	130	1800
4-71T	90	145	1500
	90	165	1800
6-71N	70	160	1500
	70	195	1800
6-71T	90	220	1500
	90	260	1800
8V-71N	70	215	1500
	70	260	1800
8V-71T	90	295	1500
	90	335	1800
12V-71N	70	320	1500
	70	390	1800
12V-71T	90	435	1500
	90	525	1800
16V-71N	70	430	1500
	70	515	1800
12V-149	130	600	1500
	130	700	1800
12V-149T	150	825	1500
	150	975	1800
12V-149TI	150	817	1500 Jacket Water Intercooling
	150	960	1800 " " "
	180	896	1500 85°F. Water Intercooling
	180	1050	1800 " " "
16V-149TI	150	1090	1500 Jacket Water Intercooling
	150	1280	1800 " " "
	180	1195	1500 85°F. Water Intercooling
	180	1400	1800 " " "

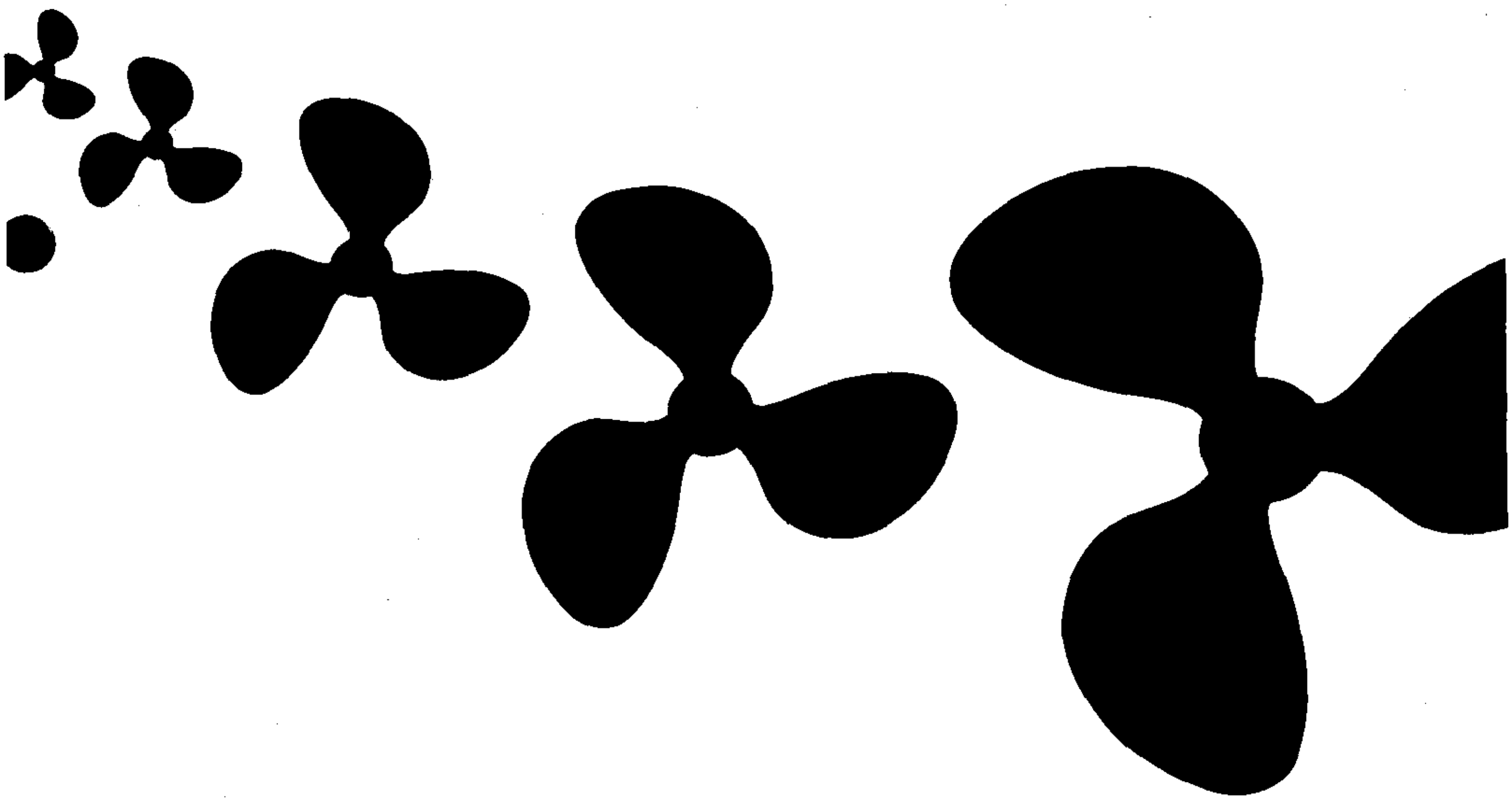
LLOYD'S REGISTER OF SHIPPING

Engine	Injector	BHP	Full Load rpm
4-71N	N70	110	1500
	N70	130	1800
4-71T	N90	145	1500
	N90	165	1800
6-71	N70	160	1500
	N70	195	1800
6-71T	N90	220	1500
	N90	260	1800

DDA AUXILIARY ENGINES APPROVED BY LLOYD'S REGISTER OF SHIPPING (CONT'D)

Engine	Injector	BHP	Full Load
8V-71N	N70	240	1800
8V-71T	N90	295	1500
	N90	335	1800
12V-71N	N70	320	1500
	N70	390	1800
16V-71N	N70	431	1500
	N70	513	1800
12V-149	130	600	1500
	130	700	1800
12V-149T	165	825	1500
	165	975	1800
12V-149TI	180	890	1500
	180	1050	1800
16V-149	130	800	1500
	130	930	1800
16V-149T	165	1100	1500
	165	1300	1800
16V-149TI	180	1190	1500
	180	1400	1800

PROPELLER SELECTION GUIDE



DETROIT DIESEL ALLISON MARINE ENGINE

Propeller Selection Guide

This guide contains the engine rating curves and propeller selection tables of current Bedford and Detroit Diesel marine engines. This engine information is grouped by engine type and arranged in order of increasing shaft horsepower.

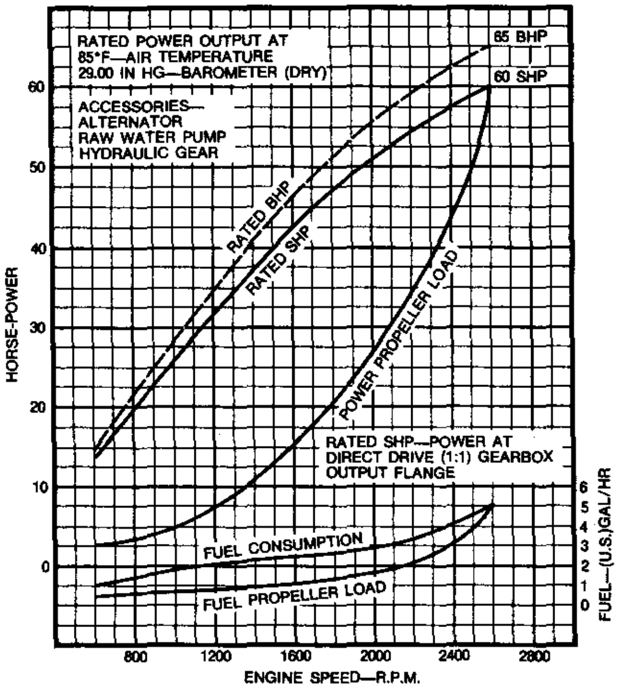
The engine rating curves display rated SHP and fuel consumption for the available engine speeds. The propeller load curves indicate the HP absorbed by a typical propeller and the curresponding fuel consumption.

The propeller selection tables have been prepared for specific marine models and show 3 and 4 blade propellers with the various reduction gears available. Speed is expressed in both knots and miles per hour. When selecting a new propeller, the goal is to determine the best possible combination of power and propeller which will provide the performance required.

To use these propeller selection tables, first select the engine model, propeller type and reduction gear ratio. Then follow the gear ratio column to the anticipated boat speed. This intersection will present the theoretically optimum propeller, listed by diameter and pitch, for the initial input information. Boat speed cannot be computed using these tables.

While the final propeller choice will be made from actual experience, the number of propellers to be tested can be reduced by using the data in this guide.

The data contained in this guide is current and accurate but is of a general nature and cannot replace the more precise technical advice available from a naval architect or Detroit Diesel marine engine specialist.



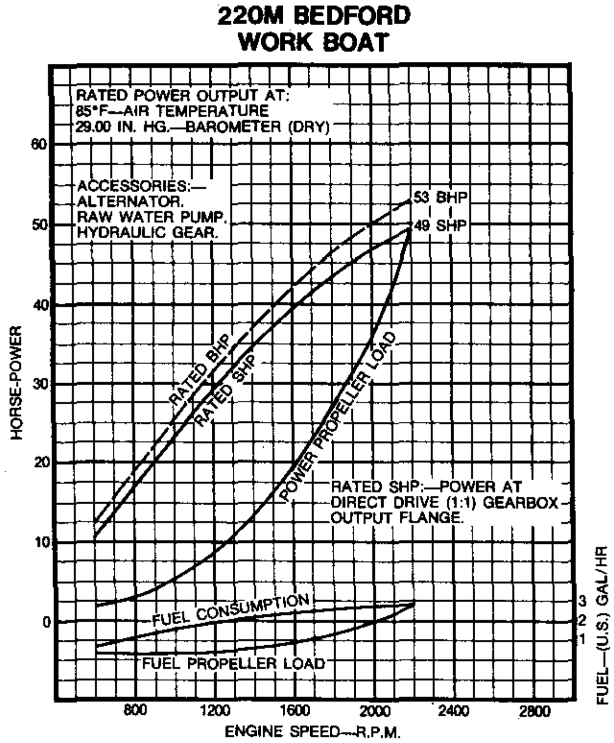
220M

BEDFORD PLEASURE CRAFT

WARNER 71C SERIES MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
		*1.91	2.10	2.91	*1.91	2.10	2.91
4.4	5			25 x 16			24 x 16
5.2	6	20 x 12	21 x 13	25 x 16		20 x 13	24 x 16
6.1	7	20 x 12	21 x 13	25 x 17	19 x 13	20 x 13	24 x 17
6.9	8	20 x 13	21 x 14	25 x 17	18 x 13	19 x 14	24 x 17
7.8	9	20 x 13	21 x 14	25 x 18	18 x 13	19 x 14	23 x 18
8.7	10	19 x 14	21 x 15	25 x 18	18 x 14	19 x 15	23 x 19
9.7	11	19 x 14	21 x 15	25 x 19	18 x 14	19 x 15	23 x 19
10.4	12	19 x 15	20 x 16	25 x 20	18 x 15	19 x 16	23 x 20
11.2	13	19 x 15	20 x 16	24 x 21	18 x 15	19 x 16	23 x 21
12.1	14	19 x 16	20 x 17	24 x 22	18 x 16	19 x 17	23 x 22
13.0	15	19 x 16	20 x 17	24 x 23	18 x 16	19 x 18	23 x 23
13.8	16	19 x 17	20 x 18	24 x 24	18 x 17	19 x 18	
14.7	17	19 x 17	20 x 19		18 x 17	19 x 19	
15.6	18	19 x 18	20 x 19		18 x 18	19 x 19	
16.5	19	18 x 18	19 x 20		18 x 18	19 x 20	
17.3	20	18 x 19			17 x 19		

*Rotates opposite engine rotation.

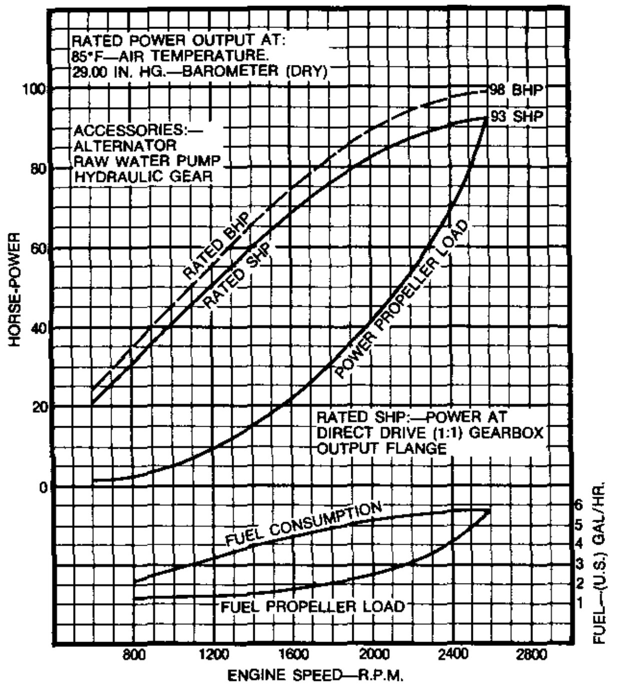


220M BEDFORD WORK BOAT

WARNER 71C SERIES MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER GEAR RATIOS			4-BLADE PROPELLER GEAR RATIOS		
		*1.91	2.10	2.91	*1.91	2.10	2.91
3.5	4			27 x 16			
4.4	5			27 x 17			25 x 17
5.2	6	21 x 13	22 x 14	27 x 17	20 x 13	21 x 14	25 x 18
6.1	7	21 x 13	22 x 14	27 x 18	20 x 14	21 x 15	25 x 18
6.9	8	21 x 14	22 x 15	27 x 19	19 x 14	21 x 15	25 x 19
7.8	9	21 x 14	22 x 15		19 x 15	20 x 16	25 x 20

*Rotates opposite engine rotation.



330M

BEDFORD PLEASURE CRAFT

ALLISON 72C SERIES MARINE GEAR

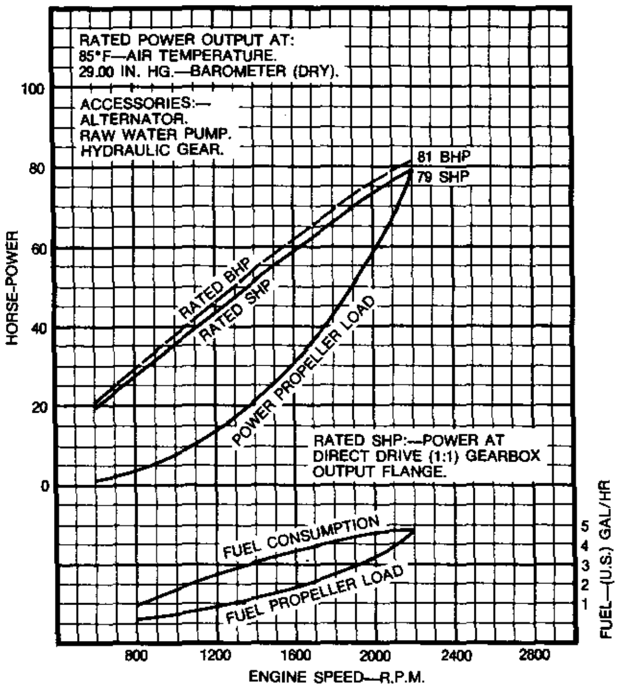
		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	*1.90	2.10	2.91	*1.90	2.10	2.91
4.4	5			28 x 17			
5.2	6			28 x 17			26 x 17
6.1	7	21 x 13	23 x 14	28 x 18	20 x 13	21 x 14	26 x 18
6.9	8	21 x 14	23 x 15	28 x 18	20 x 14	21 x 15	26 x 19
7.8	9	21 x 14	23 x 15	27 x 19	20 x 14	21 x 15	26 x 19
8.7	10	21 x 14	23 x 15	27 x 20	20 x 15	21 x 16	25 x 20
9.7	11	21 x 15	22 x 16	27 x 20	20 x 15	21 x 16	25 x 21
10.4	12	21 x 15	22 x 16	27 x 21	20 x 16	21 x 17	25 x 21
11.2	13	21 x 16	22 x 17	27 x 22	20 x 16	21 x 17	25 x 22
12.1	14	21 x 16	22 x 18	27 x 23	20 x 17	21 x 18	25 x 23
13.0	15	21 x 17	22 x 18	26 x 24	20 x 17	21 x 18	25 x 24
13.8	16	21 x 17	22 x 19	26 x 24	19 x 18	21 x 19	25 x 24
14.7	17	21 x 18	22 x 19		19 x 18	20 x 20	
15.6	18	20 x 19	22 x 20		19 x 19	20 x 20	
16.5	19	20 x 19	21 x 21		19 x 19	20 x 21	
17.3	20	20 x 20	21 x 21		19 x 19	20 x 21	
18.2	21	20 x 20	21 x 22		19 x 20		
19.1	22	20 x 21					
19.9	23	20 x 21					
20.8	24	20 x 22					

*Rotates opposite engine rotation.

330M BEDFORD WORK BOAT

ALLISON 72C SERIES MARINE GEAR

330M BEDFORD WORK BOAT



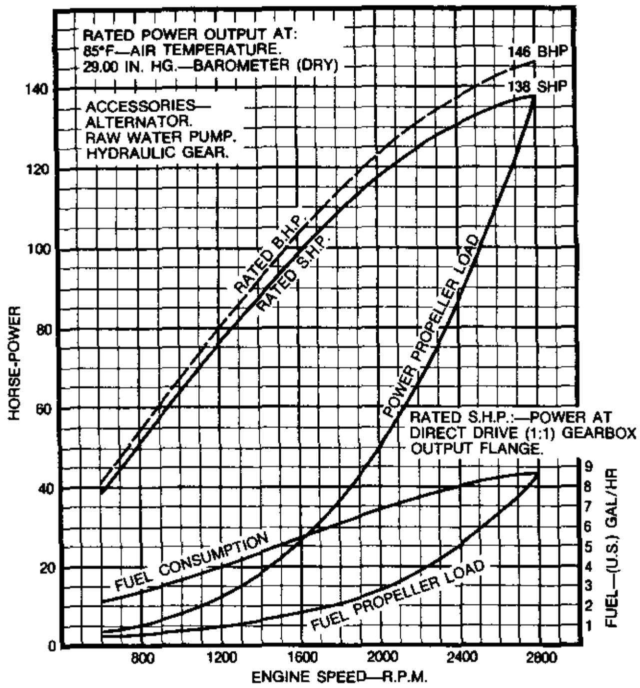
KNOTS	MPH	3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
		*1.91	2.10	2.91	*1.91	2.10	2.91
4.4	5			30 x 18			28 x 18
5.2	6	23 x 14	24 x 15	30 x 19		23 x 15	28 x 19
6.1	7	23 x 15	24 x 16	29 x 19	22 x 15	23 x 16	28 x 20
6.9	8	23 x 15	24 x 16	29 x 20	21 x 15	23 x 16	27 x 20
7.8	9	23 x 15	24 x 16	29 x 21	21 x 16	23 x 17	27 x 21
8.7	10	23 x 16	24 x 17	29 x 22	21 x 16	22 x 17	27 x 22
9.7	11				21 x 17	22 x 18	

*Rotates opposite engine rotation.

466M
BEDFORD PLEASURE CRAFT

ALLISON 72C SERIES MARINE GEAR

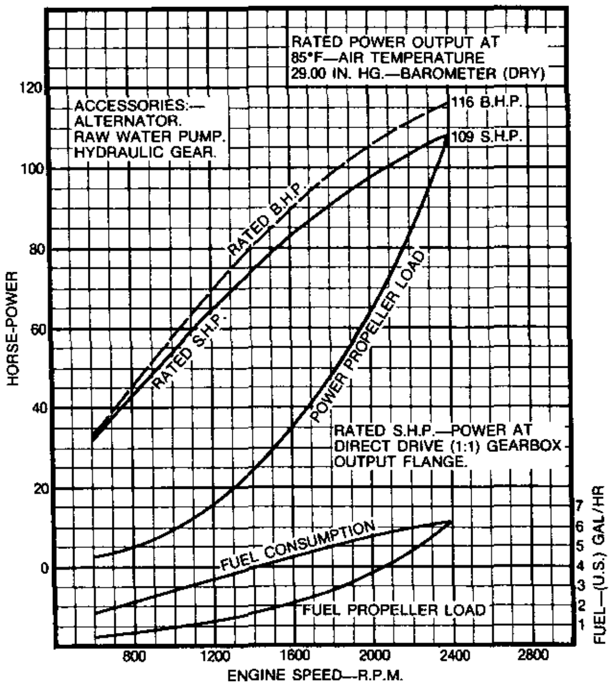
466M BEDFORD PLEASURE CRAFT



KNOTS	MPH	3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
		1.5	*2.0	3.0	1.5	*2.0	3.0
5.2	6			29 x 18			28 x 18
6.1	7			29 x 18			27 x 19
6.9	8	19 x 12	23 x 14	29 x 19		22 x 15	27 x 19
7.8	9	19 x 12	23 x 15	29 x 19	18 x 12	21 x 15	27 x 20
8.7	10	19 x 12	23 x 15	29 x 20	18 x 13	21 x 15	27 x 20
9.7	11	19 x 13	23 x 15	29 x 21	18 x 13	21 x 16	27 x 21
10.4	12	19 x 13	23 x 16	29 x 21	18 x 13	21 x 16	27 x 22
11.2	13	19 x 13	23 x 16	28 x 22	18 x 13	21 x 17	27 x 22
12.1	14	19 x 14	22 x 17	28 x 23	18 x 14	21 x 17	27 x 23
13.0	15	19 x 14	22 x 17	28 x 24	18 x 14	21 x 18	26 x 24
13.8	16	19 x 14	22 x 18	28 x 25	18 x 15	21 x 18	26 x 25
14.7	17	19 x 15	22 x 18	28 x 25	18 x 15	21 x 19	26 x 25
15.6	18	19 x 15	22 x 19	28 x 26	17 x 15	21 x 19	26 x 26
16.5	19	19 x 15	22 x 19	27 x 27	17 x 16	21 x 19	26 x 27
17.3	20	19 x 16	22 x 20		17 x 16	21 x 20	
18.2	21	18 x 16	22 x 20		17 x 16	20 x 20	
19.1	22	18 x 17	22 x 21		17 x 17	20 x 21	
19.9	23	18 x 17	21 x 21		17 x 17	20 x 21	
20.8	24	18 x 17	21 x 22		17 x 17	20 x 22	
21.7	25	18 x 18	21 x 23		17 x 18		
22.5	26	18 x 18			17 x 18		
23.4	27	18 x 19			17 x 18		
24.3	28	18 x 19			17 x 19		

*Rotates opposite engine rotation.

466M BEDFORD WORK BOAT



466M

BEDFORD WORK BOAT

ALLISON 72C SERIES MARINE GEAR

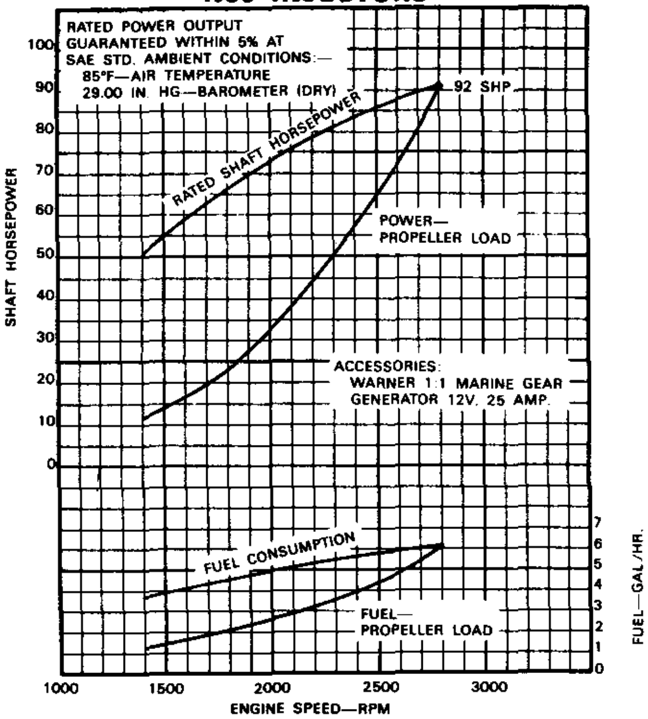
		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	1.5	*2.0	3.0	1.5	*2.0	3.0
4.4	5			31 x 18			
5.2	6			31 x 19			29 x 19
6.1	7		24 x 15	30 x 20		23 x 15	29 x 20
6.9	8	20 x 13	24 x 15	30 x 20	19 x 13	22 x 16	28 x 21
7.8	9	20 x 13	24 x 16	30 x 21	19 x 13	22 x 16	28 x 21
8.7	10	20 x 13	24 x 16	30 x 22	19 x 13	22 x 16	28 x 22
9.7	11	20 x 14	24 x 17	30 x 22	19 x 14	22 x 17	28 x 23
10.4	12	20 x 14	24 x 17		19 x 14	22 x 17	
11.2	13				19 x 15		

*Rotates opposite engine rotation.

3-53N

PLEASURE CRAFT
N50 INJECTORS

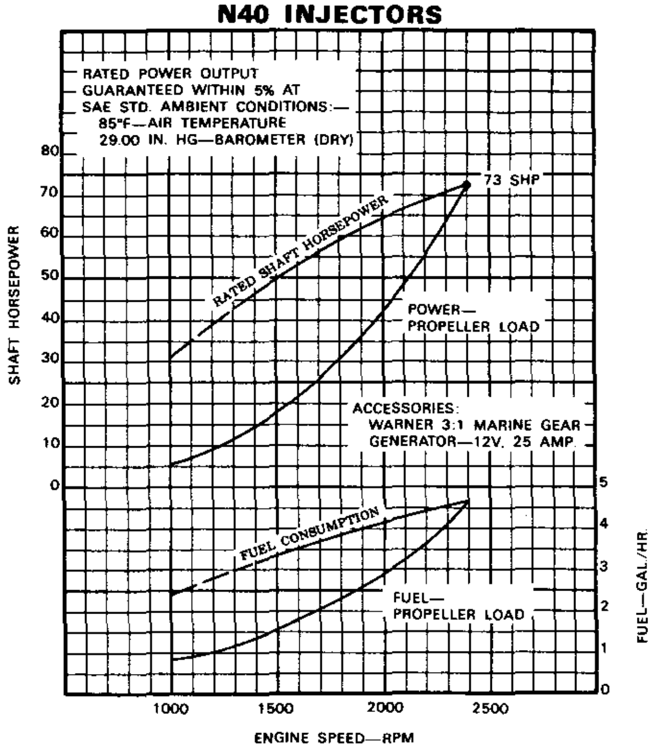
3-53N PLEASURE CRAFT
N50 INJECTORS



WARNER SERIES 71
MARINE GEAR

		3-BLADE PROPELLER						4-BLADE PROPELLER					
		GEAR RATIOS						GEAR RATIOS					
KNOTS	MPH	1.0	1.52	1.91	2.10	2.57	2.91	1.0	1.52	1.91	2.10	2.57	2.91
5.2	6					25 x 15	26 x 16						25 x 16
6.1	7			21 x 13	22 x 14	24 x 16	26 x 17			19 x 13	20 x 14	23 x 16	25 x 17
6.9	8		18 x 11	20 x 13	22 x 14	24 x 16	26 x 17		17 x 11	19 x 13	20 x 14	23 x 16	25 x 18
7.8	9	14 x 09	18 x 11	20 x 13	22 x 14	24 x 16	26 x 18	13 x 09	17 x 12	19 x 14	20 x 14	23 x 17	24 x 18
8.7	10	14 x 09	18 x 12	20 x 14	22 x 15	24 x 17	26 x 19	13 x 09	17 x 12	19 x 14	20 x 15	23 x 17	24 x 19
9.7	11	14 x 09	18 x 12	20 x 14	21 x 15	24 x 18	26 x 19	13 x 09	17 x 12	19 x 14	20 x 15	23 x 18	24 x 19
10.4	12	14 x 09	18 x 12	20 x 15	21 x 16	24 x 18	26 x 20	13 x 09	17 x 13	19 x 15	20 x 16	22 x 18	24 x 20
11.2	13	14 x 09	18 x 13	20 x 15	21 x 16	24 x 19	26 x 21	13 x 10	16 x 13	19 x 15	20 x 16	22 x 19	24 x 21
12.1	14	14 x 10	18 x 13	20 x 15	21 x 17	24 x 19	26 x 21	13 x 10	16 x 13	19 x 16	20 x 17	22 x 20	24 x 22
13.0	15	14 x 10	18 x 13	20 x 16	21 x 17	24 x 20	25 x 22	13 x 10	16 x 14	19 x 16	20 x 17	22 x 20	24 x 22
13.8	16	14 x 10	17 x 14	20 x 16	21 x 18	23 x 21	25 x 23	13 x 10	16 x 14	19 x 17	20 x 18	22 x 21	24 x 23
14.7	17	14 x 10	17 x 14	20 x 17	21 x 18	23 x 21	25 x 24	13 x 10	16 x 14	19 x 17	20 x 18	22 x 22	24 x 24
15.6	18	14 x 11	17 x 15	20 x 17	21 x 19	23 x 22	25 x 25	13 x 11	16 x 15	18 x 18	20 x 19	22 x 22	
16.5	19	14 x 11	17 x 15	19 x 18	21 x 19	23 x 23		13 x 11	16 x 15	18 x 18	19 x 19	22 x 23	
17.3	20	13 x 11	17 x 15	19 x 18	20 x 20	23 x 24		13 x 11	16 x 15	18 x 18	19 x 20	22 x 23	
18.2	21	13 x 11	17 x 16	19 x 19	20 x 20	23 x 24		13 x 11	16 x 16	18 x 19	19 x 20	22 x 24	
19.1	22	13 x 11	17 x 16	19 x 19	20 x 21			13 x 12	16 x 16	18 x 19	19 x 21		
19.9	23	13 x 12	17 x 16	19 x 20	20 x 22			13 x 12	16 x 16	18 x 20			
20.8	24	13 x 12	17 x 17					13 x 12	16 x 17				
21.7	25	13 x 12	17 x 17					12 x 12	16 x 17				
22.5	26	13 x 13	16 x 18					12 x 12					
23.4	27	13 x 13						12 x 13					
24.3	28	13 x 13						12 x 13					
25.2	29	13 x 13						12 x 13					
26.0	30	13 x 14											
26.9	31	13 x 14											

3-53N WORK BOAT
N40 INJECTORS



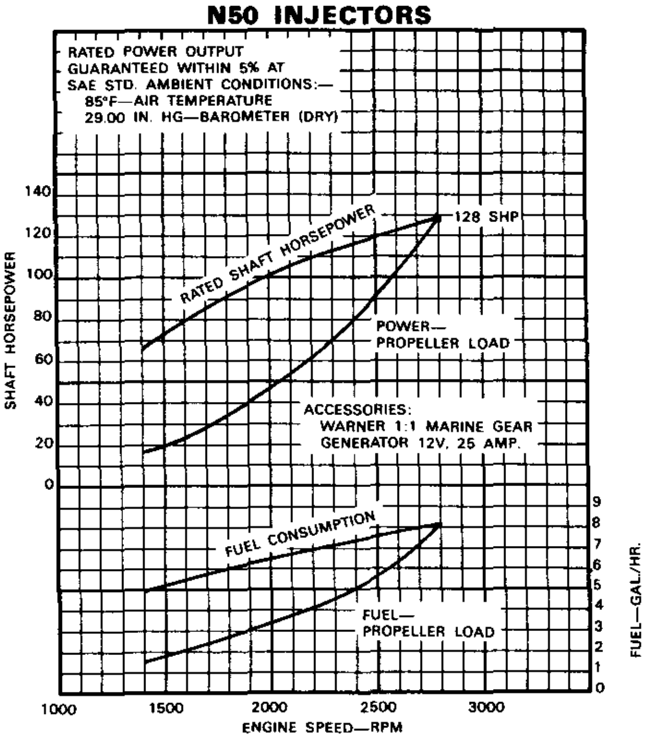
3-53N

WORK BOAT
N40 INJECTORS

WARNER SERIES 71
MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER						4-BLADE PROPELLER					
		GEAR RATIOS						GEAR RATIOS					
		1.0	1.52	1.91	2.10	2.57	2.91	1.0	1.52	1.91	2.10	2.57	2.91
4.4	5						28 x 17						26 x 17
5.2	6			22 x 13	23 x 14	26 x 16	28 x 17				22 x 14	24 x 16	26 x 18
6.1	7		19 x 12	21 x 14	23 x 14	26 x 17	27 x 18		18 x 12	20 x 14	21 x 15	24 x 17	26 x 18
6.9	8	15 x 09	19 x 12	21 x 14	23 x 15	26 x 17	27 x 19	14 x 09	18 x 12	20 x 14	21 x 15	24 x 17	26 x 19
7.8	9	15 x 09	19 x 12	21 x 14	23 x 15	25 x 18	27 x 19	14 x 09	17 x 12	20 x 15	21 x 16	24 x 18	25 x 20
8.7	10	15 x 09	19 x 13	21 x 15	22 x 16	25 x 18	27 x 20	14 x 10	17 x 13	20 x 15	21 x 16	24 x 19	25 x 20
9.7	11	14 x 10	19 x 13	21 x 15	22 x 16	25 x 18		14 x 10	17 x 13	20 x 16	21 x 17	23 x 19	25 x 21
10.4	12	14 x 10	18 x 13	21 x 15	22 x 16			14 x 10	17 x 14	20 x 16	21 x 17	23 x 19	
11.2	13	14 x 10	18 x 14	21 x 15				13 x 10	17 x 14	20 x 16	21 x 17		
12.1	14							13 x 11	17 x 14	20 x 16			
13.0	15							13 x 11	17 x 15				

4-53N PLEASURE CRAFT
N50 INJECTORS



4-53N

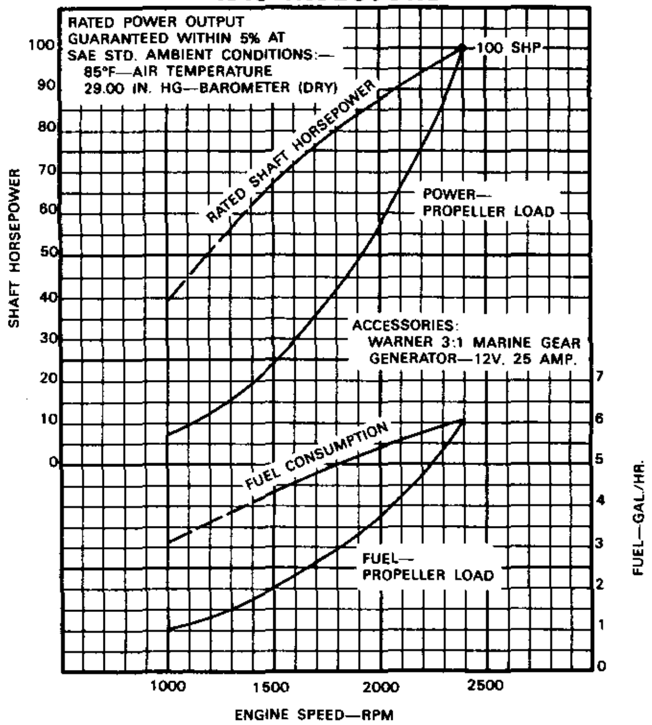
PLEASURE CRAFT
N50 INJECTORS

WARNER SERIES 71 & 72
MARINE GEAR

		3-BLADE PROPELLER						4-BLADE PROPELLER					
		GEAR RATIOS						GEAR RATIOS					
KNOTS	MPH	1.0	1.52	1.91	2.10	2.57	2.91	1.0	1.52	1.91	2.10	2.57	2.91
5.2	6						28 x 17						27 x 17
6.1	7				23 x 14	26 x 16	28 x 18					25 x 17	27 x 18
6.9	8		19 x 12	22 x 14	23 x 15	26 x 17	28 x 18			21 x 14	22 x 15	25 x 17	26 x 18
7.8	9		19 x 12	22 x 14	23 x 15	26 x 17	28 x 19		18 x 12	21 x 14	22 x 15	24 x 18	26 x 19
8.7	10	15 x 09	19 x 12	22 x 14	23 x 15	26 x 18	28 x 19	14 x 09	18 x 13	20 x 15	22 x 16	24 x 18	26 x 20
9.7	11	15 x 10	19 x 13	22 x 15	23 x 16	26 x 18	28 x 20	14 x 10	18 x 13	20 x 15	21 x 16	24 x 19	26 x 20
10.4	12	15 x 10	19 x 13	22 x 15	23 x 16	26 x 19	28 x 21	14 x 10	18 x 13	20 x 15	21 x 17	24 x 19	26 x 21
11.2	13	15 x 10	19 x 13	22 x 16	23 x 17	26 x 20	28 x 21	14 x 10	18 x 13	20 x 16	21 x 17	24 x 20	26 x 22
12.1	14	15 x 10	19 x 14	22 x 16	23 x 17	26 x 20	27 x 22	14 x 10	18 x 14	20 x 16	21 x 18	24 x 20	26 x 22
13.0	15	15 x 10	19 x 14	21 x 17	23 x 18	25 x 21	27 x 23	14 x 10	18 x 14	20 x 17	21 x 18	24 x 21	25 x 23
13.8	16	15 x 11	19 x 14	21 x 17	23 x 18	25 x 22	27 x 24	14 x 11	17 x 15	20 x 17	21 x 19	24 x 22	25 x 24
14.7	17	15 x 11	19 x 15	21 x 18	22 x 19	25 x 22	27 x 24	14 x 11	17 x 15	20 x 18	21 x 19	24 x 22	25 x 25
15.6	18	15 x 11	19 x 15	21 x 18	22 x 19	25 x 23	27 x 25	14 x 11	17 x 15	20 x 18	21 x 20	24 x 23	25 x 25
16.5	19	15 x 11	18 x 15	21 x 19	22 x 20	25 x 24	26 x 26	14 x 11	17 x 16	20 x 19	21 x 20	23 x 23	25 x 26
17.3	20	14 x 11	18 x 16	21 x 19	22 x 21	25 x 24		14 x 12	17 x 16	20 x 19	21 x 21	23 x 24	
18.2	21	14 x 12	18 x 16	21 x 19	22 x 21	24 x 25		14 x 12	17 x 16	20 x 19	21 x 21	23 x 25	
19.1	22	14 x 12	18 x 17	21 x 20	22 x 22	24 x 26		13 x 12	17 x 17	20 x 20	21 x 21		
19.9	23	14 x 12	18 x 17	20 x 21	22 x 22			13 x 12	17 x 17	19 x 20	21 x 22		
20.8	24	14 x 12	18 x 17	20 x 21	21 x 23			13 x 13	17 x 17	19 x 21			
21.7	25	14 x 13	18 x 18	20 x 22				13 x 13	17 x 18				
22.5	26	14 x 13	18 x 18					13 x 13	17 x 18				
23.4	27	14 x 13	18 x 19					13 x 13					
24.3	28	14 x 13	18 x 19					13 x 13					
25.2	29	14 x 14						13 x 14					
26.0	30	14 x 14						13 x 14					
26.9	31	14 x 14						13 x 14					

4-53N ●
WORK BOAT
N40 INJECTORS

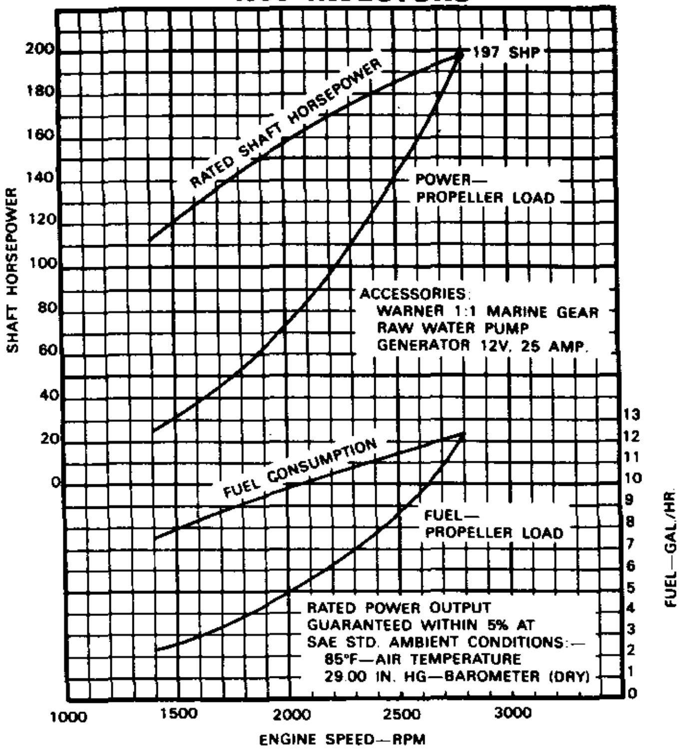
4-53N WORK BOAT
N40 INJECTORS



WARNER SERIES 71 & 72
MARINE GEAR

		3-BLADE PROPELLER						4-BLADE PROPELLER					
		GEAR RATIOS						GEAR RATIOS					
KNOTS	MPH	1.0	1.52	1.91	2.10	2.57	2.91	1.0	1.52	1.91	2.10	2.57	2.91
4.4	5						30 x 18						
5.2	6					27 x 17	29 x 18					26 x 17	28 x 19
6.1	7		20 x 12	23 x 14	24 x 15	27 x 17	29 x 19			22 x 14	23 x 15	26 x 18	28 x 19
6.9	8		20 x 13	23 x 15	24 x 16	27 x 18	29 x 20		19 x 13	21 x 15	23 x 16	26 x 18	27 x 20
7.8	9	16 x 10	20 x 13	23 x 15	24 x 16	27 x 18	29 x 20	15 x 10	19 x 13	21 x 15	23 x 16	25 x 19	27 x 21
8.7	10	15 x 10	20 x 13	23 x 15	24 x 17	27 x 19	29 x 21	15 x 10	19 x 13	21 x 16	22 x 17	25 x 19	27 x 21
9.7	11	15 x 10	20 x 14	23 x 16	24 x 17	27 x 20	29 x 22	14 x 10	18 x 14	21 x 16	22 x 17	25 x 20	27 x 22
10.4	12	15 x 10	20 x 14	23 x 16	24 x 17	27 x 20		14 x 11	18 x 14	21 x 17	22 x 18	25 x 20	
11.2	13	15 x 11	20 x 14	23 x 16	24 x 17			14 x 11	18 x 15	21 x 17	22 x 18		
12.1	14	15 x 11	20 x 15	23 x 16				14 x 11	18 x 15	21 x 17			
13.0	15	15 x 11	19 x 15					14 x 11	18 x 15				
13.8	16							14 x 12					

6V-53N PLEASURE CRAFT
N50 INJECTORS

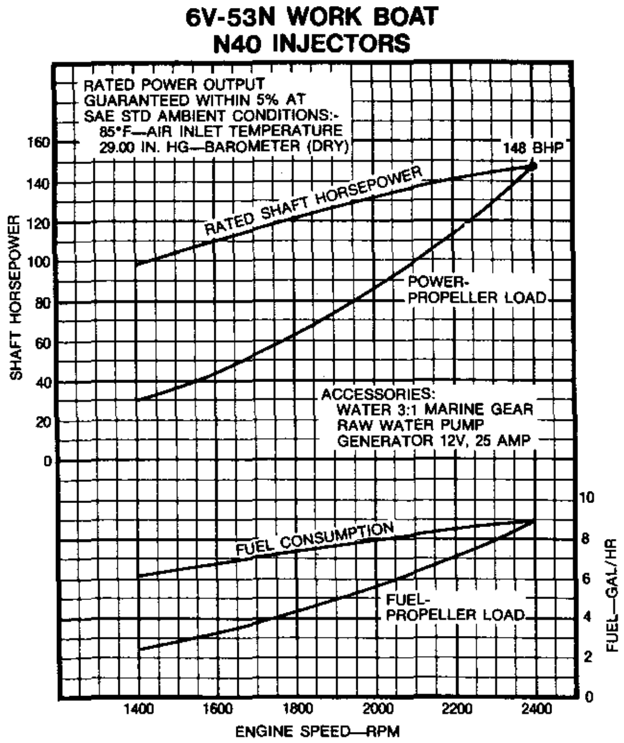


6V-53N

PLEASURE CRAFT
N50 INJECTORS

WARNER SERIES 73 MARINE GEAR

		3-BLADE PROPELLER				4-BLADE PROPELLER			
		GEAR RATIOS				GEAR RATIOS			
KNOTS	MPH	1.0	1.5	2.0	3.0	1.0	1.5	2.0	3.0
5.2	6				31 x 19				
6.1	7				31 x 20				30 x 20
6.9	8			25 x 15	31 x 20			23 x 15	29 x 20
7.8	9		21 x 13	25 x 16	31 x 21		20 x 13	23 x 16	29 x 21
8.7	10	16 x 10	21 x 13	24 x 16	31 x 21		19 x 13	23 x 16	29 x 21
9.7	11	16 x 10	21 x 13	24 x 16	31 x 22	15 x 10	19 x 14	23 x 17	29 x 22
10.4	12	16 x 10	21 x 14	24 x 17	31 x 22	15 x 11	19 x 14	23 x 17	29 x 23
11.2	13	16 x 11	20 x 14	24 x 17	31 x 23	15 x 11	19 x 14	23 x 17	29 x 23
12.1	14	16 x 11	20 x 14	24 x 18	31 x 24	15 x 11	19 x 15	23 x 18	29 x 24
13.0	15	16 x 11	20 x 15	24 x 18	30 x 25	15 x 11	19 x 15	22 x 18	28 x 25
13.8	16	16 x 11	20 x 15	24 x 19	30 x 26	15 x 11	19 x 15	22 x 19	28 x 26
14.7	17	16 x 11	20 x 15	24 x 19	30 x 26	15 x 12	19 x 16	22 x 19	28 x 26
15.6	18	16 x 12	20 x 16	24 x 20	30 x 27	15 x 12	19 x 16	22 x 20	28 x 27
16.5	19	16 x 12	20 x 16	24 x 20	30 x 28	15 x 12	19 x 16	22 x 20	28 x 28
17.3	20	16 x 12	20 x 16	24 x 21	29 x 29	15 x 12	19 x 17	22 x 21	
18.2	21	16 x 12	20 x 17	23 x 21		15 x 12	19 x 17	22 x 21	
19.1	22	16 x 13	20 x 17	23 x 22		15 x 13	19 x 17	22 x 22	
19.9	23	16 x 13	20 x 18	23 x 22		15 x 13	19 x 18	22 x 22	
20.8	24	16 x 13	20 x 18	23 x 23		15 x 13	19 x 18	22 x 22	
21.7	25	16 x 13	20 x 18	23 x 23		15 x 13	19 x 18	22 x 23	
22.5	26	16 x 13	19 x 19	23 x 24		15 x 14	18 x 19		
23.4	27	16 x 14	19 x 19	23 x 24		15 x 14	18 x 19		
24.3	28	15 x 14	19 x 19	23 x 25		15 x 14	18 x 19		
25.2	29	15 x 14	19 x 20			15 x 14	18 x 20		
26.0	30	15 x 14	19 x 20			14 x 14	18 x 20		
26.9	31	15 x 15	19 x 21			14 x 15			
27.8	32	15 x 15				14 x 15			
28.6	33	15 x 15				14 x 15			
29.6	34	15 x 16							
30.5	35	15 x 16							
31.3	36	15 x 16							

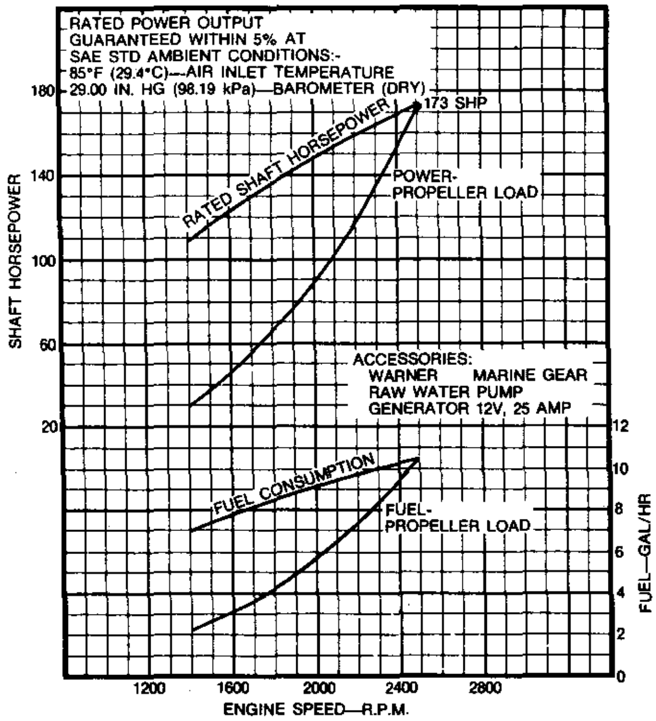


6V-53N WORK BOAT N40 INJECTORS

WARNER SERIES 73 MARINE GEAR

		3-BLADE PROPELLER				4-BLADE PROPELLER			
		GEAR RATIOS				GEAR RATIOS			
KNOTS	MPH	1.0	1.5	2.0	3.0	1.0	1.5	2.0	3.0
5.2	6				32 x 20				31 x 20
6.1	7			25 x 16	32 x 21				30 x 21
6.9	8		21 x 13	25 x 16	32 x 21		20 x 13	24 x 16	30 x 22
7.8	9	17 x 10	21 x 14	25 x 17	32 x 22		20 x 14	24 x 17	30 x 22
8.7	10	17 x 11	21 x 14	25 x 17	32 x 23	16 x 11	20 x 14	24 x 17	30 x 23
9.7	11	17 x 11	21 x 14	25 x 17	32 x 23	16 x 11	20 x 14	24 x 18	30 x 24
10.4	12	17 x 11	21 x 15	25 x 18	32 x 24	16 x 11	20 x 15	23 x 18	30 x 24
11.2	13	17 x 11	21 x 15	25 x 19		16 x 11	20 x 15	23 x 19	
12.1	14	17 x 11	21 x 15			16 x 12	20 x 16		
13.0	15	17 x 12				15 x 12			
13.8	16	17 x 12				15 x 12			

6V-53N CREW BOAT
N45 INJECTORS

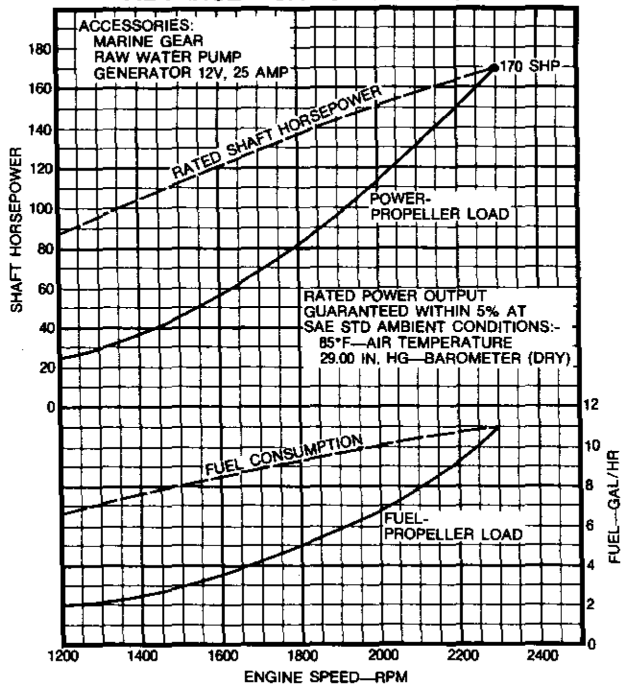


6V-53N
CREW BOAT
N45 INJECTORS

WARNER SERIES 73
MARINE GEAR

		3-BLADE PROPELLER				4-BLADE PROPELLER			
		GEAR RATIOS				GEAR RATIOS			
KNOTS	MPH	1.0	1.5	2.0	3.0	1.0	1.5	2.0	3.0
5.2	6				33 x 20				31 x 20
6.1	7				33 x 21				31 x 21
6.9	8		22 x 13	26 x 16	33 x 21			24 x 16	31 x 21
7.8	9		22 x 14	26 x 17	32 x 22		20 x 14	24 x 17	30 x 22
8.7	10	17 x 11	21 x 14	25 x 17	32 x 22	16 x 11	20 x 14	24 x 17	30 x 23
9.7	11	17 x 11	21 x 14	25 x 17	32 x 23	16 x 11	20 x 14	24 x 18	30 x 24
10.4	12	17 x 11	21 x 15	25 x 18	32 x 24	16 x 11	20 x 15	24 x 18	30 x 24
11.2	13	17 x 11	21 x 15	25 x 18	32 x 25	16 x 11	20 x 15	24 x 19	30 x 25
12.1	14	17 x 11	21 x 15	25 x 19	32 x 26	16 x 12	20 x 16	23 x 19	30 x 26
13.0	15	17 x 12	21 x 16	25 x 19	32 x 27	16 x 12	20 x 16	23 x 20	30 x 27
13.8	16	17 x 12	21 x 16	25 x 20	31 x 27	16 x 12	20 x 16	23 x 20	29 x 28
14.7	17	17 x 12	21 x 16	25 x 21	31 x 28	16 x 12	20 x 17	23 x 21	29 x 28
15.6	18	17 x 12	21 x 17	25 x 21	31 x 29	15 x 13	20 x 17	23 x 21	29 x 29
16.5	19	17 x 13	21 x 17	25 x 22		15 x 13	20 x 17	23 x 22	
17.3	20	16 x 13	21 x 18	24 x 22		15 x 13	19 x 18	23 x 22	
18.2	21	16 x 13	21 x 18	24 x 23		15 x 13	19 x 18	23 x 23	
19.1	22	16 x 13	21 x 19	24 x 23		15 x 14	19 x 19	23 x 23	
19.9	23	16 x 14	20 x 19	24 x 24		15 x 14	19 x 19	23 x 24	
20.8	24	16 x 14	20 x 19	24 x 25		15 x 14	19 x 19	23 x 24	
21.7	25	16 x 14	20 x 20	24 x 25		15 x 14	19 x 20	23 x 25	
22.5	26	16 x 15	20 x 20	23 x 26		15 x 15	19 x 20		
23.4	27	16 x 15	20 x 21			15 x 15			
24.3	28	16 x 15	20 x 21			15 x 15			
25.2	29	16 x 15	20 x 22			15 x 15			
26.0	30	16 x 16				15 x 16			
26.9	31	16 x 16				15 x 16			
27.8	32	.16 x 16				15 x 16			
28.6	33	16 x 17							
29.6	34	16 x 17							

4-71M PLEASURE CRAFT
N80 INJECTORS
ADVANCED CAMSHAFT TIMING



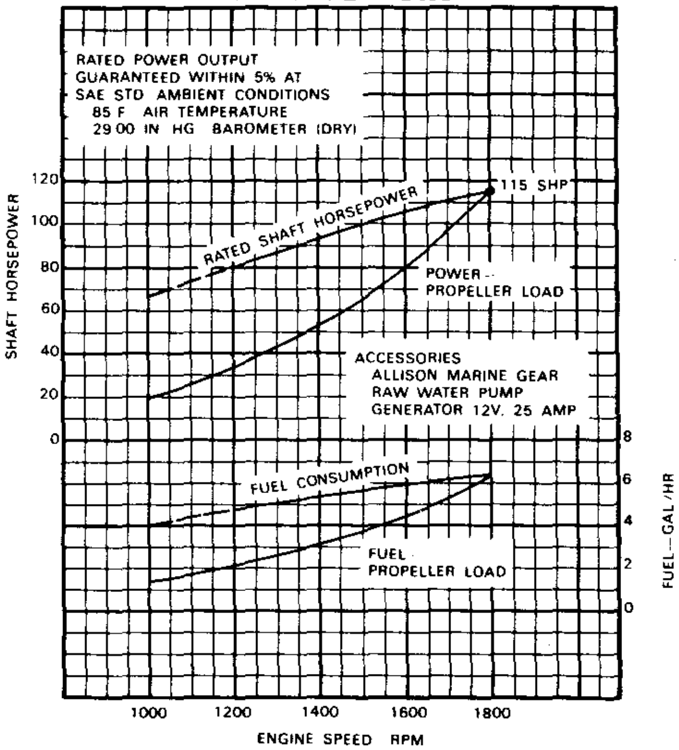
4-71M

PLEASURE CRAFT
N80 INJECTORS

▲ ALLISON M SERIES
★ TWIN DISC MG-506
MARINE GEAR

		3-BLADE PROPELLER					4-BLADE PROPELLER				
		GEAR RATIOS					GEAR RATIOS				
KNOTS	MPH	▲1.06	▲1.52	▲2.05	★1.5	★1.97	▲1.06	▲1.52	▲2.05	★1.5	★1.97
6.1	7			27 x 17		29 x 18			26 x 17		
6.9	8		23 x 14	27 x 17		29 x 18		21 x 14	26 x 17		27 x 18
7.8	9	18 x 11	23 x 14	27 x 18	24 x 15	29 x 18		21 x 15	25 x 18	23 x 15	27 x 19
8.7	10	18 x 12	23 x 15	27 x 18	24 x 16	29 x 19	17 x 12	21 x 15	25 x 18	23 x 16	27 x 19
9.7	11	18 x 12	23 x 15	27 x 19	24 x 16	29 x 19	17 x 12	21 x 15	25 x 18	23 x 16	27 x 20
10.4	12	18 x 12	23 x 15	27 x 19	24 x 16	28 x 20	17 x 12	21 x 16	25 x 19	23 x 17	27 x 20
11.2	13	18 x 12	22 x 16	27 x 20	24 x 17	28 x 20	17 x 13	21 x 16	25 x 20	23 x 17	27 x 21
12.1	14	18 x 13	22 x 16	27 x 20	24 x 17	28 x 21	17 x 13	21 x 17	25 x 20	23 x 17	26 x 21
13.0	15	18 x 13	22 x 17	27 x 21	24 x 18	28 x 21	17 x 13	21 x 17	25 x 21	22 x 18	26 x 22
13.8	16	18 x 13	22 x 17	26 x 22	24 x 18	28 x 22	17 x 13	21 x 17	25 x 21	22 x 18	26 x 22
14.7	17	18 x 13	22 x 18	26 x 22	24 x 18	28 x 23	17 x 14	21 x 18	25 x 22	22 x 19	26 x 23
15.6	18	18 x 13	22 x 18	26 x 23	24 x 19	28 x 23	17 x 14	21 x 18	25 x 23	22 x 19	26 x 23
16.5	19	18 x 14	22 x 19	26 x 24	24 x 19	28 x 24	17 x 14	21 x 19	25 x 23	22 x 19	26 x 24
17.3	20	18 x 14	22 x 19	26 x 24	24 x 20	28 x 24	17 x 15	21 x 19	24 x 24	22 x 20	26 x 25
18.2	21	18 x 14	22 x 20	26 x 25	23 x 20	27 x 25	17 x 15	20 x 20	24 x 24	22 x 20	26 x 25
19.1	22	18 x 15	22 x 20	25 x 26	23 x 21	27 x 26	17 x 15	20 x 20	24 x 25	22 x 21	26 x 26
19.9	23	18 x 15	21 x 20	25 x 26	23 x 21	27 x 26	17 x 15	20 x 21	24 x 25	22 x 21	26 x 26
20.8	24	18 x 16	21 x 21	25 x 27	23 x 22	27 x 27	17 x 16	20 x 21	24 x 26	22 x 22	26 x 27
21.7	25	17 x 16	21 x 21	25 x 28	23 x 22	27 x 28	16 x 16	20 x 22		22 x 22	26 x 27
22.5	26	17 x 16	21 x 22		23 x 22	27 x 28	16 x 16			22 x 22	25 x 28
23.4	27	17 x 17			23 x 23	26 x 29	16 x 17			22 x 23	
24.3	28	17 x 17			23 x 23		16 x 17				
25.2	29	17 x 17			23 x 24		16 x 17				
26.0	30	17 x 18									
26.9	31	17 x 18									

4-71N WORKBOAT
N55 INJECTORS



4-71N

WORK BOAT
N55 INJECTORS

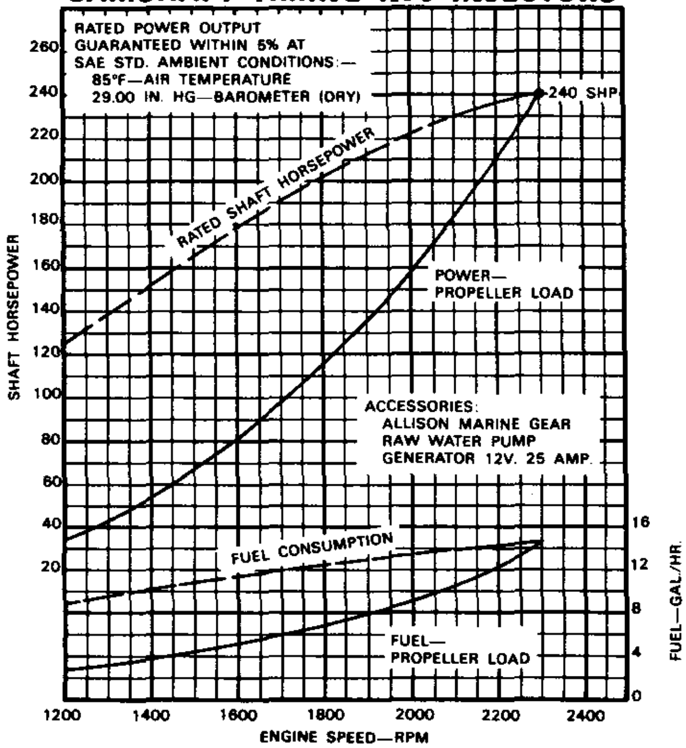
ALLISON MH SERIES MARINE GEAR

		3-BLADE PROPELLER					4-BLADE PROPELLER				
		GEAR RATIOS					GEAR RATIOS				
KNOTS	MPH	1.97	2.50	2.96	3.71	4.50	1.97	2.50	2.96	3.71	4.50
3.5	4					47 x 28					45 x 29
4.4	5			37 x 22	42 x 26	47 x 30				40 x 26	44 x 30
5.2	6	29 x 18	33 x 21	37 x 23	42 x 27	47 x 31	27 x 18	31 x 21	34 x 23	39 x 27	44 x 31
6.1	7	28 x 18	33 x 21	37 x 24	42 x 28	47 x 32	27 x 18	31 x 22	34 x 24	39 x 28	44 x 32
6.9	8	28 x 19	33 x 22	37 x 25	42 x 29	47 x 33	27 x 19	31 x 22	34 x 25	39 x 29	44 x 34
7.8	9	28 x 19	33 x 23	36 x 26	41 x 30	46 x 35	26 x 19	30 x 23	34 x 26	39 x 31	43 x 35
8.7	10	28 x 20	32 x 24	36 x 27	41 x 32	46 x 37	26 x 20	30 x 24	33 x 27	38 x 32	43 x 37
9.7	11	28 x 21	32 x 24	35 x 28	41 x 33		26 x 21	30 x 25	33 x 28	38 x 33	43 x 39
10.4	12	28 x 21	32 x 25	35 x 29	41 x 35		26 x 21	30 x 26	33 x 29	38 x 35	
11.2	13	28 x 22	32 x 26	35 x 30			26 x 22	30 x 27	33 x 30		
12.1	14	28 x 23	32 x 28				26 x 23	30 x 28			
13.0	15	27 x 24					26 x 24				
13.8	16						26 x 25				

6V-71N

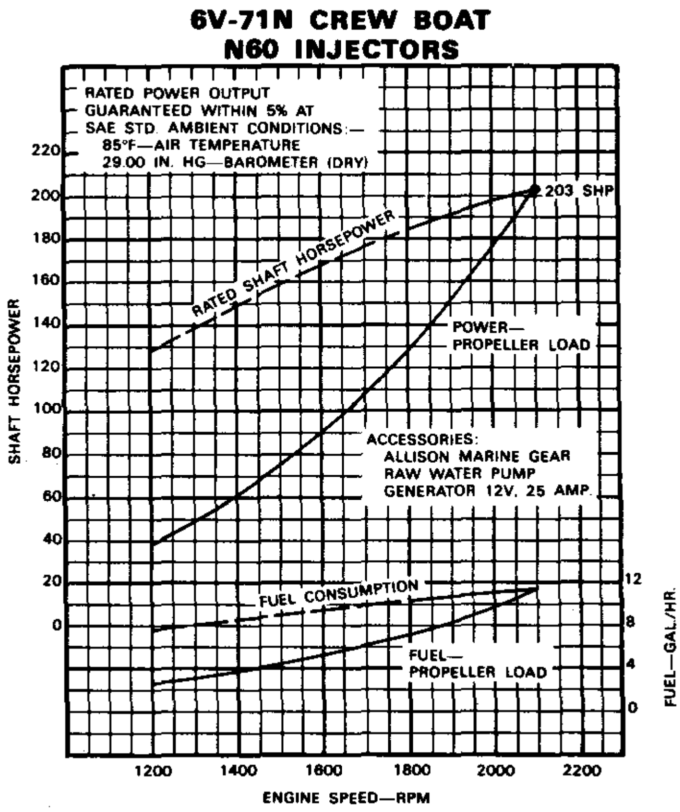
PLEASURE CRAFT
N70 INJECTORS

6V-71N PLEASURE CRAFT—ADVANCED CAMSHAFT TIMING N70 INJECTORS



ALLISON M SERIES MARINE GEAR

		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	1.06	1.52	2.05	1.06	1.52	2.05
6.1	7			29 x 18			
6.9	8			29 x 18			28 x 18
7.8	9		24 x 15	29 x 19		23 x 15	27 x 19
8.7	10	20 x 12	24 x 16	29 x 19	19 x 12	23 x 16	27 x 19
9.7	11	20 x 13	24 x 16	29 x 20	18 x 13	23 x 16	27 x 20
10.4	12	20 x 13	24 x 16	29 x 20	18 x 13	23 x 17	27 x 20
11.2	13	20 x 13	24 x 17	29 x 21	18 x 13	23 x 17	27 x 21
12.1	14	19 x 13	24 x 17	29 x 21	18 x 13	22 x 17	27 x 22
13.0	15	19 x 14	24 x 18	29 x 22	18 x 14	22 x 18	27 x 22
13.8	16	19 x 14	24 x 18	28 x 23	18 x 14	22 x 18	27 x 23
14.7	17	19 x 14	24 x 18	28 x 23	18 x 14	22 x 19	26 x 23
15.6	18	19 x 14	24 x 19	28 x 24	18 x 15	22 x 19	26 x 24
16.5	19	19 x 15	24 x 19	28 x 24	18 x 15	22 x 20	26 x 25
17.3	20	19 x 15	24 x 20	28 x 25	18 x 15	22 x 20	26 x 25
18.2	21	19 x 15	23 x 20	28 x 26	18 x 15	22 x 20	26 x 26
19.1	22	19 x 16	23 x 21	28 x 26	18 x 16	22 x 21	26 x 26
19.9	23	19 x 16	23 x 21	27 x 27	18 x 16	22 x 21	26 x 27
20.8	24	19 x 16	23 x 22	27 x 28	18 x 16	22 x 22	26 x 27
21.7	25	19 x 17	23 x 22	27 x 28	18 x 17	22 x 22	26 x 28
22.5	26	19 x 17	23 x 23	27 x 29	18 x 17	22 x 22	
23.4	27	19 x 17	23 x 23		18 x 17	22 x 23	
24.3	28	19 x 18	23 x 24		18 x 17	22 x 23	
25.2	29	18 x 18	22 x 24		18 x 18	22 x 24	
26.0	30	18 x 18	22 x 25		17 x 18		
26.9	31	18 x 19			17 x 18		
27.8	32	18 x 19			17 x 19		
28.6	33	18 x 19			17 x 19		
29.6	34	18 x 20					

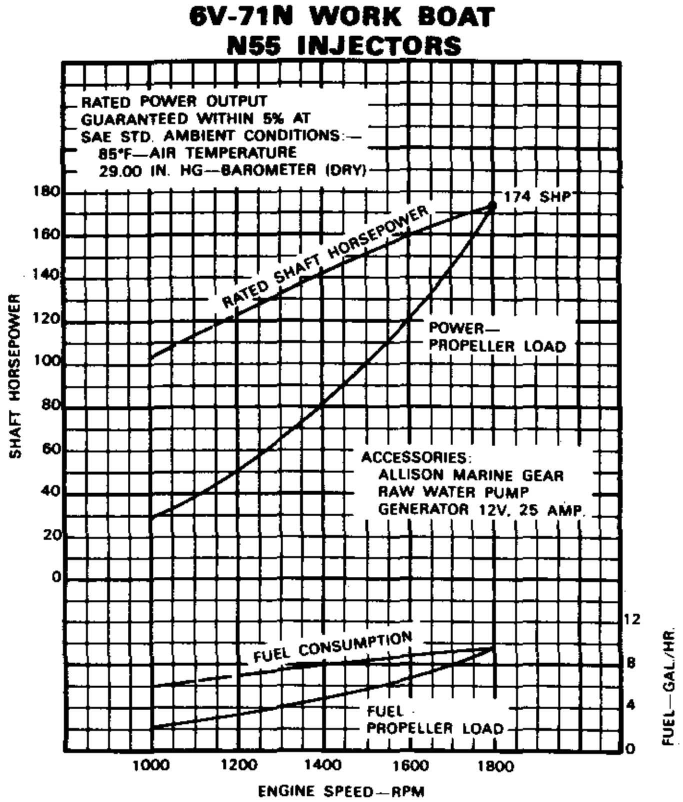


6V-71N

CREW BOAT
N60 INJECTORS

ALLISON M SERIES
MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER		4-BLADE PROPELLER	
		GEAR RATIOS		GEAR RATIOS	
		1.52	2.05	1.52	2.05
6.1	7		30 x 18		28 x 19
6.9	8	25 x 15	30 x 19	24 x 16	28 x 19
7.8	9	25 x 16	30 x 19	23 x 16	28 x 20
8.7	10	25 x 16	30 x 20	23 x 16	28 x 20
9.7	11	25 x 17	30 x 20	23 x 17	28 x 21
10.4	12	25 x 17	29 x 21	23 x 17	27 x 21
11.2	13	25 x 17	29 x 22	23 x 18	27 x 22
12.1	14	25 x 18	29 x 22	23 x 18	27 x 23
13.0	15	24 x 18	29 x 23	23 x 19	27 x 23
13.8	16	24 x 19	29 x 24	23 x 19	27 x 24
14.7	17	24 x 19	29 x 24	23 x 20	27 x 25
15.6	18	24 x 20	29 x 25	23 x 20	27 x 25
16.5	19	24 x 20	28 x 26	23 x 21	27 x 26
17.3	20	24 x 21	28 x 27	22 x 21	27 x 27
18.2	21	24 x 21	28 x 27	22 x 21	27 x 27
19.1	22	24 x 22	28 x 28	22 x 22	27 x 28
19.9	23	23 x 22	28 x 29	22 x 22	26 x 28
20.8	24	23 x 23		22 x 23	
21.7	25	23 x 23		22 x 23	
22.5	26	23 x 24		22 x 24	
23.4	27	23 x 25			



6V-71N

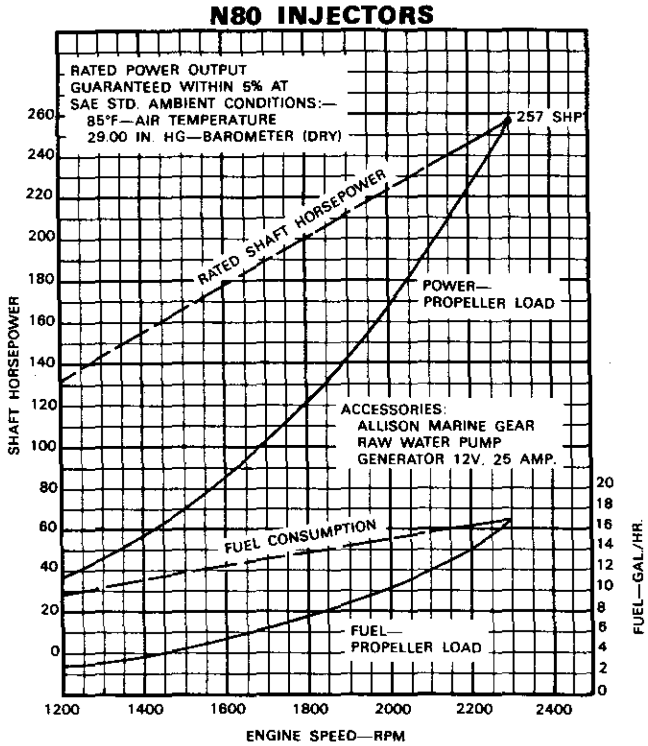
WORK BOAT
N55 INJECTORS

ALLISON MH SERIES MARINE GEAR

		3-BLADE PROPELLER				4-BLADE PROPELLER			
		GEAR RATIOS				GEAR RATIOS			
KNOTS	MPH	2.50	2.96	3.71	4.50	2.50	2.96	3.71	4.50
3.5	4				51 x 30				
4.4	5			46 x 28	51 x 32				48 x 32
5.2	6	36 x 22	40 x 25	46 x 29	51 x 33	34 x 22	38 x 25	43 x 29	48 x 33
6.1	7	36 x 23	40 x 26	45 x 30	51 x 34	34 x 23	38 x 26	43 x 30	48 x 35
6.9	8	36 x 23	40 x 26	45 x 31	51 x 35	33 x 24	37 x 27	42 x 31	47 x 36
7.8	9	35 x 24	40 x 27	45 x 32	50 x 37	33 x 24	37 x 28	42 x 32	47 x 37
8.7	10	35 x 25	39 x 28	45 x 33	50 x 38	33 x 25	37 x 29	42 x 34	47 x 39
9.7	11	35 x 26	39 x 29	45 x 35	50 x 40	33 x 26	37 x 30	42 x 35	47 x 41
10.4	12	35 x 27	39 x 30	44 x 36		33 x 27	36 x 31	42 x 37	
11.2	13	35 x 28	39 x 32	44 x 38		32 x 28	36 x 32	41 x 38	
12.1	14	35 x 29	38 x 33			32 x 29	36 x 33		
13.0	15	34 x 30				32 x 30			

6-71M
PLEASURE CRAFT
N80 INJECTORS

6-71M PLEASURE CRAFT
N80 INJECTORS



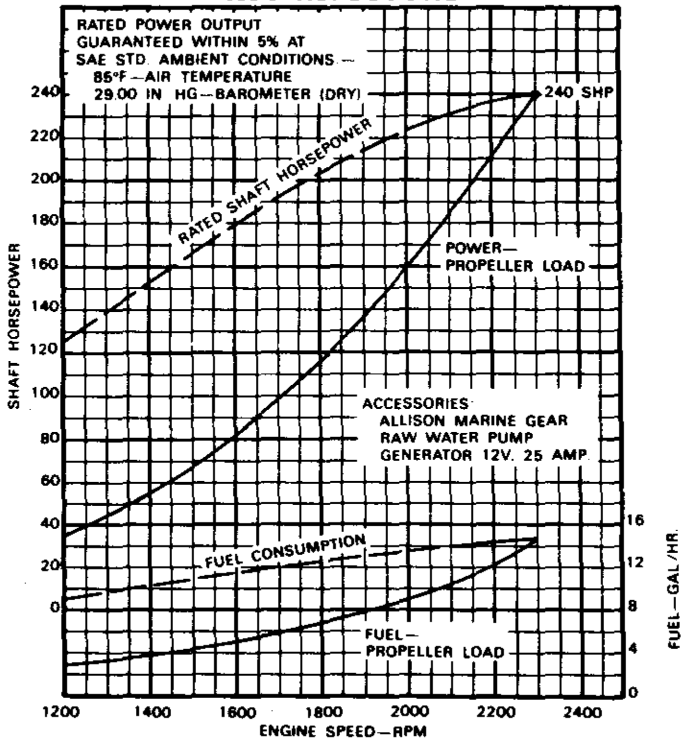
ALLISON M SERIES MARINE GEAR

		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	1.06	1.52	2.05	1.06	1.52	2.05
6.1	7			30 x 18			
6.9	8			30 x 18			28 x 19
7.8	9		25 x 15	29 x 19		23 x 16	28 x 19
8.7	10	20 x 12	25 x 16	29 x 19	19 x 13	23 x 16	28 x 20
9.7	11	20 x 13	25 x 16	29 x 20	19 x 13	23 x 16	27 x 20
10.4	12	20 x 13	25 x 16	29 x 20	19 x 13	23 x 17	27 x 21
11.2	13	20 x 13	24 x 17	29 x 21	19 x 13	23 x 17	27 x 21
12.1	14	20 x 13	24 x 17	29 x 22	18 x 14	23 x 18	27 x 22
13.0	15	20 x 14	24 x 18	29 x 22	18 x 14	23 x 18	27 x 22
13.8	16	20 x 14	24 x 18	29 x 23	18 x 14	23 x 18	27 x 23
14.7	17	20 x 14	24 x 19	29 x 23	18 x 14	23 x 19	27 x 24
15.6	18	20 x 15	24 x 19	29 x 24	18 x 15	23 x 19	27 x 24
16.5	19	20 x 15	24 x 19	28 x 25	18 x 15	22 x 20	27 x 25
17.3	20	19 x 15	24 x 20	28 x 25	18 x 15	22 x 20	27 x 25
18.2	21	19 x 15	24 x 20	28 x 26	18 x 16	22 x 21	27 x 26
19.1	22	19 x 16	24 x 21	28 x 27	18 x 16	22 x 21	26 x 26
19.9	23	19 x 16	24 x 21	28 x 27	18 x 16	22 x 21	26 x 27
20.8	24	19 x 16	23 x 22	28 x 28	18 x 16	22 x 22	26 x 28
21.7	25	19 x 17	23 x 22	27 x 29	18 x 17	22 x 22	26 x 28
22.5	26	19 x 17	23 x 23	27 x 29	18 x 17	22 x 23	26 x 29
23.4	27	19 x 17	23 x 23	27 x 30	18 x 17	22 x 23	
24.3	28	19 x 18	23 x 24		18 x 18	22 x 23	
25.2	29	19 x 18	23 x 24		18 x 18	22 x 24	
26.0	30	19 x 18	23 x 25		18 x 18		
26.9	31	19 x 19			18 x 18		
27.8	32	19 x 19			18 x 19		
28.6	33	18 x 19					
29.6	34	18 x 20					

6-71N

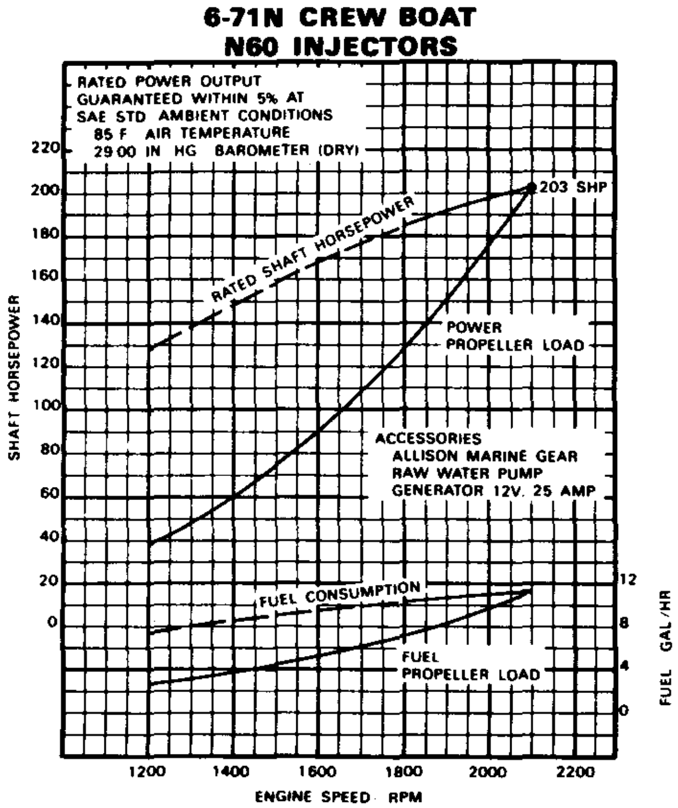
PLEASURE CRAFT
N70 INJECTORS

**6-71N PLEASURE CRAFT
ADVANCED CAMSHAFT TIMING
N70 INJECTORS**



ALLISON M SERIES MARINE GEAR

		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	1.06	1.52	2.05	1.06	1.52	2.05
6.1	7			29 x 18			
6.9	8			29 x 18			28 x 18
7.8	9		24 x 15	29 x 19		23 x 15	27 x 19
8.7	10	20 x 12	24 x 16	29 x 19	19 x 12	23 x 16	27 x 19
9.7	11	20 x 13	24 x 16	29 x 20	18 x 13	23 x 16	27 x 20
10.4	12	20 x 13	24 x 16	29 x 20	18 x 13	23 x 17	27 x 20
11.2	13	20 x 13	24 x 17	29 x 21	18 x 13	23 x 17	27 x 21
12.1	14	19 x 13	24 x 17	29 x 21	18 x 13	22 x 17	27 x 22
13.0	15	19 x 14	24 x 18	29 x 22	18 x 14	22 x 18	27 x 22
13.8	16	19 x 14	24 x 18	28 x 23	18 x 14	22 x 18	27 x 23
14.7	17	19 x 14	24 x 18	28 x 23	18 x 14	22 x 19	26 x 23
15.6	18	19 x 14	24 x 19	28 x 24	18 x 15	22 x 19	26 x 24
16.5	19	19 x 15	24 x 19	28 x 24	18 x 15	22 x 20	26 x 25
17.3	20	19 x 15	24 x 20	28 x 25	18 x 15	22 x 20	26 x 25
18.2	21	19 x 15	23 x 20	28 x 26	18 x 15	22 x 20	26 x 26
19.1	22	19 x 16	23 x 21	28 x 26	18 x 16	22 x 21	26 x 26
19.9	23	19 x 16	23 x 21	27 x 27	18 x 16	22 x 21	26 x 27
20.8	24	19 x 16	23 x 22	27 x 28	18 x 16	22 x 22	26 x 27
21.7	25	19 x 17	23 x 22	27 x 28	18 x 17	22 x 22	26 x 28
22.5	26	19 x 17	23 x 23	27 x 29	18 x 17	22 x 22	
23.4	27	19 x 17	23 x 23		18 x 17	22 x 23	
24.3	28	19 x 18	23 x 24		18 x 17	22 x 23	
25.2	29	18 x 18	22 x 24		18 x 18	22 x 24	
26.0	30	18 x 18	22 x 25		17 x 18		
26.9	31	18 x 19			17 x 18		
27.8	32	18 x 19			17 x 19		
28.6	33	18 x 19			17 x 19		
29.6	34	18 x 20					

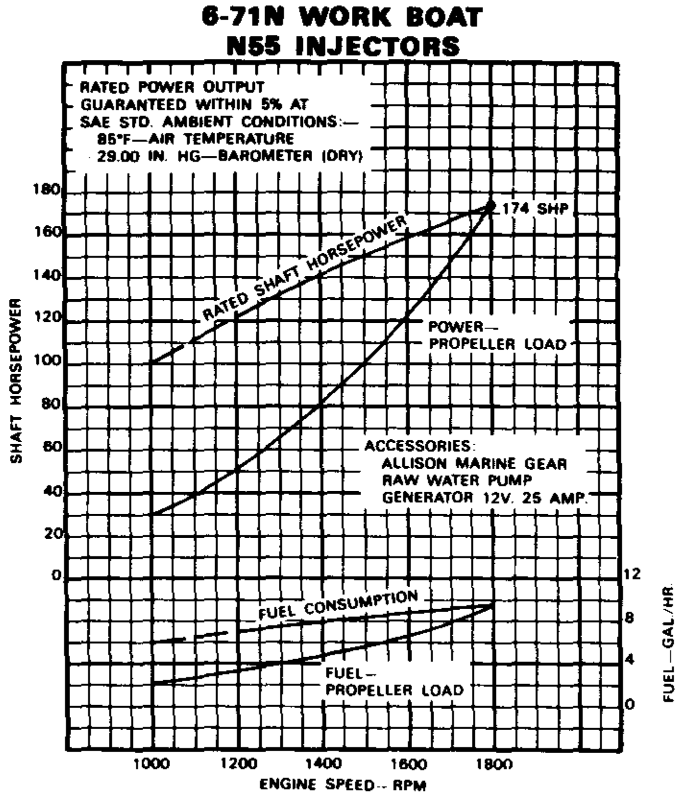


6-71N

CREW BOAT
N60 INJECTORS

ALLISON M SERIES MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER GEAR RATIOS 1.52	3-BLADE PROPELLER GEAR RATIOS 2.05	4-BLADE PROPELLER GEAR RATIOS 1.52	4-BLADE PROPELLER GEAR RATIOS 2.05
6.1	7		30 x 18		28 x 19
6.9	8	25 x 15	30 x 19	24 x 16	28 x 19
7.8	9	25 x 16	30 x 19	23 x 16	28 x 20
8.7	10	25 x 16	30 x 20	23 x 16	28 x 20
9.7	11	25 x 17	30 x 20	23 x 17	28 x 21
10.4	12	25 x 17	29 x 21	23 x 17	27 x 21
11.2	13	25 x 17	29 x 22	23 x 18	27 x 22
12.1	14	25 x 18	29 x 22	23 x 18	27 x 23
13.0	15	24 x 18	29 x 23	23 x 19	27 x 23
13.8	16	24 x 19	29 x 24	23 x 19	27 x 24
14.7	17	24 x 19	29 x 24	23 x 20	27 x 25
15.6	18	24 x 20	29 x 25	23 x 20	27 x 25
16.5	19	24 x 20	28 x 26	23 x 21	27 x 26
17.3	20	24 x 21	28 x 27	22 x 21	27 x 27
18.2	21	24 x 21	28 x 27	22 x 21	27 x 27
19.1	22	24 x 22	28 x 28	22 x 22	27 x 28
19.9	23	23 x 22	28 x 29	22 x 22	26 x 28
20.8	24	23 x 23		22 x 23	
21.7	25	23 x 23		22 x 23	
22.5	26	23 x 24		22 x 24	
23.4	27	23 x 25			



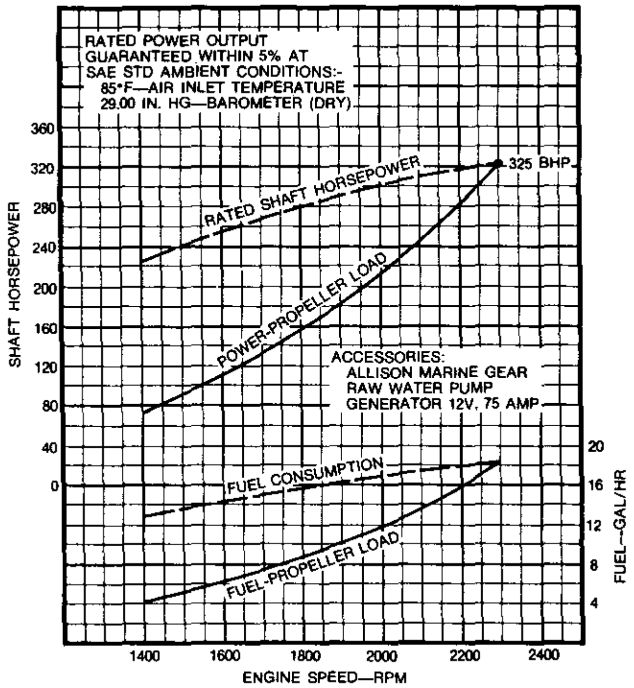
6-71N

WORK BOAT
N55 INJECTORS

ALLISON MH SERIES MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER GEAR RATIOS 2.50	2.96	3.71	4.50	4-BLADE PROPELLER GEAR RATIOS 2.50	2.96	3.71	4.50
3.5	4				51 x 30				
4.4	5			46 x 28	51 x 32				48 x 32
5.2	6	36 x 22	40 x 25	46 x 29	51 x 33	34 x 22	38 x 25	43 x 29	48 x 33
6.1	7	36 x 23	40 x 26	45 x 30	51 x 34	34 x 23	38 x 26	43 x 30	48 x 35
6.9	8	36 x 23	40 x 26	45 x 31	51 x 35	34 x 24	37 x 27	42 x 31	47 x 36
7.8	9	35 x 24	40 x 27	45 x 32	50 x 37	33 x 24	37 x 28	42 x 32	47 x 37
8.7	10	35 x 25	39 x 28	45 x 33	50 x 38	33 x 25	37 x 29	42 x 34	47 x 39
9.7	11	35 x 26	39 x 29	45 x 35	50 x 40	33 x 26	37 x 30	42 x 35	47 x 41
10.4	12	35 x 27	39 x 30	44 x 36		33 x 27	36 x 31	42 x 37	
11.2	13	35 x 28	39 x 32	44 x 38		32 x 28	36 x 32	41 x 38	
12.1	14	35 x 29	38 x 33			32 x 29	36 x 33		
13.0	15	34 x 30				32 x 30			

6-71TI PLEASURE CRAFT TURBOCHARGED/INTERCOOLED N90 INJECTORS



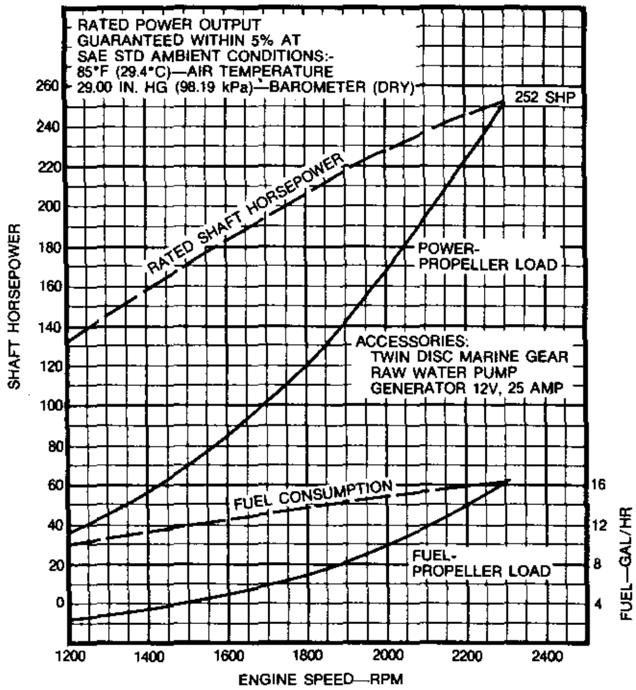
6-71TI

PLEASURE CRAFT N90 INJECTORS

ALLISON M SERIES MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER GEAR RATIOS 1.06	3-BLADE 1.52	3-BLADE 2.05	4-BLADE PROPELLER GEAR RATIOS 1.06	4-BLADE 1.52	4-BLADE 2.05
6.9	8			31 x 19			29 x 19
7.8	9		26 x 16	31 x 20		24 x 16	29 x 20
8.7	10	21 x 13	26 x 16	31 x 20		24 x 17	29 x 20
9.7	11	21 x 13	26 x 17	31 x 21	20 x 13	24 x 17	29 x 21
10.4	12	21 x 13	26 x 17	31 x 21	20 x 14	24 x 17	29 x 21
11.2	13	21 x 14	26 x 17	31 x 22	19 x 14	24 x 18	29 x 22
12.1	14	21 x 14	26 x 18	31 x 22	19 x 14	24 x 18	28 x 23
13.0	15	21 x 14	26 x 18	30 x 23	19 x 14	24 x 19	28 x 23
13.8	16	21 x 14	25 x 19	30 x 23	19 x 15	24 x 19	28 x 24
14.7	17	21 x 15	25 x 19	30 x 24	19 x 15	24 x 19	28 x 24
15.6	18	21 x 15	25 x 20	30 x 25	19 x 15	24 x 20	28 x 25
16.5	19	21 x 15	25 x 20	30 x 25	19 x 15	24 x 20	28 x 25
17.3	20	20 x 16	25 x 20	30 x 26	19 x 16	24 x 21	28 x 26
18.2	21	20 x 16	25 x 21	30 x 26	19 x 16	23 x 21	28 x 27
19.1	22	20 x 16	25 x 21	29 x 27	19 x 16	23 x 22	28 x 27
19.9	23	20 x 16	25 x 22	29 x 28	19 x 17	23 x 22	28 x 28
20.8	24	20 x 17	25 x 22	29 x 28	19 x 17	23 x 22	28 x 28
21.7	25	20 x 17	25 x 23	29 x 29	19 x 17	23 x 23	28 x 29
22.5	26	20 x 17	24 x 23	29 x 30	19 x 18	23 x 23	28 x 29
23.4	27	20 x 18	24 x 24	29 x 30	19 x 18	23 x 24	27 x 30
24.3	28	20 x 18	24 x 24		19 x 18	23 x 24	
25.2	29	20 x 18	24 x 25		19 x 18	23 x 24	
26.0	30	20 x 19	24 x 25		19 x 19	23 x 25	
26.9	31	20 x 19	24 x 26		19 x 19		
27.8	32	20 x 19			19 x 19		
28.6	33	19 x 20			19 x 20		
29.6	34	19 x 20			19 x 20		

6-71M PLEASURE CRAFT
N80 INJECTORS
ADVANCED TIMING

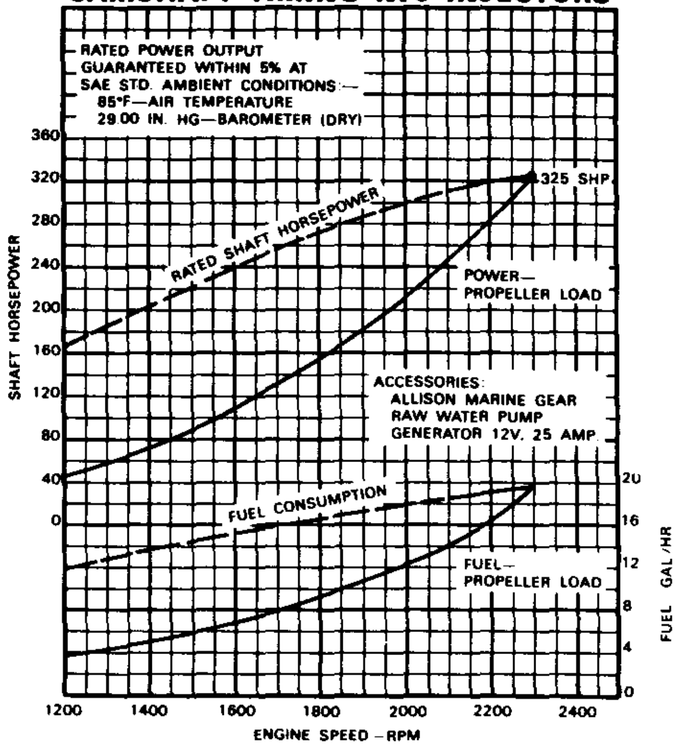


6-71M
PLEASURE CRAFT
N80 INJECTORS

TWIN DISC MG-506
MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER GEAR RATIOS 1.5	3-BLADE PROPELLER GEAR RATIOS 1.97	4-BLADE PROPELLER GEAR RATIOS 1.5	4-BLADE PROPELLER GEAR RATIOS 1.97
6.1	7		26 x 16		25 x 16
6.9	8	22 x 14	26 x 17	21 x 14	25 x 17
7.8	9	22 x 14	26 x 17	21 x 14	24 x 17
8.7	10	22 x 14	26 x 17	21 x 15	24 x 18
9.7	11	22 x 15	26 x 18	21 x 15	24 x 18
10.4	12	22 x 15	26 x 18	20 x 15	24 x 19
11.2	13	22 x 16	26 x 19	20 x 16	24 x 19
12.1	14	22 x 16	26 x 20	20 x 16	24 x 20
13.0	15	22 x 16	25 x 20	20 x 17	24 x 20
13.8	16	22 x 17	25 x 21	20 x 17	24 x 21
14.7	17	22 x 17	25 x 21	20 x 18	24 x 22
15.6	18	21 x 18	25 x 22	20 x 18	24 x 22
16.5	19	21 x 18	25 x 23	20 x 18	23 x 23
17.3	20	21 x 19	25 x 23	20 x 19	23 x 23
18.2	21	21 x 19	24 x 24	20 x 19	23 x 24
19.1	22	21 x 20	24 x 25	20 x 20	23 x 24
19.9	23	21 x 20	24 x 25	20 x 20	23 x 25
20.8	24	21 x 21	24 x 26	20 x 20	
21.7	25	21 x 21		20 x 21	
22.5	26	20 x 22			
23.4	27	20 x 22			

8V-71N PLEASURE CRAFT—ADVANCED CAMSHAFT TIMING N70 INJECTORS



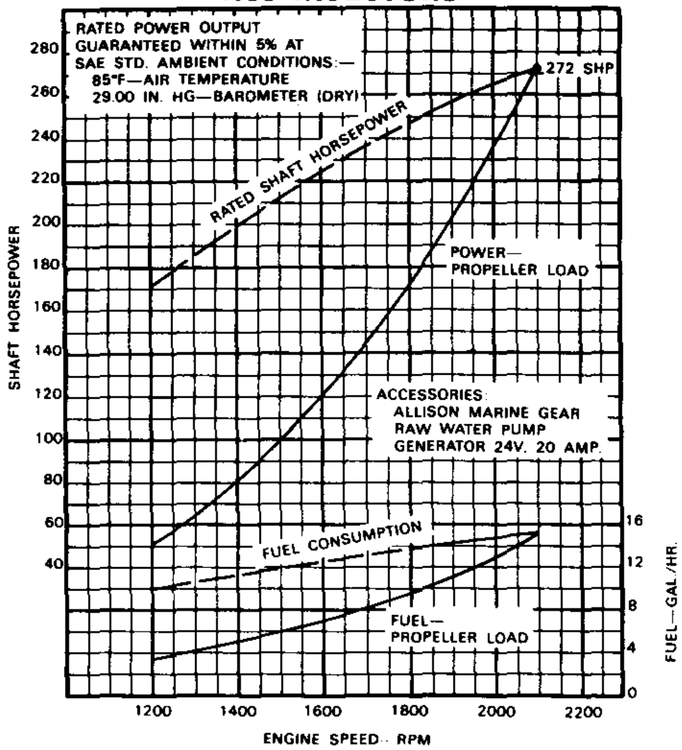
8V-71N

PLEASURE CRAFT N70 INJECTORS

ALLISON M SERIES MARINE GEAR

		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	1.06	1.52	2.05	1.06	1.52	2.05
6.9	8			31 x 19			29 x 19
7.8	9		26 x 16	31 x 20		24 x 16	29 x 20
8.7	10	21 x 13	26 x 16	31 x 20		24 x 17	29 x 20
9.7	11	21 x 13	26 x 17	31 x 21	20 x 13	24 x 17	29 x 21
10.4	12	21 x 13	26 x 17	31 x 21	20 x 14	24 x 18	29 x 21
11.2	13	21 x 14	26 x 17	31 x 22	19 x 14	24 x 18	29 x 22
12.1	14	21 x 14	26 x 18	31 x 22	19 x 14	24 x 18	28 x 23
13.0	15	21 x 14	26 x 18	30 x 23	19 x 14	24 x 19	28 x 23
13.8	16	21 x 14	25 x 19	30 x 23	19 x 15	24 x 19	28 x 24
14.7	17	21 x 15	25 x 19	30 x 24	19 x 15	24 x 19	28 x 24
15.6	18	21 x 15	25 x 20	30 x 25	19 x 15	24 x 20	28 x 25
16.5	19	21 x 15	25 x 20	30 x 25	19 x 15	24 x 20	28 x 25
17.3	20	20 x 16	25 x 20	30 x 26	19 x 16	24 x 21	28 x 26
18.2	21	20 x 16	25 x 21	30 x 26	19 x 16	23 x 21	28 x 27
19.1	22	20 x 16	25 x 21	29 x 27	19 x 16	23 x 22	28 x 27
19.2	23	20 x 16	25 x 22	29 x 28	19 x 17	23 x 22	28 x 28
20.8	24	20 x 17	25 x 22	29 x 28	19 x 17	23 x 22	28 x 28
21.7	25	20 x 17	25 x 23	29 x 29	19 x 17	23 x 23	28 x 29
22.5	26	20 x 17	24 x 23	29 x 30	19 x 18	23 x 23	28 x 29
23.4	27	20 x 18	24 x 24	29 x 30	19 x 18	23 x 24	27 x 30
24.3	28	20 x 18	24 x 24		19 x 18	23 x 24	
25.2	29	20 x 18	24 x 25		19 x 18	23 x 24	
26.0	30	20 x 19	24 x 25		19 x 19	23 x 25	
26.9	31	20 x 19	24 x 26		19 x 19		
27.8	32	20 x 19			19 x 19		
28.6	33	19 x 20			19 x 20		
29.6	34	19 x 20			19 x 20		

8V-71N CREW BOAT
N60 INJECTORS

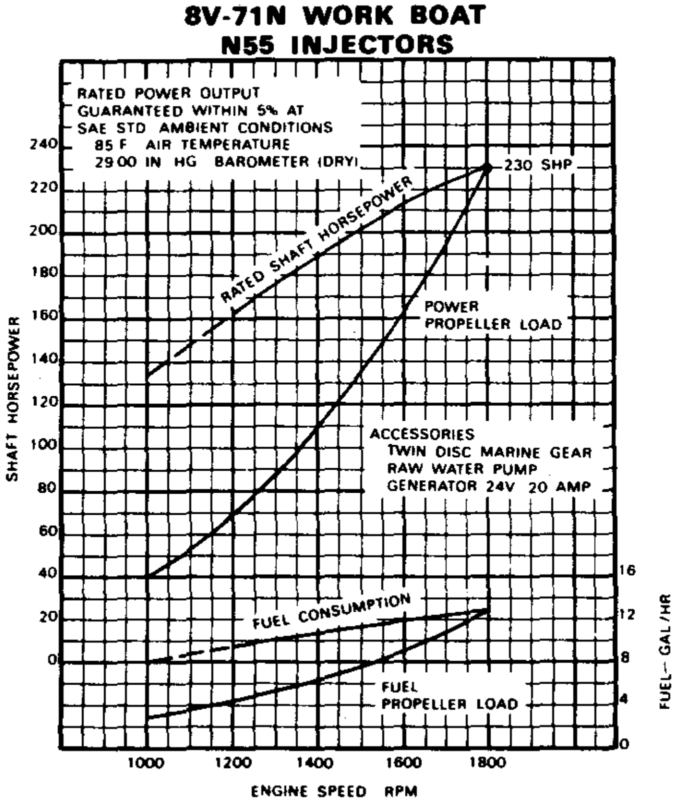


8V-71N

CREW BOAT
N60 INJECTORS

ALLISON MH SERIES MARINE GEAR

		3-BLADE PROPELLER				4-BLADE PROPELLER			
		GEAR RATIOS				GEAR RATIOS			
KNOTS	MPH	1.54	1.97	2.50	2.96	1.54	1.97	2.50	2.96
5.2	6				40 x 24				38 x 24
6.1	7			36 x 22	40 x 25			34 x 22	38 x 25
6.9	8	27 x 16	31 x 19	36 x 23	40 x 25		29 x 19	33 x 23	37 x 26
7.8	9	27 x 17	31 x 20	35 x 23	40 x 26	25 x 17	29 x 20	33 x 24	37 x 26
8.7	10	27 x 17	31 x 20	35 x 24	40 x 27	25 x 17	29 x 21	33 x 24	37 x 27
9.7	11	26 x 17	31 x 21	35 x 25	39 x 28	25 x 18	29 x 21	33 x 25	37 x 28
10.4	12	26 x 18	31 x 21	35 x 25	39 x 29	25 x 18	29 x 22	33 x 26	37 x 29
11.2	13	26 x 18	30 x 22	35 x 26	39 x 30	25 x 19	28 x 22	33 x 26	36 x 30
12.1	14	26 x 19	30 x 23	35 x 27	39 x 31	25 x 19	28 x 23	32 x 27	36 x 31
13.0	15	26 x 19	30 x 23	35 x 28	39 x 32	24 x 20	28 x 23	32 x 28	36 x 32
13.8	16	26 x 20	30 x 24	34 x 29	38 x 33	24 x 20	28 x 24	32 x 29	36 x 33
14.7	17	26 x 20	30 x 24	34 x 30	38 x 34	24 x 21	28 x 25	32 x 30	35 x 34
15.6	18	26 x 21	30 x 25	34 x 30	38 x 35	24 x 21	28 x 25	32 x 31	35 x 35
16.5	19	26 x 21	30 x 26	34 x 31	38 x 36	24 x 21	28 x 26	32 x 31	35 x 36
17.3	20	26 x 22	29 x 26	34 x 32		24 x 22	28 x 27	32 x 32	
18.2	21	26 x 22	29 x 27	33 x 33		24 x 22	28 x 27	32 x 33	
19.1	22	25 x 23	29 x 28			24 x 23	28 x 28		
19.9	23	25 x 23	29 x 28			24 x 23	27 x 28		
20.8	24	25 x 24	29 x 29			24 x 24	27 x 29		
21.7	25	25 x 24	29 x 30			24 x 24			
22.5	26	25 x 25	28 x 31			24 x 25			
23.4	27	25 x 25				24 x 25			
24.3	28	25 x 26				24 x 26			
25.2	29	24 x 27							

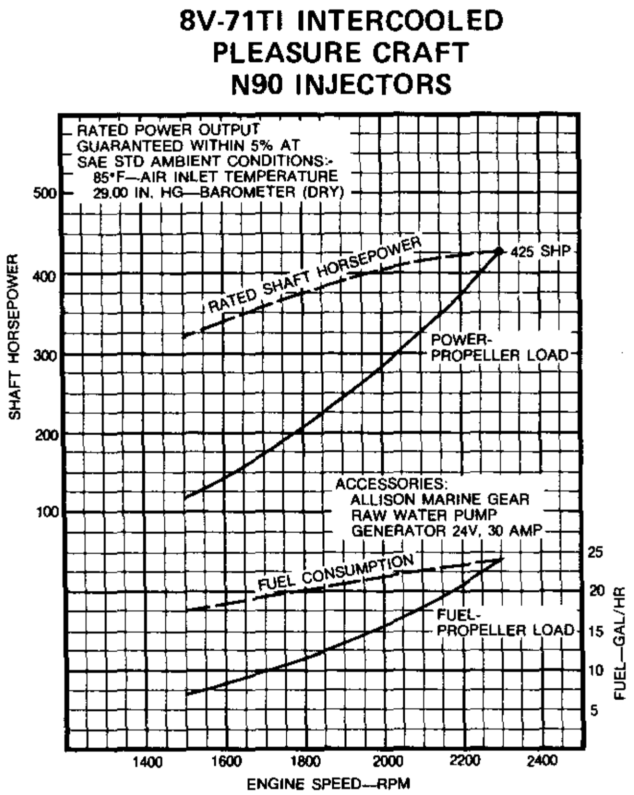


8V-71N

WORK BOAT
N55 INJECTORS

ALLISON MH SERIES
MARINE GEAR

		3-BLADE PROPELLER				4-BLADE PROPELLER			
		GEAR RATIOS				GEAR RATIOS			
KNOTS	MPH	2.50	2.96	3.71	4.50	2.50	2.96	3.71	4.50
4.4	5				54 x 33				51 x 33
5.2	6		42 x 26	48 x 30	54 x 34		40 x 26	46 x 30	51 x 35
6.1	7	38 x 24	42 x 27	48 x 31	54 x 35	36 x 24	40 x 27	45 x 32	51 x 36
6.9	8	38 x 24	42 x 27	48 x 32	54 x 37	35 x 25	39 x 28	45 x 33	50 x 37
7.8	9	38 x 25	42 x 28	48 x 33	53 x 38	35 x 26	39 x 29	45 x 34	50 x 39
8.7	10	38 x 26	42 x 29	48 x 35	53 x 40	35 x 26	39 x 30	44 x 35	50 x 40
9.7	11	38 x 27	42 x 30	47 x 36	53 x 42	35 x 27	39 x 31	44 x 36	49 x 42
10.4	12	38 x 28	41 x 31	47 x 37	52 x 43	35 x 28	39 x 32	44 x 38	49 x 44
11.2	13	37 x 29	41 x 33	47 x 39		34 x 29	38 x 33	44 x 39	49 x 46
12.1	14	37 x 30	41 x 34			34 x 30	38 x 34	44 x 41	
13.0	15	37 x 31	41 x 35			34 x 31	38 x 35		
13.8	16	37 x 32				34 x 32			



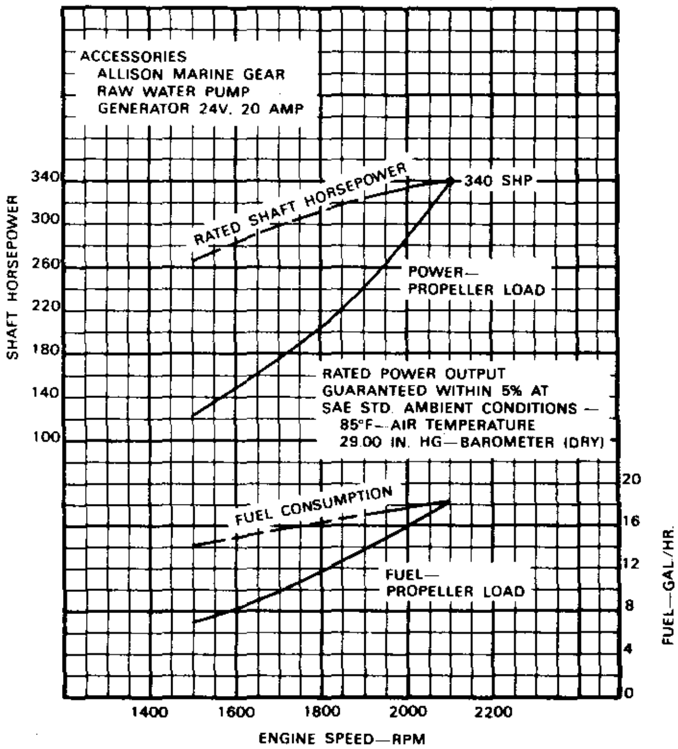
8V-71TI

INTERCOOLED PLEASURE CRAFT N90 INJECTORS

ALLISON M SERIES MARINE GEAR

		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	1.06	1.52	2.05	1.06	1.52	2.05
6.9	8			33 x 20			31 x 20
7.8	9			33 x 21			31 x 21
8.7	10		27 x 17	33 x 21		26 x 17	31 x 21
9.7	11	22 x 14	27 x 18	33 x 21	21 x 14	26 x 18	31 x 22
10.4	12	22 x 14	27 x 18	32 x 22	21 x 14	26 x 18	30 x 22
11.2	13	22 x 14	27 x 18	32 x 22	21 x 14	25 x 18	30 x 23
12.1	14	22 x 14	27 x 19	32 x 23	21 x 15	25 x 19	30 x 23
13.0	15	22 x 15	27 x 19	32 x 24	20 x 15	25 x 19	30 x 24
13.8	16	22 x 15	27 x 19	32 x 24	20 x 15	25 x 20	30 x 25
14.7	17	22 x 15	27 x 20	32 x 25	20 x 16	25 x 20	30 x 25
15.6	18	22 x 16	27 x 20	32 x 25	20 x 16	25 x 20	30 x 26
16.5	19	22 x 16	27 x 21	32 x 26	20 x 16	25 x 21	30 x 26
17.3	20	22 x 16	27 x 21	32 x 27	20 x 16	25 x 21	30 x 27
18.2	21	22 x 16	27 x 22	31 x 27	20 x 17	25 x 22	30 x 27
19.1	22	22 x 17	26 x 22	31 x 28	20 x 17	25 x 22	29 x 28
19.9	23	21 x 17	26 x 22	31 x 28	20 x 17	25 x 23	29 x 29
20.8	24	21 x 17	26 x 23	31 x 29	20 x 17	25 x 23	29 x 29
21.7	25	21 x 18	26 x 23	31 x 30	20 x 18	25 x 23	29 x 30
22.5	26	21 x 18	26 x 24	31 x 30	20 x 18	25 x 24	29 x 30
23.4	27	21 x 18	26 x 24	30 x 31	20 x 18	24 x 24	29 x 31
24.3	28	21 x 19	26 x 25	30 x 32	20 x 19	24 x 25	
25.2	29	21 x 19	26 x 25		20 x 19	24 x 25	
26.0	30	21 x 19	26 x 26		20 x 19	24 x 25	
26.9	31	21 x 20	25 x 26		20 x 20	24 x 26	
27.8	32	21 x 20	25 x 27		20 x 20		
28.6	33	21 x 20			20 x 20		
29.6	34	21 x 21			20 x 20		
30.5	35	21 x 21			20 x 21		
31.3	36	20 x 21			20 x 21		
32.1	37	20 x 22					
33.0	38	20 x 22					

8V-71TI INTERCOOLED
CREW BOAT N70 INJECTORS

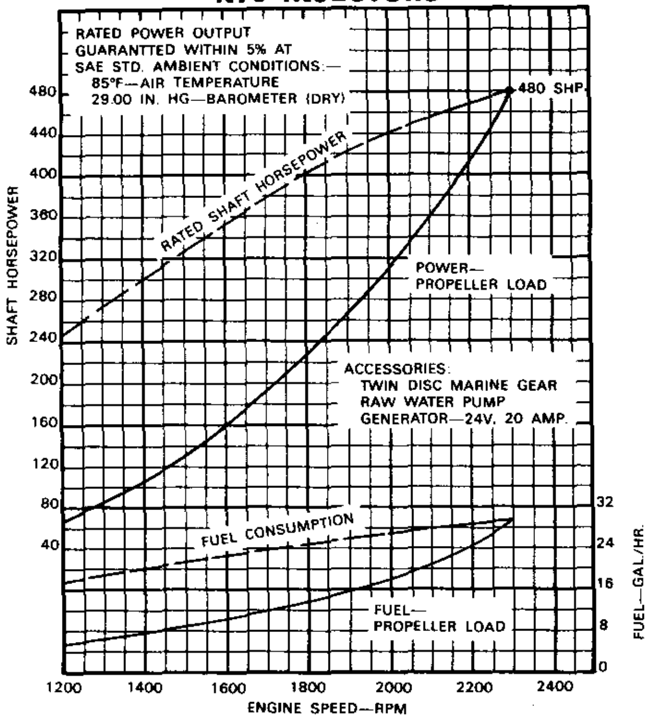


8V-71TI
INTERCOOLED CREW BOAT N70 INJECTORS

ALLISON M SERIES MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER GEAR RATIOS 1.52	3-BLADE PROPELLER GEAR RATIOS 2.05	4-BLADE PROPELLER GEAR RATIOS 1.52	4-BLADE PROPELLER GEAR RATIOS 2.05
6.1	7		33 x 20		
6.9	8		33 x 21		31 x 21
7.8	9	28 x 17	33 x 21	26 x 17	31 x 21
8.7	10	28 x 18	33 x 22	26 x 18	31 x 22
9.7	11	27 x 18	33 x 22	26 x 18	31 x 22
10.4	12	27 x 18	33 x 23	26 x 19	31 x 23
11.2	13	27 x 19	33 x 23	26 x 19	30 x 24
12.1	14	27 x 19	33 x 24	25 x 19	30 x 24
13.0	15	27 x 20	32 x 25	25 x 20	30 x 25
13.8	16	27 x 20	32 x 25	25 x 20	30 x 26
14.7	17	27 x 21	32 x 26	25 x 21	30 x 26
15.6	18	27 x 21	32 x 27	25 x 21	30 x 27
16.5	19	27 x 22	32 x 27	25 x 22	30 x 27
17.3	20	27 x 22	32 x 28	25 x 22	30 x 28
18.2	21	27 x 23	31 x 29	25 x 23	30 x 29
19.1	22	27 x 23	31 x 29	25 x 23	30 x 29
19.9	23	26 x 24	31 x 30	25 x 24	29 x 30
20.8	24	26 x 24	31 x 31	25 x 24	29 x 30
21.7	25	26 x 25	31 x 31	25 x 25	29 x 31
22.5	26	26 x 25	31 x 32	25 x 25	29 x 32
23.4	27	26 x 26	30 x 33	25 x 25	
24.3	28	26 x 26		25 x 26	
25.2	29	26 x 27			
26.0	30	25 x 27			
26.9	31	25 x 28			

12V-71N PLEASURE CRAFT
N70 INJECTORS

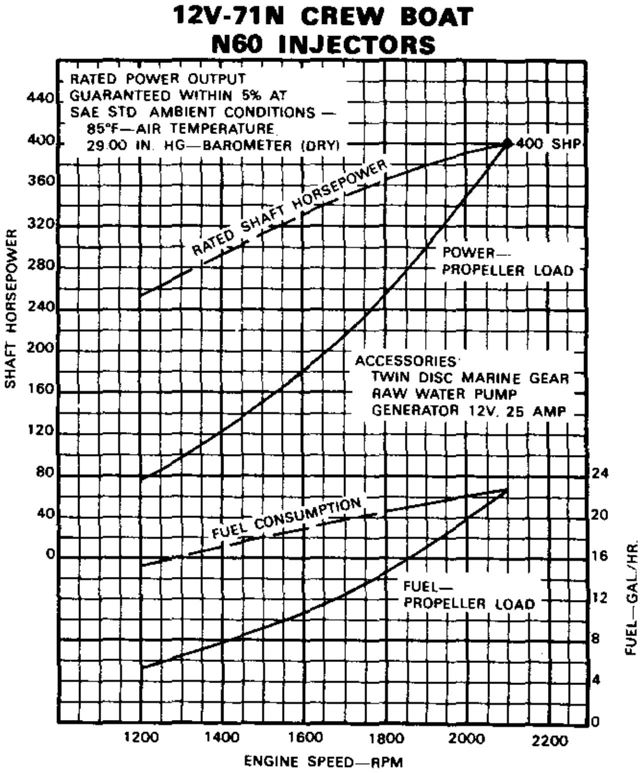


12V-71N

PLEASURE CRAFT
N70 INJECTORS

TWIN DISC MG-512 MARINE GEAR

		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	1.5	2	3	1.5	2	3
6.1	7			43 x 26			40 x 26
6.9	8			43 x 26			40 x 27
7.8	9		33 x 21	42 x 27		31 x 21	40 x 27
8.7	10	28 x 17	33 x 21	42 x 28	26 x 18	31 x 21	40 x 28
9.7	11	28 x 18	33 x 22	42 x 28	26 x 18	31 x 22	40 x 29
10.4	12	28 x 18	33 x 22	42 x 29	26 x 18	31 x 22	39 x 30
11.2	13	28 x 18	33 x 22	42 x 30	26 x 19	31 x 23	39 x 31
12.1	14	28 x 19	33 x 23	42 x 31	26 x 19	30 x 23	39 x 31
13.0	15	28 x 19	33 x 24	42 x 32	26 x 20	30 x 24	39 x 32
13.8	16	27 x 20	32 x 24	41 x 33	26 x 20	30 x 24	39 x 33
14.7	17	27 x 20	32 x 25	41 x 34	26 x 20	30 x 25	39 x 34
15.6	18	27 x 20	32 x 25	41 x 35	26 x 21	30 x 26	39 x 35
16.5	19	27 x 21	32 x 26	41 x 36	25 x 21	30 x 26	38 x 36
17.3	20	27 x 21	32 x 26	41 x 36	25 x 22	30 x 27	38 x 37
18.2	21	27 x 22	32 x 27	40 x 37	25 x 22	30 x 27	38 x 37
19.1	22	27 x 22	32 x 28	40 x 38	25 x 22	30 x 28	38 x 38
19.9	23	27 x 23	32 x 28		25 x 23	30 x 28	
20.8	24	27 x 23	31 x 29		25 x 23	30 x 29	
21.7	25	27 x 24	31 x 29		25 x 24	30 x 29	
22.5	26	27 x 24	31 x 30		25 x 24	29 x 30	
23.4	27	26 x 24	31 x 31		25 x 24	29 x 30	
24.3	28	26 x 25	31 x 31		25 x 25	29 x 31	
25.2	29	26 x 25	31 x 32		25 x 25	29 x 32	
26.0	30	26 x 26	30 x 33		25 x 26		
26.9	31	26 x 26			25 x 26		
27.8	32	26 x 27			25 x 26		
28.6	33	26 x 27			25 x 27		
29.6	34	26 x 28					



12V-71N

CREW BOAT
N60 INJECTORS

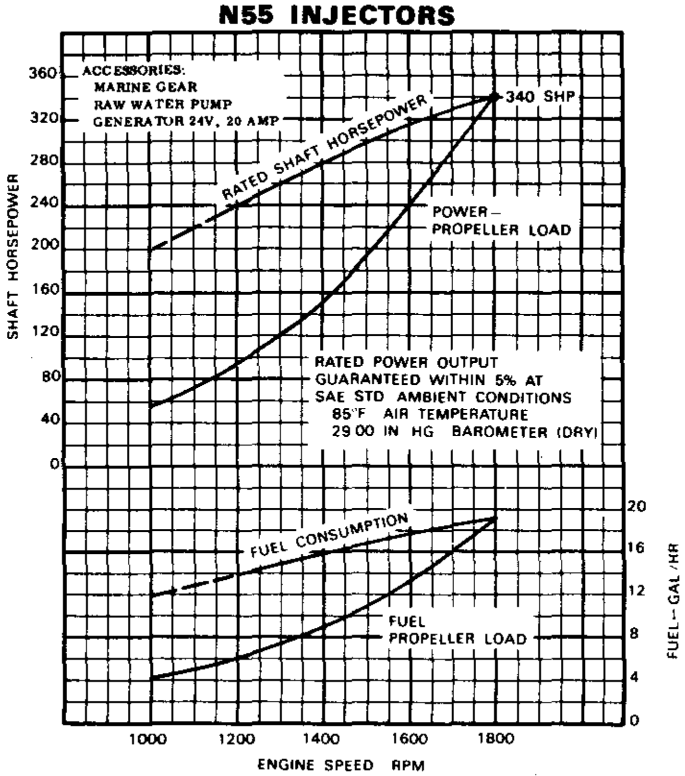
TWIN DISC MG-512 MARINE GEAR

		3-BLADE PROPELLER		4-BLADE PROPELLER	
		GEAR RATIOS		GEAR RATIOS	
KNOTS	MPH	2.0	3.0	2.0	3.0
6.1	7		43 x 27		41 x 27
6.9	8	34 x 21	43 x 27		41 x 28
7.8	9	34 x 21	43 x 28	32 x 21	41 x 28
8.7	10	33 x 22	43 x 29	31 x 22	40 x 29
9.7	11	33 x 22	43 x 30	31 x 23	40 x 30
10.4	12	33 x 23	43 x 30	31 x 23	40 x 31
11.2	13	33 x 23	43 x 31	31 x 24	40 x 32
12.1	14	33 x 24	42 x 32	31 x 24	40 x 33
13.0	15	33 x 25	42 x 33	31 x 25	40 x 34
13.8	16	33 x 25	42 x 34	31 x 26	39 x 35
14.7	17	33 x 26	42 x 35	31 x 26	39 x 36
15.6	18	33 x 27	42 x 37	31 x 27	39 x 37
16.5	19	33 x 27	41 x 38	30 x 27	39 x 38
17.3	20	32 x 28	41 x 39	30 x 28	39 x 38
18.2	21	32 x 29	41 x 40	30 x 29	
19.1	22	32 x 29		30 x 29	
19.9	23	32 x 30		30 x 30	
20.8	24	32 x 31		30 x 30	
21.7	25	31 x 31		30 x 31	
22.5	26	31 x 32		30 x 32	
23.4	27	31 x 33		30 x 32	

12V-71N

WORK BOAT
N55 INJECTORS

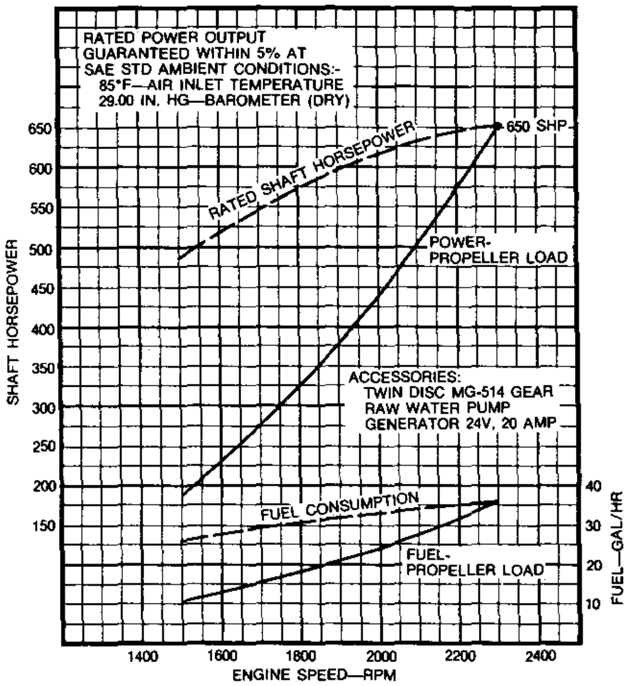
12V-71N WORK BOAT
N55 INJECTORS



TWIN DISC MG-514 MARINE GEAR

		3-BLADE PROPELLER						4-BLADE PROPELLER					
		GEAR RATIOS						GEAR RATIOS					
KNOTS	MPH	3	3.5	4.13	4.5	5.16	6	3	3.5	4.13	4.5	5.16	6
4.4	5					64 x 39	70 x 43						66 x 43
5.2	6		50 x 31	56 x 35	59 x 37	63 x 40	69 x 44		48 x 31	53 x 35	55 x 37	60 x 41	65 x 45
6.1	7	46 x 29	50 x 32	55 x 36	58 x 38	63 x 41	69 x 46	43 x 29	47 x 32	52 x 36	55 x 38	59 x 42	65 x 47
6.9	8	46 x 30	50 x 33	55 x 37	58 x 39	63 x 43	69 x 48	43 x 30	47 x 33	52 x 37	54 x 40	59 x 44	64 x 48
7.8	9	46 x 30	50 x 34	55 x 38	58 x 40	63 x 45	68 x 50	43 x 31	47 x 34	52 x 39	54 x 41	59 x 45	64 x 50
8.7	10	46 x 31	50 x 35	55 x 39	58 x 42	62 x 46	68 x 52	43 x 32	47 x 35	51 x 40	54 x 42	58 x 47	64 x 52
9.7	11	45 x 32	50 x 36	55 x 41	57 x 44	62 x 48	68 x 54	42 x 33	46 x 37	51 x 41	54 x 44	58 x 49	63 x 55
10.4	12	45 x 33	49 x 37	54 x 42	57 x 45	62 x 50	67 x 57	42 x 34	46 x 38	51 x 43	53 x 46	58 x 51	63 x 57
11.2	13	45 x 35	49 x 39	54 x 44	57 x 47	61 x 53	66 x 59	42 x 35	46 x 39	51 x 45	53 x 48	57 x 53	63 x 60
12.1	14	45 x 36	49 x 40	54 x 46	56 x 49	61 x 53		42 x 36	46 x 41	50 x 46	53 x 49	57 x 53	
13.0	15	44 x 37	48 x 42	53 x 48	56 x 49			42 x 37	46 x 42	50 x 48	53 x 49		
13.8	16	44 x 38	48 x 43	53 x 48				42 x 39	45 x 43	50 x 48			
14.7	17							41 x 40	45 x 45				

12V-71TI INTERCOOLED
PLEASURE CRAFT
N90 INJECTORS



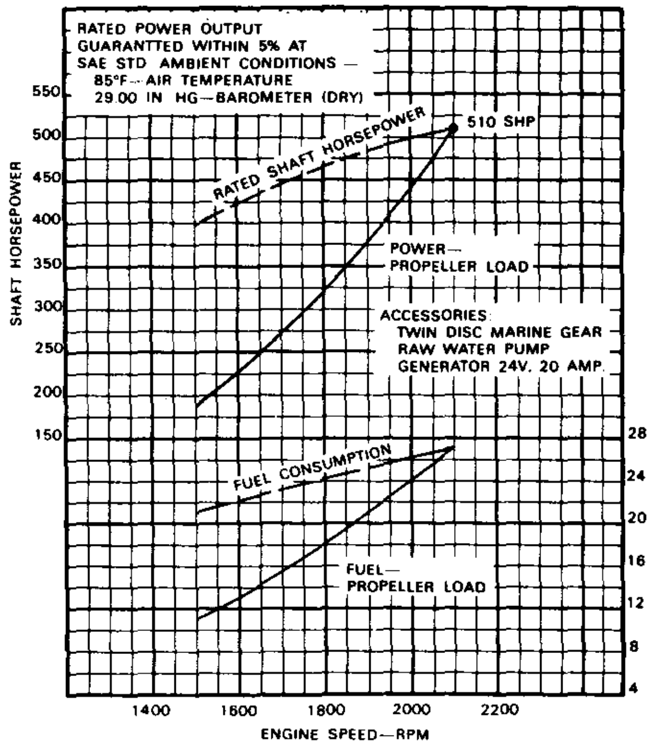
12V-71TI

INTERCOOLED PLEASURE CRAFT N90 INJECTORS

TWIN DISC MG-514 MARINE GEAR

		3-BLADE PROPELLER				4-BLADE PROPELLER			
		GEAR RATIOS				GEAR RATIOS			
KNOTS	MPH	1.51	2.0	2.5	3.0	1.51	2.0	2.5	3.0
6.9	8				45 x 28				43 x 28
7.8	9		35 x 22	41 x 25	45 x 28			38 x 25	43 x 29
8.7	10	30 x 18	35 x 22	40 x 26	45 x 29		33 x 22	38 x 26	42 x 29
9.7	11	30 x 19	35 x 23	40 x 26	45 x 30	28 x 19	33 x 23	38 x 27	42 x 30
10.4	12	30 x 19	35 x 23	40 x 27	45 x 31	28 x 19	33 x 23	38 x 27	42 x 31
11.2	13	29 x 19	35 x 23	40 x 27	45 x 31	28 x 20	33 x 24	38 x 28	42 x 32
12.1	14	29 x 20	35 x 24	40 x 28	45 x 32	28 x 20	32 x 24	37 x 29	42 x 33
13.0	15	29 x 20	35 x 25	40 x 29	44 x 33	27 x 20	32 x 25	37 x 29	41 x 34
13.8	16	29 x 21	35 x 25	40 x 30	44 x 34	27 x 21	32 x 25	37 x 30	41 x 34
14.7	17	29 x 21	34 x 26	40 x 30	44 x 35	27 x 21	32 x 26	37 x 31	41 x 35
15.6	18	29 x 21	34 x 26	40 x 31	44 x 36	27 x 22	32 x 27	37 x 31	41 x 36
16.5	19	29 x 22	34 x 27	39 x 32	44 x 37	27 x 22	32 x 27	37 x 32	41 x 37
17.3	20	29 x 22	34 x 27	39 x 33	43 x 38	27 x 22	32 x 28	37 x 33	41 x 38
18.2	21	29 x 23	34 x 28	39 x 33	43 x 38	27 x 23	32 x 28	37 x 34	41 x 39
19.1	22	29 x 23	34 x 29	39 x 34	43 x 39	27 x 23	32 x 29	37 x 34	41 x 39
19.9	23	29 x 23	34 x 29	39 x 35	42 x 40	27 x 24	32 x 29	37 x 35	40 x 40
20.8	24	29 x 24	34 x 30	38 x 36		27 x 24	32 x 30	36 x 36	
21.7	25	29 x 24	33 x 30	38 x 36		27 x 25	32 x 30	36 x 36	
22.5	26	28 x 25	33 x 31			27 x 25	31 x 31		
23.4	27	28 x 25	33 x 32			27 x 25	31 x 32		
24.3	28	28 x 26	33 x 32			27 x 26	31 x 32		
25.2	29	28 x 26	33 x 33			27 x 26	31 x 33		
26.0	30	28 x 27	33 x 34			27 x 27	31 x 33		
26.9	31	28 x 27	32 x 34			26 x 27	31 x 34		
27.8	32	28 x 28	32 x 35			26 x 27			
28.6	33	28 x 28	32 x 36			26 x 28			
29.6	34	28 x 29				26 x 28			
30.5	35	27 x 29				36 x 29			
31.3	36	27 x 30							

12V-71TI INTERCOOLED CREW BOAT N70 INJECTORS



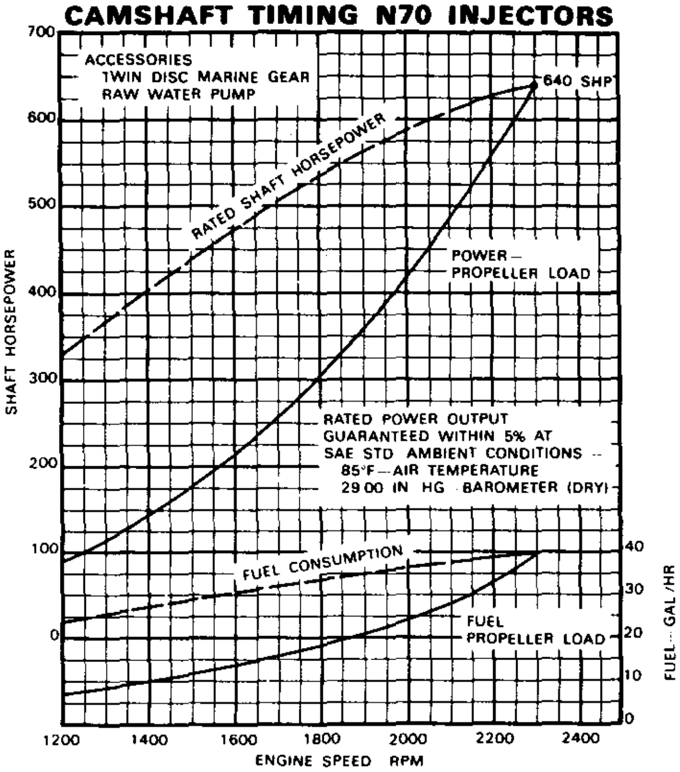
12V-71TI

INTERCOOLED CREW BOAT N70 INJECTORS

TWIN DISC MG-514 MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
		2.0	2.5	3.0	2.0	2.5	3.0
6.1	7			46 x 28			43 x 28
6.9	8		41 x 25	45 x 28		39 x 25	43 x 29
7.8	9	35 x 22	41 x 26	45 x 29	33 x 22	38 x 26	43 x 29
8.7	10	35 x 23	41 x 26	45 x 30	33 x 23	38 x 27	42 x 30
9.7	11	35 x 23	41 x 27	45 x 31	33 x 23	38 x 27	42 x 31
10.4	12	35 x 24	40 x 28	45 x 31	33 x 24	38 x 28	42 x 32
11.2	13	35 x 24	40 x 28	45 x 32	33 x 25	38 x 29	42 x 33
12.1	14	35 x 25	40 x 29	45 x 33	33 x 25	38 x 30	42 x 34
13.0	15	35 x 25	40 x 30	44 x 34	32 x 26	37 x 30	42 x 35
13.8	16	35 x 26	40 x 31	44 x 35	32 x 26	37 x 31	41 x 36
14.7	17	35 x 27	40 x 32	44 x 36	32 x 27	37 x 32	41 x 37
15.6	18	34 x 27	40 x 32	44 x 37	32 x 28	37 x 33	41 x 38
16.5	19	34 x 28	39 x 33	44 x 38	32 x 28	37 x 34	41 x 39
17.3	20	34 x 29	39 x 34	43 x 39	32 x 29	37 x 34	41 x 39
18.2	21	34 x 29	39 x 35	43 x 40	32 x 29	37 x 35	41 x 40
19.1	22	34 x 30	39 x 36	43 x 42	32 x 30	37 x 36	
19.9	23	34 x 31	39 x 37		32 x 31		
20.8	24	33 x 31	38 x 38		32 x 31		
21.7	25	33 x 32			32 x 32		
22.5	26	33 x 33			31 x 32		
23.4	27	33 x 33			31 x 33		
24.3	28	33 x 34			31 x 34		
25.2	29	33 x 35					

16V-71N PLEASURE CRAFT—ADVANCED CAMSHAFT TIMING N70 INJECTORS



16V-71N

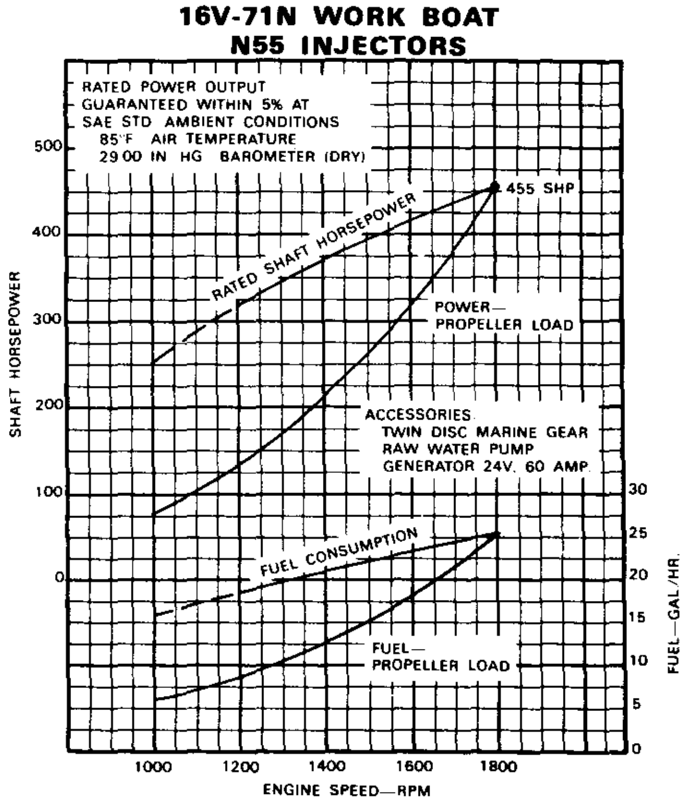
PLEASURE CRAFT N70 INJECTORS

TWIN DISC MG-521 MARINE GEAR

		3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
KNOTS	MPH	2.19	3.03	3.50	2.19	3.03	3.50
6.1	7			49 x 30			47 x 30
6.9	8		45 x 28	49 x 31		43 x 28	47 x 31
7.8	9	37 x 23	45 x 29	49 x 31	35 x 23	43 x 29	46 x 32
8.7	10	37 x 23	45 x 29	49 x 32	35 x 24	42 x 30	46 x 33
9.7	11	37 x 24	45 x 30	49 x 33	35 x 24	42 x 30	46 x 34
10.4	12	37 x 24	45 x 31	49 x 34	34 x 25	42 x 31	46 x 35
11.2	13	37 x 25	45 x 32	49 x 35	34 x 25	42 x 32	45 x 36
12.1	14	37 x 26	45 x 32	49 x 36	34 x 26	42 x 33	45 x 37
13.0	15	37 x 26	45 x 33	48 x 37	34 x 27	42 x 34	45 x 38
13.8	16	37 x 27	44 x 34	48 x 38	34 x 27	41 x 35	45 x 39
14.7	17	37 x 27	44 x 35	48 x 39	34 x 28	41 x 35	45 x 40
15.6	18	37 x 28	44 x 36	48 x 40	34 x 28	41 x 36	45 x 41
16.5	19	36 x 29	44 x 37	47 x 41	34 x 28	41 x 37	45 x 42
17.3	20	36 x 29	44 x 38	47 x 42	34 x 30	41 x 38	44 x 43
18.2	21	36 x 30	43 x 39	47 x 44	33 x 30	41 x 39	44 x 43
19.1	22	36 x 31	43 x 40	47 x 45	33 x 31	41 x 40	
19.9	23	35 x 31	43 x 41		33 x 31	41 x 40	
20.8	24	35 x 32	43 x 42		33 x 32		
21.7	25	35 x 33			33 x 33		
22.5	26	35 x 33			33 x 33		
23.4	27	35 x 34			33 x 34		
24.3	28	34 x 35			33 x 34		
25.2	29	34 x 35			33 x 35		
26.0	30	34 x 36			33 x 36		
26.9	31	34 x 37					

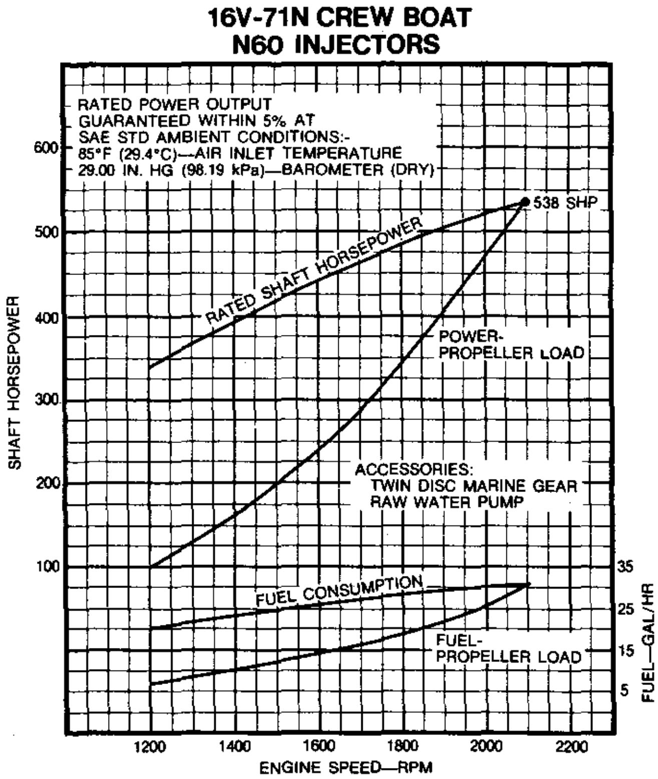
16V-71N ●

WORK BOAT
N55 INJECTORS



TWIN DISC MG-527
MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER GEAR RATIOS 2.92	3-BLADE 3.86	3-BLADE 5.17	4-BLADE PROPELLER GEAR RATIOS 2.92	4-BLADE 3.86	4-BLADE 5.17
4.4	5			68 x 41			64 x 41
5.2	6		57 x 35	67 x 42			64 x 43
6.1	7	48 x 30	57 x 36	67 x 43	45 x 30	53 x 36	63 x 44
6.9	8	48 x 30	56 x 37	67 x 45	45 x 31	53 x 37	63 x 46
7.8	9	48 x 31	56 x 38	67 x 46	45 x 32	53 x 38	62 x 47
8.7	10	48 x 32	56 x 39	66 x 48	45 x 32	52 x 40	62 x 49
9.7	11	47 x 33	56 x 40	66 x 50	44 x 33	52 x 41	62 x 51
10.4	12	47 x 34	56 x 42	66 x 52	44 x 34	52 x 42	61 x 53
11.2	13	47 x 35	55 x 43	65 x 54	44 x 36	52 x 44	61 x 55
12.1	14	47 x 36	55 x 45	65 x 57	44 x 37	51 x 45	61 x 57
13.0	15	47 x 37	55 x 47	64 x 59	44 x 38	51 x 47	61 x 59
13.8	16	46 x 39	54 x 48		44 x 39	51 x 48	
14.7	17	46 x 40			43 x 40		



16V-71N

CREW BOAT
N60 INJECTORS

TWIN DISC MG-521 MARINE GEAR

KNOTS	MPH	3-BLADE PROPELLER			4-BLADE PROPELLER		
		GEAR RATIOS			GEAR RATIOS		
		2.19	3.03	3.50	2.19	3.03	3.50
6.1	7			50 x 31			48 x 31
6.9	8	38 x 23	46 x 29	50 x 32		44 x 29	47 x 32
7.8	9	38 x 24	46 x 30	50 x 33	35 x 24	43 x 30	47 x 33
8.7	10	38 x 24	46 x 30	50 x 33	35 x 25	43 x 31	47 x 34
9.7	11	38 x 25	46 x 31	50 x 34	35 x 25	43 x 32	47 x 35
10.4	12	38 x 25	46 x 32	50 x 35	35 x 26	43 x 32	46 x 36
11.2	13	38 x 26	46 x 33	50 x 37	35 x 26	43 x 33	46 x 37
12.1	14	38 x 27	45 x 34	49 x 38	35 x 27	42 x 34	46 x 38
13.0	15	38 x 27	45 x 35	49 x 39	35 x 28	42 x 35	46 x 39
13.8	16	37 x 28	45 x 36	49 x 40	34 x 28	42 x 36	46 x 41
14.7	17	37 x 29	45 x 37	49 x 41	34 x 29	42 x 37	46 x 42
15.6	18	37 x 29	45 x 38	48 x 43	34 x 30	42 x 38	45 x 43
16.5	19	37 x 30	44 x 39	48 x 44	34 x 30	42 x 39	45 x 44
17.3	20	37 x 31	44 x 40	48 x 45	34 x 31	42 x 40	45 x 45
18.2	21	37 x 32	44 x 41		34 x 32	41 x 41	
19.1	22	36 x 32	43 x 42		34 x 32	41 x 42	
19.9	23	36 x 33			34 x 33		
20.8	24	36 x 34			34 x 34		
21.7	25	35 x 35					