6V-53 "SILVER" TURBOCHARGED-INTERCOOLED ENGINES MARINE

	2800 rpm
Lubrication System	
Lubricating oil pressure (psi):	
Normal	40–60
Minimum for safe operation	32
†Lubricating oil temperature (deg. F) – Normal	200–250
Air System	
Air box pressure (inches mercury) – min. full load:	
At zero exhaust back pressure:	
7005 injector	62.2
Air inlet restriction (inches water) – full load max.:	
Air silencer	20.0
Crankcase pressure (inches water) – max.	4.0
Exhaust back pressure (inches mercury) – max.:	
Full load	2.5
Fuel System	
Fuel pressure at inlet manifold (psi)	
Normal with .070" restriction	45–70
Minimum	35
Fuel spill (gpm) – min. at no load:	
.070" restriction	1.05
Pump suction at inlet (inches mercury) – max.:	
Clean system	6.0
Dirty system	12.0
Cooling System	
Coolant temperature (deg. F) – Normal	167–187

† The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

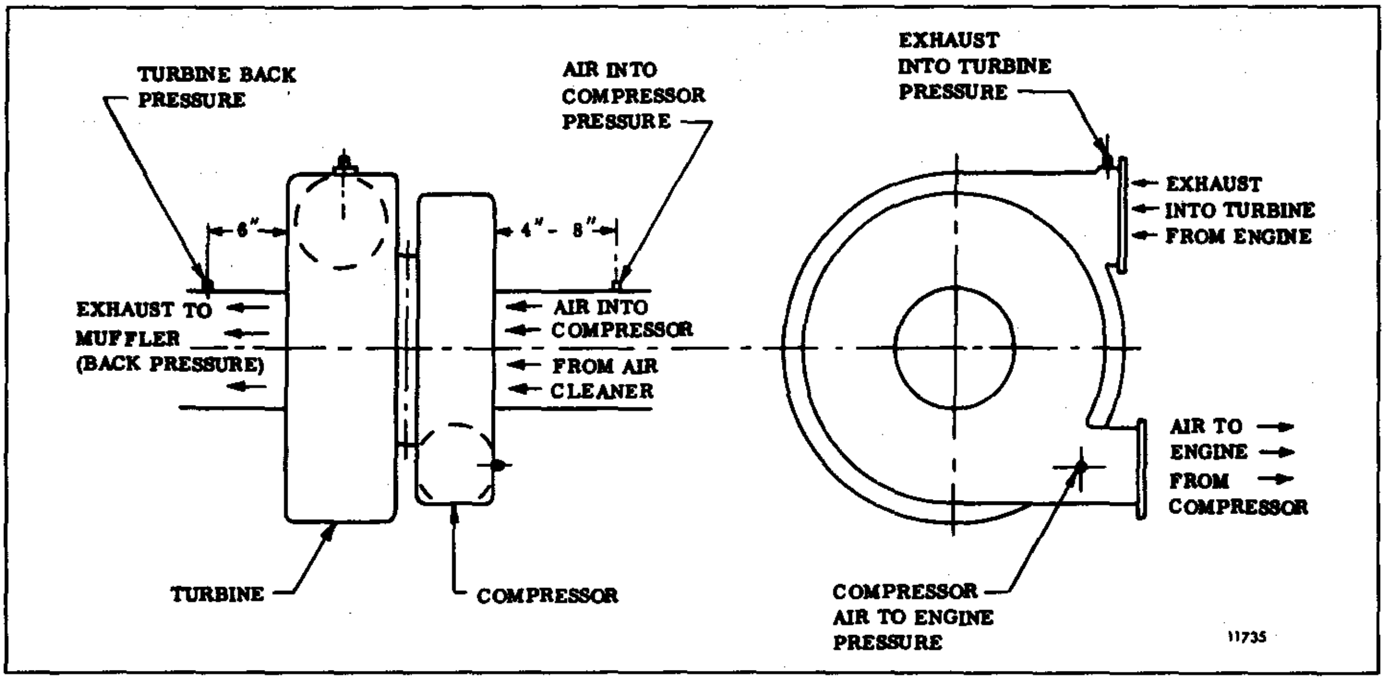


Fig. 1 – Points to Measure Intake and Exhaust Restriction

ENGINE RUN–IN INSTRUCTIONS

Following a complete overhaul or any major repair job involving the installation of piston rings, pistons, cylinder liners or bearings, the engine should be "Run–In" on a dynamometer prior to release for service.

The dynamometer is a device for applying specific loads to an engine. It permits the technician to physically and visually inspect and check the engine while it is operating. It is an excellent method of detecting improper tune–up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.

The operating temperature within the engine affects the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature (see Section 13.2) should be maintained throughout the Run–In.

The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10°F (6°C) higher than the water inlet temperature. Though a 10°F (6°C) rise across an engine is recommended, it has been found that a 15°F (8°C) temperature rise maximum can be permitted.

Thermostats are used in the engine to control the coolant flow. Therefore, be sure they are in place and fully operative or the engine will overheat during the Run–In. However, if the dynamometer has a water standpipe with a temperature control regulator, such as a Taylor valve or equivalent, the engine should be tested without thermostats.

> **NOTICE:** Because of the wet cylinder liners in the Series 53 engine, the engine should be run–in on a closed (heat exchanger type) cooling system where the coolant can be treated with a rust inhibitor (refer to Section 13.3). Use of a good rust inhibitor in the coolant system during engine Run–In will prevent the rusting of the outside diameter of cylinder liners.

The Run–In Schedule is shown on page 2. The horsepower shown is at SAE conditions: dry air density .0705 lb/cu. ft. (1.129 Kg/cu m.), air temperature of 85°F (29°C) and 500 ft. elevation.

DYNAMOMETER TEST AND RUN–IN PROCEDURES

The Basic Engine

The great number of engine applications make any attempt to establish comparisons for each individual model impractical. For this reason, each model has a basic engine rating for comparison purposes.

A basic engine includes only those items actually required to run the engine. The addition of any engine driven accessories will result in a brake horsepower figure less than the values shown in the *Basic Engine Run–In Schedule*. The following items are included on the basic engine: blower, fuel pump, water pump and governor. The fan and battery–charging alternator typify accessories not considered on the basic engine.

In situations where other than basic engine equipment is used during the test, proper record of this fact should be made on the *Engine Test Report*. The effects of this additional equipment on engine performance should then be considered when evaluating test results.

Dynamometer

The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger and a torque loading and measuring device.

The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit. The amount of power absorbed in a water brake type dynamometer, as an example, is governed by the volume of fluid within the working system. The fluid offers resistance to a rotating motion. By controlling the volume of water in the absorption unit, the load may be increased or decreased as required.

The power absorbed is generally measured in torque (lb–ft or N·m) on a suitable scale. This value for a given engine speed will show the brake horsepower developed in the engine by the following formula:

$$BHP = (T \times RPM)/5250$$

Where:

BHP = brake horsepower

T = torque in lb–ft

RPM = revolutions per minute

Some dynamometers indicate direct brake horsepower readings. Therefore, the use of the formula is not required when using these units.

During the actual operation, all data taken should be recorded immediately on an *Engine Test Report* (see sample on page 3).

BASIC ENGINE RUN–IN SCHEDULE

Time Minutes	Speed RPM	Injector Size	ENGINE BRAKE HORSEPOWER									
			4-Valve Cylinder Head							2-Valve Cyl. Head		
			3-53		4-53		6V-53		8V-53	2-53	3-53	4-53
			NA	**T	NA	**T	NA	**T	NA	NA	NA	NA
10	600	All	0	0	0	0	0	0	0	0	0	0
♦30	2800	All		0		0		0				
10	1500	All	15	15	20	20	30	30	40	10	15	20
10	Rated Speed	5A50						112				
		5A55		58		78		117				
		5A60		63		84						
		N-65		65		87						
		5N65*						138				
10	Rated Speed	5A50						225				
		5A55		117		156		234				
		5A60		126		168						
		N-65		131		175						
		5N65*						275				
120	2000	All								40		
30	2200	All	64		87		130		175			
120	2200	All									62	93
30	2800	All	85		115		171		228			
Power Check	Rated Speed	All	Final BHP to be within ±5% of rated									

♦ Turbocharged engines *must* be operated within this RPM range for a full 30 minutes.
*5N65 rating for 6V-53T Marine engine only.
After run-in, *do not* run continuous full load during first 10 hours or 500 miles.
"O" BHP indicates running at no-load for specified time and speed.
**Prior to starting the engine, remove the turbocharger oil supply line at the turbocharger and add CLEAN engine oil to the turbocharger oil inlet to ensure pre-lubrication of the unit. Reconnect the oil line and idle the engine for at least one minute after starting and before increasing the engine speed.

Instrumentation

Certain instrumentation is necessary so that data required to complete the *Engine Test Report* may be obtained. The following list contains both the minimum amount of instruments and the proper location of the fittings on the engine so that the readings represent a true evaluation of engine conditions.

a. Oil pressure gage installed in one of the engine main oil galleries.

b. Oil temperature gage installed in the oil pan, or thermometer installed in the dipstick hole in the oil pan.

c. Adaptor for connecting a pressure gage or mercury manometer to the engine air box.

d. Water temperature gage installed in the thermostat housing or water outlet manifold.

e. Adaptor for connecting a pressure gage or water manometer to the crankcase.

f. Adaptor for connecting a pressure gage or mercury manometer to the exhaust manifold at the flange.

g. Adaptor for connecting a vacuum gage or water manometer to the blower inlet.

h. Adaptor for connecting a fuel pressure gage to the fuel manifold inlet passage.

i. Adaptor for connecting a pressure gage or mercury manometer to the turbocharger.

In some cases, gages reading in pounds per square inch are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is extremely important that the scale of such a gage be of low range and finely divided if accuracy is desired. This is especially true of a gage reading in psi, the reading of which is to be converted to inches of water. The following conversion factors may be helpful.

Inches of water = psi x 27.7"
Inches of mercury = psi x 2.04"
Inches of water = kPa x 4.02"
Inches of mercury = kPa x 0.30"

NOTICE: Before starting the Run–In or starting the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on *Preparation for Starting Engine First Time* in Section 13.1.

ENGINE TEST REPORT

Date ____________________ Unit Number ____________________

Repair Order Number ____________________ Model Number ____________________

A PRE-STARTING

1. PRIME LUBE OIL SYSTEM	2. PRIME FUEL SYSTEM	3. ADJUST VALVES	4. TIME INJ.	5. ADJ. GOV.	6. ADJUST INJ. RACKS

B BASIC ENGINE RUN-IN

TIME AT SPEED	TIME		RPM	BHP	WATER TEMP.	LUBE OIL PRESS.
	START	STOP				

C BASIC RUN-IN INSPECTION

1. Check oil at rocker arm mechanism	
2. Inspect for lube oil leaks	
3. Inspect for fuel oil leaks	
4. Inspect for water leaks	
5. Check and tighten all external bolts	
6.	

D INSPECTION AFTER BASIC RUN-IN

1. Tighten Rocker Shaft Bolts		4. Adjust Governor Gap	
2. Adjust Valves (Hot)		5. Adjust Injector Racks	
3. Time Injectors		6.	

E FINAL RUN-IN

TIME		TOP RPM		BHP	AIR BOX PRESSURE FULL LOAD	EXHAUST BACK PRESSURE F/L	CRANKCASE PRESSURE F/L
START	STOP	NO LOAD	FULL LOAD				

BLOWER INTAKE RES. - F/L	FUEL OIL PRESSURE RET. MAN. F/L	WATER TEMP. FULL LOAD	LUBE OIL TEMP. F/L	LUBE OIL PRESSURE		IDLE SPEED
				FULL LOAD	IDLE	

F INSPECTION AFTER FINAL RUN

1. Inspect Air Box, Pistons, Liners, Rings	6. Tighten Oil Pump Bolts
2. Inspect Blower	7. Inspect Oil Pump Drive
3. Check Generator Charging Plate	8. Replace Lube Filter Elements
4. Wash Oil Pan, Check Gasket	9. Tighten Flywheel Bolts
5. Clean Oil Pump Screen	10. Rust Proof Cooling System

REMARKS:

Final Run OK'd ____________ Dynamometer Operator ____________ Date ____________

NOTE: Operator must initial each check and sign this report.

• Block Oil Filter Bypass Before Initial Start-Up and Dynamometer Test of Rebuilt Engines

Cold engine start-up causes the lubricating oil filter bypass valve to open until oil temperature increases. When an engine is rebuilt and then dynamometer tested, this bypass condition may result in the circulation of abrasive (harmful) debris introduced into the engine during rebuild.

To prevent unnecessary circulation of debris through the lube oil system, DDC recommends plugging the filter bypass before start-up and during basic engine run-in. This allows all the lube oil to flow through the filter(s), trapping contaminants. To plug the bypass, proceed as follows:

If the valve is secured by a retainer and screw, remove the spring and install a spacer of the appropriate length under the retainer (Fig. 1). The spacer must be long enough to contact the valve and keep it from moving during the dynamometer test. When the test is completed, remove the spacer and reinstall the spring. Then change the filter(s).

If the valve is secured by a plug, drill and tap a 1/4" - 20 hole in a filter bypass valve plug. Install a bolt long enough to contact the valve and keep it from opening and a nut to lock the bolt in position (Fig. 2). When the dynamometer test is completed, replace the modified plug with a standard plug and change the filter(s).

NOTICE: To avoid damaging the phenolic bypass valve, the bolt should be finger-tightened only and then secured in place with the lock nut. On filter adaptors with more than one bypass valve, install modified valve plugs in all valve openings before starting or dynamometer testing the engine.

DDC recommends bringing lube oil temperature up to at least 60°F (15.6°C) before starting the engine prior to testing. If the lube oil is too cold when the engine is started, the resistance to flow of the heavier oil may cause filter gasket leakage or bearing surface damage from inadequate oil film.

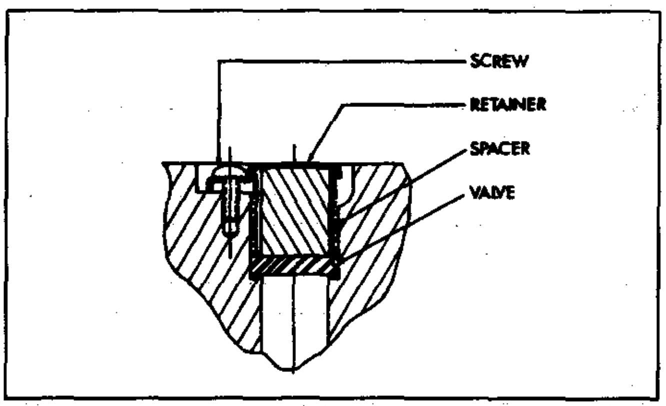


Fig. 1 - Bypass Valve with Spacer Installed

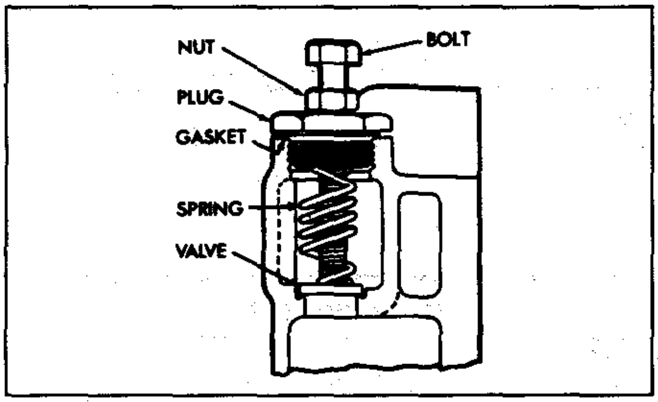


Fig. 2 - Bypass Valve with Modified Valve Plug Installed

Run-In Procedure

The procedure outlined below will follow the order of the sample *Engine Test Report.*

A. PRE-STARTING

1. Fill the lubrication system as outlined under *Lubrication System — Preparation for Starting Engine First Time* in Section 13.1.

2. Prime the fuel system as outlined under *Fuel System* — Preparation for Starting Engine First Time in Section 13.1.

3. preliminary valve clearance adjustment must be made before the engine is started. See *Valve Clearance Adjustment* in Section 14.1.

4. A preliminary injector timing check must be made before starting the engine. See *Fuel Injector Timing* in Section 14.2.

5. Preliminary governor adjustments must be made as outlined in Section 14.

6. Preliminary injector rack adjustment must be made (Section 14).

NOTICE: Prior to starting a turbocharged engine, remove the oil supply line at each turbocharger and add clean engine oil to the oil inlet to ensure pre-lubrication of the turbochargers. Reconnect the oil lines and idle the engine for at least one minute after starting and before increasing the speed.

B. BASIC ENGINE RUN–IN

The operator should be observant at all times, so that any malfunction which may develop will be detected. Since the engine has just been reconditioned, this Run–In will be a test of the workmanship of the technician who performed the overhaul. Minor difficulties should be detected and corrected so that a major problem will not develop.

After performing the preliminary steps, be sure all water valves, fuel valves, etc. are open. Also, inspect the exhaust system, air cleaner and air inlet piping to insure that it is properly connected to the engine. Always start the engine with minimum dynamometer resistance.

After the engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb–ft (7 N·m) on the torque gage (or 10–15 HP on a horsepower gage). This is necessary, on some units, to lubricate the absorption unit seals and to protect them from damage.

Set the engine throttle at idle speed, check the lubricating oil pressure and check all connections to be sure there are no leaks.

Refer to the *Engine Test Report* sample which establishes the sequence of events for the Test and Run–In, and to the *Basic Engine Run–In Schedule* which indicates the speed (rpm), length of time and the brake horsepower required for each phase of the test. Also, refer to the *Operating Conditions* in Section 13.2 which presents the engine operating characteristics. These characteristics will be a guide for tracing faulty operation or lack of power.

Engine governors in most cases must be reset at the maximum full–load speed designated for the Run–In. If a governor is encountered which cannot be adjusted to this speed, a stock governor should be installed for the Run–In.

After checking the engine performance at idle speed and being certain the engine and dynamometer are operating properly, increase the engine speed to half speed and apply the load indicated on the *Basic Engine Run–In Schedule.*

The engine should be run at this speed and load for 10 minutes to allow sufficient time for the coolant temperature to reach the normal operating range. Record length of time, speed, brake horsepower, coolant temperature and lubricating oil pressure on the *Engine Test Report.*

Run the engine at each speed and rating for the length of time indicated in the *Basic Engine Run–In Schedule.* This is the Basic Run–In. During this time, engine performance will improve as new parts begin to "seat in". Record all of the required data.

C. BASIC RUN–IN INSPECTION

While the engine is undergoing the Basic Run–In, check each item indicated in Section "C" of the *Engine Test Report.* Check for fuel oil or water leaks in the rocker arm compartment.

During the final portion of the Basic Run–In, the engine should be inspected for fuel oil, lubricating oil and water leaks.

Upon completion of the Basic Run–In and Inspection, remove the load from the dynamometer and reduce the engine speed gradually to idle and then stop the engine.

D. INSPECTION AFTER BASIC RUN–IN

The primary purpose of this inspection is to provide a fine engine tune–up. First, tighten the cylinder head and rocker arm shaft bolts to the proper torque. Next, complete the applicable tune–up procedure. Refer to Section 14.

E. FINAL RUN–IN

After all of the tests have been made and the *Engine Test Report* is completed through Section "D", the engine is ready for final test. This portion of the Test and Run–In procedure will assure the engine owner that his engine has been rebuilt to deliver factory rated performance at the same maximum speed and load which will be experienced in the installation.

If the engine has been shut down for one hour or longer, it will be necessary to have a warm–up period of 10 minutes at the same speed and load used for warm–up in the Basic Run–In. If piston rings, cylinder liners or bearings have been replaced as a result of findings in the Basic Run–In, the entire Basic Run–In must be repeated as though the Run–In and Test procedure were started anew.

All readings observed during the Final Run–In should fall within the range specified in the *Operating Conditions* in Section 13.2 and should be taken at full load unless otherwise specified. Following is a brief discussion of each condition to be observed.

The engine *water temperature* should be taken during the last portion of the Basic Run–In at full load. It should be recorded and should be within the specified range.

The *lubricating oil temperature* reading must be taken while the engine is operating at full load and after it has been operating long enough for the temperature to stabilize. This temperature should be recorded and should be within the specified range.

The *lubricating oil pressure* should be recorded in psi after being taken at engine speeds indicated in the *Operating Conditions,* Section 13.2.

The *fuel oil pressure* at the fuel manifold inlet passage should be recorded and should fall within the specified range. Fuel pressure should be recorded at maximum engine speed during the Final Run–In.

Check the *air box pressure* while the engine is operating at maximum speed and load. This check may be made by attaching a suitable gage (0–15 psi) or manometer (15–0–15) to an air box drain or to a hand hole plate prepared for this purpose. If an air box drain is used as a source for this check, it must be clean. The air box pressure should be recorded in inches of mercury.

Check the *crankcase pressure* while the engine is operating at maximum Run–In speed. Attach a manometer, calibrated to read in inches of water, to the oil level dipstick opening. Normally, crankcase pressure should decrease during the Run–In indicating that new rings are beginning to "seat–in".

Check the *air inlet restriction* with a water manometer connected to a fitting in the air inlet ducting located 2" above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to a fitting installed in the 1/4" pipe tapped hole in the engine air inlet housing on naturally aspirated engines. If a hole is not provided, a stock housing should be drilled, tapped and kept on hand for future use.

The restriction at this point should be checked at a specific full–load engine speed. Then the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading. On turbocharged engines, take the reading on the inlet side of one of the turbochargers (see Chart at the end of Section 13.2). The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

Check the normal *air intake vacuum* at various speeds (at no–load) and compare the results with the *Engine Operating Conditions* in Section 13.2. Record these readings on the *Engine Test Report.*

Check the *exhaust back pressure* (except turbocharged engines) at the exhaust manifold companion flange or within one inch of this location. This check should be made with a mercury manometer through a tube adaptor installed at the tapped hole. If the exhaust manifold does not provide a 1/8" pipe tapped hole, such a hole can be incorporated by reworking the exhaust manifold. Install a fitting for a pressure gage or manometer in this hole. Care should be exercised so that the fitting does not protrude into the stack. On turbocharged engines, check the exhaust back pressure in the exhaust piping 6" to 12" from the turbine outlet. The tapped hole must be in a comparatively straight area for an accurate measurement. The manometer check should produce a reading in inches that is below the *Maximum Exhaust Back Pressure* for the engine (refer to Section 13.2).

Turbocharger compressor outlet pressure and turbine inlet pressures are taken at full–load and no–load speeds.

Refer to the *Final Engine Run–In Schedule* and determine the maximum rated brake horsepower and the full–load speed to be used during the Final Run–In. Apply the load thus determined to the dynamometer. If a hydraulic governor is used, the droop may be adjusted at this time by following the prescribed procedure. The engine should be run at this speed and load for 1/2 hour. While making the Final Run–In, the engine should develop, within 5%, the maximum rated brake horsepower indicated for the speed at which it is operating. If this brake horsepower is not developed, the cause should be determined and corrections made.

When the above conditions have been met, adjust the maximum no–load speed to conform with that specified for the particular engine. This speed may be either higher or lower than the maximum speed used during the Basic Run–In. This will ordinarily require a governor adjustment.

All information required in Section "E", Final Run–In, of the *Engine Test Report* should be determined and filled in. After the prescribed time for the Final Run–In has elapsed, remove the load from the dynamometer and reduce the engine speed gradually to idle speed and then stop the engine. The Final Run–In is complete.

F. INSPECTION AFTER FINAL RUN–IN

After the Final Run–In and before the *Engine Test Report* is completed, a final inspection must be made. This inspection will provide final assurance that the engine is in proper working order. During this inspection, the engine is also made ready for any brief delay in delivery or installation which may occur. This is accomplished by rustproofing the fuel system as outlined in Section 15.3 and adding a rust inhibitor into the cooling system (refer to Section 13.3). The lubricating oil filters should also be changed.

> **NOTICE:** A rust inhibitor in the coolant system of a Series 53 engine is particularly important because of the wet cylinder liners. Omission of a rust inhibitor will cause rusting of the outside diameter of the cylinder liners and interference with liner heat transfer.

LUBRICATING OIL, FUEL OIL AND FILTER RECOMMENDATIONS

Selection of the proper quality of fuel and lubricating oil is important to achieve the long and trouble-free service for which Detroit Diesel engines are designed. Conversely, operation with improper fuels and lubricants can cause problems. The manufacturer's warranty applicable to Detroit Diesel engines provides, in part, that warranty shall not apply to any engine which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow manufacturer's fuel or lubricating recommendations may not be covered by the warranty.

A requirement of Detroit Diesel Corporation's extended warranty program (Power Protection Plan) is that the customer use the lubricants, fuels and filters recommended in this publication.

It is Detroit Diesel's policy to build engines which will operate satisfactorily with fuels and lubricants available in the commercial market. However, not all fuels and lubricants are adequate. Product selection should be made based on these recommendations and in consultation with a reliable supplier who understands the equipment and its application.

LUBRICATING OIL

Engine service life depends upon selecting the proper lubricating oil and maintaining proper oil drain and filter change intervals.

LUBRICANT SELECTION

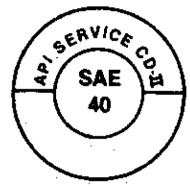
There are hundreds of commercial oils marketed today, but labeling terminology differs among suppliers and can be confusing. Some marketers may claim that their lubricant is suitable for all makes of diesel engines and may list engine makes and types, including Detroit Diesel, on their containers. Such claims by themselves are insufficient as a method of lubricant selection for Detroit Diesel engines.

The proper lubricating oil for all Detroit Diesel engines is selected based on SAE Viscosity Grade and API (American Petroleum Institute) Service Designation. Both of these properties are displayed on oil containers in the API symbol. In addition, military specifications may be used for selecting engine lubricants. Mil-L-2104D represents the most current military specification for diesel lubricants and the only one recommended for Detroit Diesel engines. For two-cycle Detroit Diesel engines, the proper lubricant must also possess a sulfated ash content below 1.0% mass. Refer to the following specific recommendations.

TWO-CYCLE ENGINES
Detroit Diesel Series 53, 71, 92, 149

LUBRICANT RECOMMENDATION

API Symbol:



SAE Viscosity Grade: 40
API Classification: CD-II
Military Spec.: Mil-L-2104D
Sulfated Ash: less than 1.0%

This is the only engine oil recommended for Detroit Diesel two-cycle engines. Lubricants meeting these criteria have provided maximum engine life when used in conjunction with recommended oil drain and filter maintenance schedules.

A more detailed description of each of these selection criteria may be found in a further section of this publication. Certain engine operating conditions may require exceptions to this recommendation. They are as follows:

1. For continuous high temperature operation (over 100°F ambient or 200°F Coolant Out) the use of an SAE grade 50 lubricant in all series two-cycle DDC engines is recommended.

2. At ambient temperatures below freezing where starting aids are not available or at very cold temperatures (0 to -25°F), the use of multiviscosity grade 15W-40 or monograde SAE 30 lubricants will improve startability. **Exception: Do not use these lubricants in two-cycle marine engines or DDC series 149 engines under any circumstances.**

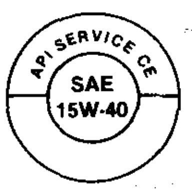
3. The API category CD-II is relatively new and may not be fully in use at the time of this publication. API category CD may be used provided the recommended military specification is satisfied. Oils with API designation CE are not recommended in DDC two-cycle engines unless accompanied by CD-II.

4. When the use of high sulfur fuel is unavoidable, lubricants with a Total Base Number exceeding 10 are recommended. Such a lubricant may have a Sulfated Ash content above 1.0% mass. High sulfur fuels require modification to oil drain intervals. For further information refer to that section of this publication.

FOUR-CYCLE ENGINES
Detroit Diesel Series 60 and 8.2L

LUBRICANT RECOMMENDATION

API Symbol:



SAE Viscosity Grade: 15W-40
API Classification: CE
Military Spec.: Mil-L-2104D

This is the only engine oil recommended for Detroit Diesel Series 60 and 8.2L engines. Lubricants meeting these criteria have provided maximum engine life when used in conjunction with recommended oil drain and filter maintenance schedules.

When the use of high sulfur fuel is unavoidable, lubricants with a TBN exceeding 10 are recommended. High sulfur fuels require modification to oil drain intervals. For further information refer to that section of this publication.

LUBRICATING OIL SELECTION CRITERIA

SAE VISCOSITY GRADE

Viscosity is a measure of an oil's ability to flow at various temperatures. The SAE Viscosity Grade system is defined in SAE Standard J300 which designates a viscosity range with a grade number. Lubricants with two grade numbers separated by a "W" are classified as multigrade, while those with a single number are monograde. The higher the number the higher the viscosity.

API SERVICE CLASSIFICATION

The American Petroleum Institute has established a means of classifying lubricant performance suitable for different types of engines and types of service. The higher performance or quality API classifications for diesel engines include CD, CE (for four-cycle diesel engines) and CD-II (for two-cycle diesel engines). Detroit Diesel does not recommend the use of the older and lower performance classifications such as CC, CB and CA.

Multiple API Service Classifications such as "API SERVICE CD, CE" or "API SERVICE CE/CD-II" are frequently listed. Additional classifications not listed here may also be included. It is important that the DDC recommended classification be among those listed.

API SYMBOL

Lubricant marketers have adopted a uniform method of displaying the SAE viscosity grade and API service classification information on product containers and in product literature. The three segment "donut" contains the SAE grade number in the center, and the API service in the top segment. The lower segment is used to designate energy conserving status for gasoline engine use and has no significance for diesel engine use.

MILITARY SPECIFICATION

U.S. Military specifications are another means of classifying the performance of lubricants. As with the API system, lubricants must meet performance criteria before approval is given. The essential difference, however, is that lubricants meeting military specifications, particularly those possessing Qualified Products Listing (QPL) Numbers, have been reviewed by a committee consisting of engine manufacturers, including Detroit Diesel.

Military Specification Mil-L-2104D represents the current specification for heavy-duty diesel engines and the only one recommended by Detroit Diesel Corporation.

SULFATED ASH AND TOTAL BASE NUMBER

This is a lubricant property obtained by a laboratory test (ASTM D874) to determine potential for the formation of metallic ash. The ash residue is related to the oil's additive composition and is significant in predicting lubricants which may cause valve distress under certain operating conditions. Sulfated ash is related to Total Base Number (TBN), also a laboratory test (ASTM D2896) which measures an oil's ability to neutralize acids. As TBN increases, sulfated ash also increases to where lubricants with TBNs above 10 will likely have sulfated ash contents above 1.0% mass.

Total Base Number is important to deposit control in four-cycle diesel engines and to neutralize the effects of high sulfur fuel in all diesel engines. In general, Detroit Diesel recommends lubricants with sulfated ash contents below 1.0% mass and TBNs between 7 and 10 for all Series engines operating on low sulfur fuel.

UNIVERSAL OILS

Universal oils are designed for use in both gasoline and diesel engines and provide an operational convenience in mixed fuel engine fleets. These products are identified with combination API category designations such as SF/CD or SG/CE. Although such products can be used in Detroit Diesel engines (provided they satisfy all DDC requirements), their use is not as desirable as lubricants formulated specifically for diesel engines, and bearing only the API CD-II or CE designations.

SYNTHETIC OILS

Synthetic oils may be used in Detroit Diesel engines provided they meet the viscosity, performance classification and chemical recommendations listed for non–synthetic lubricants. Product information about synthetic oils should be reviewed carefully since these lubricants are often claimed to be of monograde viscosity. Their use does not permit extension of recommended oil drain intervals.

MARINE LUBRICANTS, RAILROAD DIESEL LUBRICANTS

The petroleum industry markets specialty lubricants for use in diesel engines designed specifically for marine propulsion or railroad locomotive use. These lubricants take into consideration the unique environments and operational characteristics of this type of duty, and consequently, they are formulated quite differently from the types of lubricants recommended by Detroit Diesel. Although in some cases they may be suitable in Detroit Diesel engines, they should not be used without specific consultation with your Detroit Diesel distributor or regional office and the lubricant supplier.

USE OF SUPPLEMENTAL ADDITIVES

Lubricants meeting the Detroit Diesel recommendations outlined in this publication already contain a balanced additive treatment. The use of supplemental additives, such as break–in oils, top oils, graphitizers, and friction–reducing compounds, is generally unnecessary and can even be harmful. Never use a lubricant supplement to "fix" a mechanical problem, and be cautious of products purporting to prevent one. The best approach is to follow DDC's lubricant recommendations.

EVIDENCE OF SATISFACTORY LUBRICANT PERFORMANCE

These recommendations are intended to provide a guideline for lubricating oil selection based on favorable service history in typical applications of Detroit Diesel engines. Specific situations may warrant consideration of a lubricant that does not fit these guidelines. Such a lubricant may perform satisfactorily in certain circumstances, and be inappropriate for others.

For such products, evidence of satisfactory performance should be obtained from the oil supplier on the specific lube oil blend being considered and compared with the performance of a DDC recommended lubricant as reference. Comparative performance evidence would include stationary engine tests and field testing in a similar application and severity.

The type of field test used by the oil supplier depends on the series engine in which the candidate oil will be used and the service application. The candidate test oil engines should all operate for the mileage/hours indicated in the table below. Any serious mechanical problems should be recorded. At the conclusion of the test, the engines should be disassembled and quantitatively compared with reference oil engines for:

- Ring conditions (broken, stuck and wear)
- Cylinder liner and piston skirt scuffing
- Exhaust valve face and seat deposits and distress
- Piston pin and slipper bushing wear
- Piston ring land deposits
- Overall valve train and bearing wear

Several stationary engine tests have been designed by and utilized by Detroit Diesel for evaluation of lubricants. These tests include:

100 Hour Series 92 Accelerated Engine Test
– evaluates liners, rings and slipper bushings

Series 71 Valve Guttering Test
– evaluates effects of high ash on valve distress

100 Hour Series 60 Truck Cycle Test
– evaluates deposit and ring sticking

240 Hour 6V53T Endurance Test (FTM 355)
– evaluates liner and ring wear (used for CD–II)

LUBRICATING OIL FIELD TESTING GUIDELINES

ENGINE SERIES	SERVICE APPLICATION	TEST DURATION	NO. ENGINES ON CANDIDATE TEST OIL	NO. ENGINES ON REFERENCE BASELINE OIL
53	Pickup & Delivery	50,000 Miles	5	5
60, 71, 92	Highway Truck, GVW 78,000 lbs	200,000 Miles	5	5
149	Off–Road 120 Ton Rear Dump	10,000 Hours	3	3

Although stationary engine testing provides important lubricant performance evaluation, it should be considered secondary to a properly conducted field test evaluation.

Upon completion of the field and stationary testing of products which meet or exceed the performance of lubricants recommended in this publication, Detroit Diesel will issue a written approval for their use in the application field tested. Such approval will be limited to the specific formulation (identical basestock and additive treatment) in which the testing was conducted.

OIL CHANGE INTERVALS

During use, engine lubricating oil undergoes deterioration from combustion by-products and contamination. For this reason, regular oil drain intervals are necessary. These intervals however, may vary in length depending upon engine operation, fuel quality, and lubricant quality. The oil drain interval may be established on recommendations of a Detroit Diesel Oil Analysis Program until the most practical oil change interval has been determined. Under no circumstances, however, should the drain intervals in the chart be exceeded. Refer to the "Used Lubricating Oil Analysis" section of this publication for more information. All engine oil filters should be changed when the lube oil is changed.

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS (Normal Operation)

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL
Highway Truck	60, 71 & 92	20,000 Miles (32,000 kM)
City Transit Coaches	53, 71 & 92	6,000 Miles (9,600 kM)
Pick-up & Delivery, Stop & Go, Short Trip	53, 71, 92 8.2L	12,000 Miles (19,000 kM) 6,000 Miles (9,600 kM)
Industrial, Agricultural and Marine	149NA 149T	500 Hrs. or 1 Yr. 300 Hrs. or 1 Yr.
	53, 60, 71, 92 & 8.2L	150 Hrs.
Stationary Units Full Time	53, 71, 92 & 149	500 Hrs. or 1 Mo.
Standby	53, 71, 92, 149 & 8.2L	150 Hrs. or 1 Yr.

OIL CHANGE INTERVALS WHEN USING HIGH SULFUR FUEL

When the continuous use of high sulfur fuel (greater than 0.5%) is unavoidable, lubricant selection and oil drain interval must be modified. A lubricant with a Total Base Number (TBN per ASTM D 2896) above 10 is recommended. It is likely that such a lubricant will also exhibit a sulfated ash above 1.0%. The proper oil drain interval must be determined by oil analysis when operating on high sulfur fuel. A reduction in TBN (D 2896) to one third of the initial value provides a general drain interval guideline.

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS

FUEL SULFUR 0.5% TO 1.0%
Use a lubricant with TBN (ASTM D 2896) 10 to 30

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL 10–19 TBN	20–30 TBN
Highway Truck	60, 71 & 92	15,000 Mi. (24,000 kM)	20,000 Mi. (32,000 kM)
City Transit Coaches	53, 71 & 92	4,000 Mi. (6,400 kM)	6,000 Mi. (9,600 kM)
Pick-up & Delivery Stop & Go, Short Trip	53, 71 & 92	8,000 Mi. (12,500 kM)	12,000 Mi. (20,000 kM)
	8.2L	4,000 Mi. (6,400 kM)	6,000 Mi. (9,600 kM)
Industrial, Agricultural and Marine	149NA	300 Hrs.	500 Hrs.
	149T	200 Hrs.	300 Hrs. (or 1 Yr. Maximum)
	53, 60, 71, 92 & 8.2L	100 Hrs.	150 Hrs.
Stationary Units Full Time	53, 71, 92 & 149	300 Hrs.	500 Hrs. (or 1 Mo. Maximum)
Standby	53, 71, 92, 149 & 8.2L	100 Hrs.	150 Hrs. (or 1 Yr. Maximum)

MAXIMUM RECOMMENDED OIL DRAIN INTERVALS

FUEL SULFUR ABOVE 1.0%
Use a lubricant with TBN (ASTM D 2896) 10 to 30

SERVICE APPLICATION	ENGINE SERIES	OIL DRAIN INTERVAL 10–19 TBN	20–30 TBN
Highway Truck	60, 71 & 92	7,500 Mi. (12,000 kM)	15,000 Mi. (24,000 kM)
City Transit Coaches	53, 71 & 92	2,000 Mi. (3,000 kM)	4,000 Mi. (6,400 kM)
Pick-up & Delivery Stop & Go, Short Trip	53, 71 & 92	4,000 Mi. (6,500 kM)	8,000 Mi. (12,500 kM)
	8.2L	2,000 Mi. (3,000 kM)	4,000 Mi. (6,400 kM)
Industrial, Agricultural and Marine	149NA	150 Hrs.	300 Hrs.
	149T	100 Hrs.	200 Hrs. (or 6 Mos. Maximum)
	53, 60, 71, 92 & 8.2L	50 Hrs.	100 Hrs.
Stationary Units Full Time	53, 71, 92 & 149	150 Hrs.	300 Hrs.
Standby	53, 71, 92, 149 & 8.2L	50 Hrs.	100 Hrs. (or 6 Mos. Maximum)

USED LUBRICATING OIL ANALYSIS

A used lubricating oil analysis program such as the Detroit Diesel Oil Analysis Program is recommended for the monitoring of crankcase oil in all engines. Since an oil analysis indicates the condition of the engine, not the lubricating oil, it should not be used to extend oil drain intervals. The oil should be changed immediately if any contamination is present in concentrations exceeding the warning limits shown in the table. It should not however, be concluded that the engine is worn out based on *a single* measurement that exceeds the warning level. Imminent engine wearout can only be determined through a *continuous* oil analysis program wherein the change in data or deviation from baseline data can be used to interpret condition of engine parts.

Characteristics relating to lubricating oil dilution should trigger corrective action to identify and fix the source(s).

Confirmation of the need for engine overhaul should be based on operational data (increasing oil consumption and crankcase pressure, for example) and physical inspection of parts.

USED LUBRICATING OIL ANALYSIS WARNING LIMITS

These values indicate the need for an immediate oil change, but do not necessarily indicate internal engine problems requiring engine teardown.

WARNING LIMITS

	ASTM Designation	Two Cycle		Four Cycle
		53, 71, 92	149	60, 8.2
Pentane Insolubles Mass % Max.	D 893	1.0	1.0	1.0
Carbon (Soot) Content, TGA Mass % Max.	E 1131	0.8		1.5
Viscosity at 40°c St % Max. Increase % Max. Decrease	D 445 & D 2161	40.0 15.0	40.0 15.0	40.0 15.0
Total Base Number (TBN) Min. Min.	D 664 D 2986	1.0 2.0	1.0 2.0	1.0 2.0
Water Content (dilution) Vol. % Max.	D 95	0.30	0.30	0.30
Flash Point °C Reduction Max.	D 92	40.0	40.0	40.0
Fuel Dilution Vol. % Max.	*	2.5	1.0	2.5
Glycol Dilution PPM Max.	D 2982	1000	1000	1000
Iron Content PPM Fe Max.	**	150	35	60=150 8.2=250
Copper Content PPM Cu Max.	**	25	25	60=90 8.2=30
Sodium Content PPM Na Over Baseline Max.	**	50	50	50
Boron Content PPM B Over Baseline Max.	**	20	20	20

* No ASTM Designation
** Elemental Analysis are conducted using either emission or atomic absorption spectroscopy. Neither method has an ASTM designation.

FUEL OIL

QUALITY AND SELECTION

The quality of fuel used is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels. DDC engines are designed to operate on most diesel fuels marketed today. In general, fuels meeting the properties of ASTM Designation D 975 (grades 1-D and 2-D) have provided satisfactory performance. The ASTM D 975 specification however does not in itself adequately define the fuel characteristics necessary for assurance of fuel quality. The properties listed in the Fuel Oil Selection Chart have provided optimum engine performance.

FUEL OIL SELECTION CHART

General Fuel Classification	ASTM Test	No. 1 ASTM 1-D	No. 2* ASTM 2-D
Gravity, °API #	D 287	40–44	33–37
Flash Point Min. °F (°C)	D 93	100 (38)	125 (52)
Viscosity, Kinematic cST @ 100°F (40°C)	D 445	1.3–2.4	1.9–4.1
Cloud Point °F #	D 2500	See Note 1	See Note 1
Sulfur Content wt%, Max.	D 129	0.5	0.5
Carbon Residue on 10%, wt%, Max.	D 524	0.15	0.35
Accelerated Stability Total Insolubles mg/100 ml, Max. #	D 2274	1.5	1.5
Ash, wt%, Max.	D 482	0.01	0.01
Cetane Number, Min. +	D 613	45	45
Distillation Temperature, °F (°C)	D 86		
IBP, Typical #		350 (177)	375 (191)
10% Typical #		385 (196)	430 (221)
50% Typical #		425 (218)	510 (256)
90% +		500 (260) Max.	625 (329) Max.
End Point #		550 (288) Max.	675 (357) Max.
Water & Sediment %, Max.	D 1796	0.05	0.05

\# Not specified in ASTM D 975
\+ Differs from ASTM D 975
* No. 1 diesel fuel is recommended for use in city coach engine models. No. 2 diesel fuel may be used in city coach engine models which have been certified to pass Federal and California emission standards.

Note 1: The cloud point should be 10°F (6°C) below the lowest expected fuel temperature to prevent clogging of fuel filters by wax crystals.

Note 2: When prolonged idling periods or cold weather conditions below 32°F (0°C) are encountered, the use of 1-D fuel is recommended. Number 1-D fuels should also be considered when operating continuously at altitudes above 5000 ft.

FUEL OIL SELECTION CRITERIA

DISTILLATION

The boiling range is a very important property in consideration of diesel fuel quality. The determination of boiling range is made using ASTM Test Method D 86. Many specifications contain a partial listing of the distillation results, ie., Distillation Temperature At 90% Recovered. Many diesel fuels are blended products which may contain constituents with boiling ranges much different than the majority of the fuel composition. The full boiling range as shown in the Fuel Oil Selection Chart should be used for proper selection.

FINAL BOILING POINT

Fuel can be burned in an engine only after it has been vaporized. The temperature at which fuel is completely vaporized is described as the End point Temperature in ASTM D 86 Distillation Test Method. This temperature must be low enough to permit complete vaporization at combustion chamber temperatures. The combustion chamber temperature depends on ambient temperature, engine speed and load. Poor vaporization is more apt to occur during severe cold weather, prolonged idling, and/or light load operation. Therefore engines operating under these conditions should utilize fuels with lower distillation end point temperatures.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material. That is, the fuel should exhibit no less than 98% recovery when subjected to the ASTM D 86 Distillation Test Method.

CETANE NUMBER

Cetane Number is mistakenly used to indicate fuel quality. However, Cetane Number is most useful in predicting engine startup. A high Cetane Number should not be considered alone when evaluating fuel quality. Other properties such as end point distillation temperature and carbon residue should also be considered. Calculated Cetane Index is sometimes reported instead of Cetane Number. Cetane Index is an empirical property determined through the use of a mathematical equation whereas Cetane Number is determined through an engine test.

FUEL STABILITY

Diesel Fuel oxidizes in the presence of air and water, particularly if the fuel contains cracked products which are relatively unstable. The oxidation of fuel can result in the formation of undesirable gums and sediment. Such undesirable products can cause filter plugging, combustion chamber deposit formation and gumming or lacquering of injection system components with resultant sticking or wear.

ASTM Test Method D 2274 measures diesel fuel oxidative stability. Although the results of the test may vary with actual field storage, it does measure characteristics which will effect fuel storage stability for periods up to 12 months.

FUEL SULFUR CONTENT

The sulfur content of the fuel should be as low as possible to avoid premature wear and excessive deposit formation. Fuel containing no more than 0.5% sulfur are recommended. If the use of fuels with sulfur contents above 0.5% are unavoidable, lube oil drain intervals and lubricant selection need to be changed. Detroit Diesel recommends that the Total Base Number (TBN D 2896) of the lubricant be monitored and the oil drain interval be reduced.

FUEL OPERATING TEMPERATURE AND VISCOSITY

Since Diesel Fuel provides cooling of the injection system, the temperature of the fuel may vary considerably due to the ambient temperature, engine operating temperature, and the amount of fuel remaining in the tank. As fuel temperature increases, the fuel viscosity and therfore the lubrication capabilities of the fuel diminish. Maintaining proper fuel temperatures in combination with selection of fuels with the viscosity ranges shown in the Fuel Oil Selection Chart will assure proper injection system functioning.

DIESEL FUEL STORAGE

Fuel oil should be clean and free of contamination. Storage tanks and stored fuel should be inspected regularly for dirt, water, and sludge; and cleaned if contaminated. Diesel fuel tanks can be made of aluminum, monel stainless steel, black iron, welded steel or reinforced (non-reactive) plastic.

> **NOTICE:** Galvanized steel or sheet metal tanks and galvanized pipes or fittings should never be used in any diesel fuel storage, delivery or fuel system. The fuel oil will react chemically with the zinc coating, forming a compound which can clog the filters and can cause engine damage.

FUEL ADDITIVES

Detroit Diesel engines operate satisfactorily on a wide range of diesel fuels without the addition of supplemental additives. Such additives increase operating costs without providing benefit.

Fuel additives specifically NOT recommended include:

- Used Lubricating Oil
- Gasoline

Detroit Diesel does NOT recommend the use of drained lubricating oil or gasoline in diesel fuel. Furthermore Detroit Diesel Corporation will not be responsible for any detrimental effects which it determines resulted form this practice.

Some fuel additives provide temporary benefits but do not replace good fuel handling practices. Such additives are helpful when water contamination is suspected:

- Isopropyl Alcohol—1 pint per 125 gallons of fuel for winter freeze up protection.
- Biocide—For treatment of microbe growth or black "slime". Follow manufacturers' instructions for treatment.

Other fuel additives are of questionable benefit. These include a variety of independently marketed products which claim to be:

- Cetane Improvers
- Combustion Improvers
- Cold Weather Flow Improvers

These products should be accompanied with performance data supporting their merit. It is not the policy of Detroit Diesel Corporation to approve or endorse such products.

FILTER RECOMMENDATIONS

Filters make up an integral part of fuel and lubricating oil systems. Proper filter selection and maintenence are important to satisfactory engine operation and service life. Filters should be utilized for maintaining a clean system, not for cleaning up a contaminated system.

FUEL FILTER RECOMMENDATION
Regular Service

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Primary	30	—	AC Spark Plug Div. GM	T552 T553 T541 T632 T915 T936 T958
Secondary	12	—	AC Spark Plug Div. GM	TP509 TP540X TP624 TP916 TP928 TP959

FUEL FILTER RECOMMENDATION
Severe Duty Service

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Primary	—	—	Racor	B32002
Secondary	3	200	Pall Corp.	Head HH7400A12UPRBP Element HC7400SUP-4H
Secondary (Alternate)	5	—	AC Spark Plug	TP916L TP928L TP959L

LUBRICATING OIL FILTER RECOMMENDATION
Series 53

Filter Type	Micron Rating	Beta Ratio	Manufacturer	Filter No.
Full Flow	12	75	AC Spark Plug Div. GM	PF911L P/N 25013192

COOLANT SPECIFICATIONS

COOLANT REQUIREMENTS

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, the heat of combustion is conveyed through the cylinder walls and the cylinder head into the coolant. Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. In general, water containing various materials in solution is used for this purpose.

The water/ethylene glycol/inhibitor coolant mixture used in Detroit Diesel engines must meet the following basic requirements:

- Provide for adequate heat transfer.
- Provide a corrosion–resistant environment within the cooling system.
- Prevent formation of scale or sludge deposits in the cooling system.
- Be compatible with cooling system hose and seal materials.
- Provide adequate freeze and boil–over protection.

WATER

Water, whether of drinking quality or not, can produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, inhibitors *must* be added to control corrosion and scale deposits.

Chlorides, sulfates, magnesium, and calcium are among the materials which make up dissolved solids and may cause scale deposits, sludge deposits, corrosion, or a combination of these. Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) causes deposits of scale. Water within the limits specified in Table A–1 is satisfactory as an engine coolant when properly inhibited. The procedure for evaluating water intended for use in a coolant solution is shown in Table A–2. Use of distilled water is ideal.

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

TABLE A–1

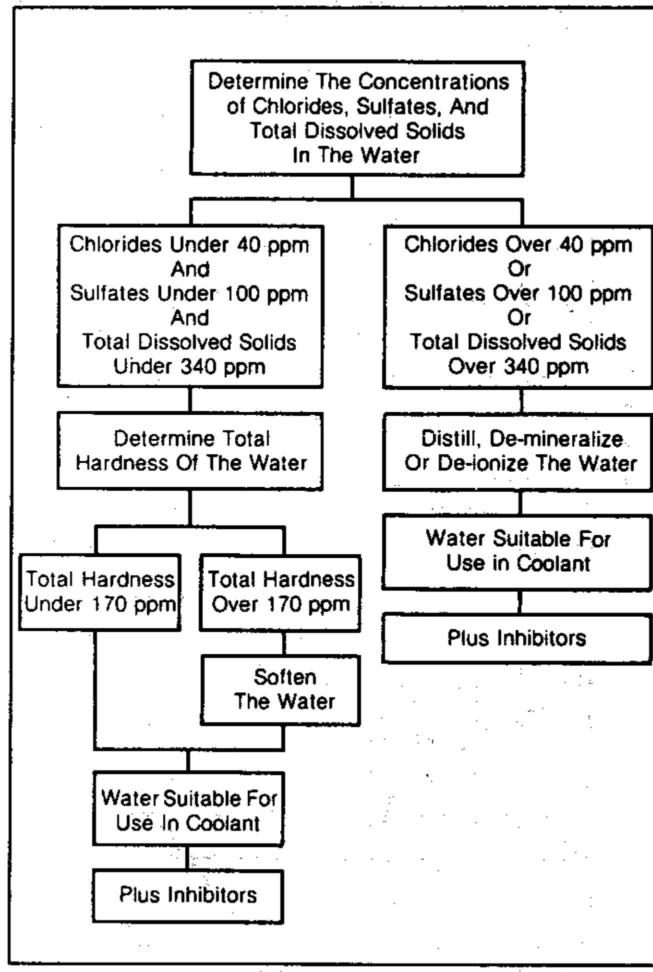


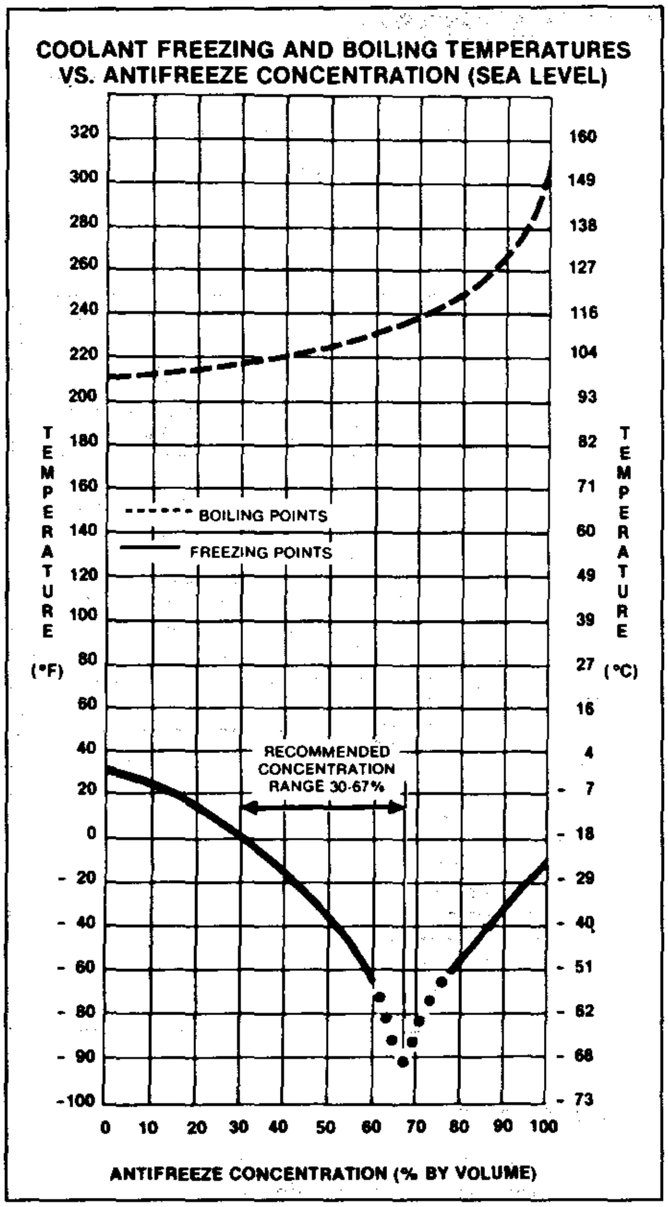
TABLE A–2

ANTIFREEZE

Use an ethylene glycol antifreeze that meets the GM 6038–M formulation, which limits silicate to 0.15% maximum, or an equivalent formulation meeting the 0.15% maximum silicate and GM 1899–M perfomance requirements. Ethylene glycol–base antifreeze meeting ASTM D 3306 requirements is also acceptable for use in Detroit Diesel engines.

A 50% antifreeze solution is normally used as a factory fill. Concentrations over 67% are not recommended because of poor heat transfer capability, adverse freeze protection and possible silicate drop–out. Concentrations below 30% offer little freeze, boil–over or corrosion protection.

Although most antifreezes contain inhibitor packages, all DDC and Perkins engines (except Perkins 500 Series) require supplemental inhibitors be added to the cooling system after an intial fill and maintained at proper protection level.



Antifreeze solution should be used year–round to provide freeze and boil–over protection as well as a stable environment for seals and hoses.

Only non–chromate inhibitors should be used with antifreeze solutions.

Coolant concentrate must be checked periodically at each oil change (600 hours or 20,000 miles maximum). Adjust concentration, if not at the proper protection level.

Pre–mix antifreeze/water makeup solution at the proper concentration before adding to the cooling system. This should prevent over– or under–coolant concentration problems.

Methyl alcohol–based antifreeze is not recommended for use in DDC engines because of its effect on the non–metallic components of the cooling system and its low boiling point. Methoxy propanol–based antifreeze is also not recommended for DDC engines because it is not compatible with fluoroelastomer seals found in the cooling system.

A cooling system properly maintained and protected with supplemental inhibitors can be operated up to two years, 200,000 miles, or 6000 hours, whichever comes first. At this interval the antifreeze must be drained, discarded in an appropriate manner, and the cooling system thoroughly cleaned. Inspect all components that make up the cooling system and make necessary repairs at this time. Refill the cooling system with a recommended ethylene glycol–base antifreeze and water solution in the required concentration (see graph). Add required inhibitors. After filling, run engine until thermostat(s) open and top off to recommended *full* level. Reinstall fill/pressure cap.

INHIBITOR

The importance of a properly inhibited coolant cannot be overemphasized. A coolant which has insufficient inhibitors, the wrong inhibitors, or no inhibitors at all invites the formation of rust, scale, sludge and mineral deposits within the cooling system. These deposits can cause water pump seal wear and coat the walls of the cylinder block, liners, and coolant passages. Heat transfer rate is reduced as the deposits build up. An engine affected in this manner can cause an overheating condition, resulting in liner scuffing, scoring, piston seizure and cylinder head cracking. This may occur quickly or over a long period of time, depending on the location and amount of deposits.

An improperly inhibited coolant can become corrosive enough to "eat away" coolant passages and seal ring grooves and cause coolant leaks to develop. If the coolant leak is internal and accumulates on top of a piston, a hydrostatic look can occur. This can result in a bent connecting rod.

Insufficiently inhibited coolant can also contribute to *cavitation erosion*. Cavitation erosion is caused by the collapse of bubbles (vapor pockets) against the surfaces of various engine coolant passages. The collapsing bubble forms a pin point of very high pressure. Over a period of time these collapsing bubbles can wear (erode) away internal engine surfaces. Components such as fresh water pump impellers, cylinder liners, and blocks are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

INHIBITOR SYSTEMS

An inhibitor system is a combination of chemical componds which provide corrosion protection, pH control, water–softening ability and cavitation suppresion. These systems are available in various forms, such as coolant filter elements, liquid and dry inhibitor additive packages, and as integral parts of antifreeze.

A corrosion inhibitor is a water–soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosive inhibitors are borates, nitrites, nitrates, chromates and soluble oil.

Chromates and soluble oils are not recommended as corrosion inhibitors for DDC engines.

- pH control chemicals are used to maintain an acid–free solution.
- Water–softening chemicals deter formation of mineral deposits.
- Cavitation suppression chemicals minimize the fomation of vapor pockets, preventing erosion of cooling system surfaces.

It is imperative that a supplemental inhibitor be added to the coolant on all DDC and Perkins engines after an initial fill and maintained at proper protection level.

NON–CHROMATES

Non–chromate inhibitor (borates, nitites, nitrates, etc.) systems are recommended for use with DDC engines. These systems can be used with either water or water–and–antifreeze solutions and provide corrosion protection, pH control, and water softening. Most non–chromate inhibitor systems offer the additional advantage of a simple on–site test to determine protection level. Since they are added directly to the coolant, no additional hardware or plumbing is required.

All inhibitors become depleted through normal operation, and additional inhibitor must be added to the coolant as required to maintain original strength levels.

> **NOTICE:** Overinhibiting antifreeze solutions can cause silicate dropout. Always follow the manufacturer's recommendations on usage and handling.

SOLUBLE OIL

Soluble oils are not recommended for use in DDC engine cooling systems. A small amount of oil concentration has an adverse affect on heat transfer capabilities. For example, a 1.25% concentration of soluble oil in the cooling sytem increases fire deck temperature 6%, while a 2.50% concentration raises fire deck temperature 15%.

CHROMATES

Chromate inhibitors are not recommended for use in DDC engine cooling systems. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate and causing engine overheating. Cooling systems (engine included) operated with chromate–inhibited coolant must be chemically cleaned and flushed with plain water prior to refilling with a recommended coolant mixture. A commercial heavy–duty descaler should be used in accordance with the manufacture's recommendation for this purpose.

COOLANT FILTER ELEMENT

Replaceable elements are available with various chemical inhibitor systems. There are two types of filters containing supplemental coolant additives (SCA's). One is a pre–charge which must be used at the time of initial cooling system fill. The second is a maintenance filter which is used at each service interval. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed with coolant filters using magnesium lower support plates. The coolant solution attacks the plate, allowing dissolved magnesium to be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate is recommended to prevent these deposits.

High chloride coolants have a detrimental effect on the water–softening capabilities of systems using ion–exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by the regenerative process caused by high chloride–content solutions.

Change coolant filters at regular intervals per manufacturer's recommendation.

INHIBITOR TESTING PROCEDURES

Test kits and test strips are commercially available to check engine coolant for inhibitor strength. Coolants should be tested at each oil change (600 hours or 20,000 miles maximum) to ensure that the inhibitor levels are maintained within the following ranges for two commonly available inhibitor systems:

SUPPLEMENTAL COOLANT ADDITIVE VALUES WITH GM 6038–M/ASTM D–3306 ANTIFREEZE

	Nitrate/ Borate System		Phosphate/ Molybdate System	
	Min. PPM	Max. PPM	Min. PPM	Max. PPM
Boron (B)	1000	1500	600	900
Nitite (NO_2)	800	2400	300	600
Nitrates (NO_3)	1000	2000	800	1800
Silica (S_i)	100	500	100	500
Phosphorous (P)	300	500	800	1200
Molybdenum (Mo)	—	—	200	400
pH	8.5	10.5	8.5	10.5

Do not use one manufacturer's test to measure the inhibitor strength of another manufacturer's product. Always follow the manufacturer's recommended test procedures.

SILICATE DROPOUT

Excessive amounts of chemicals in the engine coolant can cause *silicate dropout*, which creates a gel–type deposit that reduces heat transfer and coolant flow.

The gel takes the color of the coolant in the wet state, but appears as a white powdery deposit when dry. Although silica gel is non–abrasive, it can pick up solid particles in the coolant and become gritty, causing excessive wear of water pump seals and other cooling system components. The wet gel can be removed by non–acid (alkali) type heavy–duty cleaners, while the dried silicate requires engine disassembly and caustic solution or mechanical cleaning of individual components.

The total amount of chemicals in the coolant can be controlled to desirable levels by using GM 6038–M formulation antifreeze at the needed freeze protection concentration, adding inhibitors according to manufacturer's recommendations and water that meets DDC requirements.

NOTICE: Failure to use and maintain antifreeze/water and inhibitor coolant mixture at sufficient concentration levels can result in damage to the cooling system and its related components. Conversely, overconcentration of antifreeze and/or inhibitor can result in poor heat transfer, leading to engine overheat, silicate dropout, or both. Always maintain concentrations at recommended levels.

GENERAL COOLING SYSTEM RECOMMENDATIONS

Always maintain cooling system at the proper coolant level – Check daily. A low coolant level may cause aeration of the coolant. Air bubbles in the coolant can "insulate" the cylinder walls, preventing adequate heat transfer. Abnormally low coolant level can cause the water pump to become "air–bound", resulting in no coolant flow. Aerated coolant or an "air–bound" water pump can be catastrophic to engine life.

Overfilling a cooling system can result in unnecessary loss of cooolant and, in some rare cases, engine overcooling, especially during cold weather operation.

The cooling system must be pressurized to prevent localized boiling of the coolant. The system must be kept clean and leak–free. The fill cap or pressure relief valve must always be installed and checked periodically for proper operation.

Summary of Coolant Recommendations

1. Always use recommended antifreeze, inhibitor and water at proper concentration levels.
2. Use only ethylene glycol antifreeze meeting the GM 6038–M or ASTM D 3306 formulation or an equivalent antifreeze with a 0.15% maximum silicate content meeting GM 1899–M performance specifications.
3. Use an antifreeze solution year–round for freeze and boil–over protection. Seasonal changing of coolant from an antifreeze solution to an inhibitor/water solution is not recommended.
4. Pre–mix antifreeze makeup solutions at the proper concentration before adding to the cooling system.
5. Maintain the prescribed inhibitor strength levels as required. Test at each oil change interval and add inhibitor as needed. Do not use one manufacturer's test kits to measure the inhibitor strength of another manufacturer's product.
6. Follow the manufacturer's recommendations on inhibitor usage and handling. Do not mix different base inhibitor packages.
7. Use only non–chromate inhibitors.
8. Supplemental cavitation suppression inhibitors *must* be added to Series 53, 60, 92 and 149 engines after initial fill and *must* be maintained.
9. Change coolant filters at regular intervals per manufacturer's recommendation.
10. DO NOT USE THE FOLLOWING:
    - Soluble oil
    - Chromate inhibitor
    - Methoxy propanol–base antifreeze
    - Methyl alcohol–base antifreeze
    - Sealer additives or antifreezes containing sealer additives
11. Use only water meeting specifications found in Tables A–1 & A–2 (page 9). Use of distilled water is ideal.
12. Always maintain proper coolant level.
13. A cooling system properly maintained and protected with antifreeze and supplemental inhibitors can be operated up to two years, 200,000 miles, or 6000 hours, whichever comes first. At this interval the coolant must be drained, discarded in a safe manner, and the

cooling system cleaned thoroughly. Refill cooling system with a recommended water/antifreeze /inhibitor mixture at appropriate concentration level.

CAUTION: Never remove fill cap while coolant is hot. Remove cap *slowly* and only when coolant is at ambient conditions. A sudden release of pressure from a heated cooling system can result in possible personal injury from the expulsion of hot coolant.

SECTION 14

ENGINE TUNE-UP

CONTENTS

ENGINE TUNE-UP PROCEDURES

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanism, governor, etc. should only be required periodically to compensate for normal wear on parts.

To comply with emissions regulations for on-highway vehicle engines; injector timing, exhaust valve clearance, engine idle and no-load speeds, throttle delay or fuel modulator settings must be checked and adjusted, if necessary, at 50,000 mile intervals (refer to Section 15.1).

The type of governor used depends upon the engine application. Since each governor has different characteristics, the tune-up procedure varies accordingly. The following types of governors are used:

1. Limiting speed mechanical.
2. Variable speed mechanical.
3. Constant speed mechanical.
4. Hydraulic.

The mechanical governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S, stamped on the name plate denote a double-weight limiting speed governor. A single-weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if a cylinder head, governor or injectors have been replaced or overhauled, then certain tune-up adjustments are required. Accurate tune-up adjustments are very important if maximum performance and economy are to be obtained.

NOTICE: If a supplementary governing device, such as a load limit device, is used, it must be disconnected prior to the tune-up. After the governor and injector rack adjustments are completed, the supplementary governing device must be reconnected and adjusted.

To tune-up an engine completely, perform all of the adjustments in the applicable tune-up sequence given below.

CAUTION: To prevent the possibility of personal injury, use turbocharger inlet shield J 26554-A anytime the turbocharger inlet is exposed.

Use new valve rocker cover gaskets after the tune-up is completed.

Tune-Up Sequence For Mechanical Governor

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover, the service technician must determine that the injector racks move to the no-fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

CAUTION: An overspeeding engine can result in engine damage which could cause personal injury.

1. Adjust the exhaust valve clearance, cold.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).
9. Adjust the supplementary governing device, if used.

Tune-up Sequence For Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the fuel rod.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Compensation adjustment (PSG governors only).
7. Adjust the speed droop.
8. Adjust the maximum no-load speed.

EMISSION REGULATIONS FOR ON-HIGHWAY VEHICLE ENGINES

On-highway vehicle and coach engines built by Detroit Diesel Corporation are certified to be in compliance with Federal and California Emission Regulations established for each model year beginning with 1970.

Engine certification is dependent on five physical characteristics:

1. Fuel injector type.
2. Maximum full-load engine speed.
3. Camshaft timing.
4. Fuel injector timing.
5. Throttle delay (orifice size).

The following Charts summarize all of the pertinent data concerning the specific engine configurations required for each model year.

When serviced, all on-highway vehicle and coach engines should comply with the specifications for the specific model year in which the engine was built.

Trucks in a fleet containing engines of various model years can be tuned to the latest model year, provided the engines have been updated to meet the specifications for that particular year.

1970-1973 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Year	1970	1971	1972	1973
Engines	3-53N 4-53N 6V-53N 8V-53N	3-53N 4-53N 6V-53N 8V-53N	3-53N 4-53N 6V-53N 8V-53N	3-53N 4-53N 6V-53N 8V-53N
Injectors	N40 N45 N50**	N40 N45 N50**	N40 N45 N50	C40 C45 C50
▼ Maximum Full-load Engine Speed	2800	2800	2800	2800
Camshaft Timing	Adv.	Adv.	Adv.	Adv.
■ Injector Timing	1.460"	1.460"	1.460"	1.460"
Timing Gage	J 1853	J 1853	J 1853	J 1853
Throttle Delay	No	No	*Yes	*Yes
Yield Link	—	—	—	—

*Throttle delay must have .016" diameter orifice.
**Exempt for fire fighting apparatus.
▼No-load engine speed will vary with injector size and governor type.
■The adjusted height of the fuel injector follower in relation to the injector body.

1974-1976 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Year	1974	1975	1976
Engines	4-53N 6V-53N	4-53N 6V-53N	4-53N 6V-53N
Injectors	C40 C45 C50	C40 C45 C50	C40 C45 C50
▼ Maximum Full-load Engine Speed	2800	2800	2800
Camshaft Timing	Adv.	Adv.	Adv.
■ Injector Timing	1.470"	1.470"	1.470"
Timing Gage	J 24236	J 24236	J 24236
Throttle Delay	Yes ●	Yes ●	Yes ●
Yield Link	Yes	Yes	Yes

▼No-Load engine speed will vary with injector size and governor type.
■The adjusted height of the fuel injector follower in relation to the injector body.
●.250" diameter fill hole, .016" diameter discharge orifice.

1977 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Engine	4-53N	6V-53N
(a) Injectors	C40 C45 C50	C40 C45 C50
(a) Maximum Rated Speed	2800	2800
(a) Minimum Rated Speed	2800 (C40) 2400 (C45) 2500 (C50)	2600 (C40) 2500 (C45) 2100 (C50)
Gear Train Timing	Adv.	Adv.
Injector Timing	1.470"	1.470"
Timing Gage	J 24236	J 24236
Throttle Yield Link Setting	(e) Yes .454"	(e) Yes .454"
Liner Port Height Compression Ratio Blower Drive Ratio	.840" 21:1 2.487:1	.840" 21:1 2.487:1
Governor Type	Limiting Speed	
Thermostat	170-180° F (77-82° C) Nominal Opening Temperature	

(a) Not to exceed injector size and maximum operating speed that has been established. No-load speed will vary with injector size and governor type.

(e) Large fill hole (.250" dia), .016" discharge orifice. Use a minimum idle speed at 500 rpm on all engines.

1978 CERTIFIED AUTOMOTIVE CONFIGURATIONS

	FEDERAL			CALIFORNIA
ENGINE FAMILIES	4L-53N	4-53T	6V-53N	4-53TC
INJECTORS (a)	C40 C45 C50	5A55 5A60	C40 C45 C50	5A55 5A60
MAXIMUM FULL LOAD SPEED (b)	2800	2500	2800	2500
MINIMUM FULL LOAD SPEED	2400	2500	2400	2500
CAMSHAFT LOBE POSITION	ADV.	STD.	ADV.	STD.
INJECTOR TIMING	1.470	1.496	1.470	5A55-1.496 5A60-1.508
THROTTLE DELAY YIELD LINK	(e) REQ.	FUEL MODULATOR	(e) REQ.	FUEL MODULATOR
TURBOCHARGER A/R		T04B98 .96 3LM-353 2.7 Sq. In.		T04B98 .96 3LM-353 2.7 Sq. In.

(a) See Engine Application Rating (Sales Tech Data Book 1, Vol. 3) for specific application usage of injector size and full-load speed combination. No-load speed will wary with injector size and governor type.

(b) Use a minimum idle speed of 400 rpm on all coach engines with throttle delay and a minimum idle speed of 500 rpm on all other engines.

(e) Large fill hole (.250" dia.), .016" discharge orifice.

FUEL INJECTOR TIMING GAGE CHART

INJECTOR	TOOL NO.	SETTING	CAM LOBE POSITION
5A55	J 9595	1.496	Standard
5A60	J 9595	1.496	Standard
5A60 (Calif. Cert. only)	J 8909	1.508	Standard

1979 CERTIFIED AUTOMOTIVE CONFIGURATIONS

	FEDERAL		CALIFORNIA	
FAMILIES	4L-53T	6V-63T	4L-53TC	6V-53TC
INJECTORS	5A55 5A60	5A50	5A55 5A60	5A50
MAXIMUM FULL LOAD SPEED	2500	2600	2500	2600
MINIMUM FULL LOAD SPEED	2500	2500	2500	2500
MINIMUM IDLE SPEED	500	500	500	500
GEAR TRAIN TIMING	STD.	STD.	STD.	STD.
INJECTOR TIMING	1.496	1.490	5A55-1.496 5A60-1.508	1.500
FUEL MODULATOR SETTING #	.365#	.404#	5A55-.365 5A60-.404#	.404#
LINER PORT HEIGHT	.84	.84	.84	.84
LINER PART NUMBER	5132803	5132803	5132803	5132803
TURBOCHARGER A/R	TO4B98 .96 A/R ##	TV6123 1.20 A/R	TO4B98 .96 A/R ##	TV6123 1.20 A/R
TURBOCHARGER PART NUMBER	5103905##	5104082	5103905##	5104082
BLOWER DRIVE RATIO	2.49:1	2.49:1	2.49:1	2.49:1
BLOWER PART NUMBER	5103563-LH 5103466-RH	5104298	5103563-L 5103466-R	5104298
COMPRESSION RATIO	18.7:1	18.7:1	18.7:1	18.7:1
EXHAUST VALVE MATERIAL	NIMONIC 90	NIMONIC 90	NIMONIC 90	NIMONIC 90
EXHAUST VALVE PART NUMBER	5109925	5109925	5109925	5109925
CERTIFICATION LABEL NUMBER	14B7-264	14B7-266	14B7-265	14B7-267

53T Uses fuel modulator.
Optional 3LM-353, 2.7 Sq. In., 5104803.

THROTTLE DELAY AND STARTING AID GAGES

J 28779 For .365"
J 28479 For .395"
J 9509-2 For .404"
J 23190 For .454"
J 25559 For .570"
J 26646 For .290"

PIN GAGE

J 25558 For .069" & .072"

TIMING GAGES

J 1853 For 1.460"
J 24236 For 1.470"
J 1242 For 1.484"
J 29066 For 1.490"
J 9595 For 1.496"
J 25454 For 1.500"
J 8909 For 1.508"

FEDERAL

ENGINE FAMILIES	4L-53T	6V-53T
INJECTORS (a)	5A55 5A60	5A50
MAXIMUM FULL LOAD SPEED (a)	2500	2600
MINIMUM FULL LOAD SPEED	2500	2500 (b) 2200 (c)
MINIMUM IDLE SPEED	500	600
GEAR TRAIN TIMING	STD.	STD.
INJECTOR TIMING	1.496	1.490
THROTTLE DELAY SETTING	.365 (e)	.404 (e)
TURBOCHARGER A/R	T04B98 .96 A/R 3LM-353 2.7 Sq. In.	TV6123 21.20 A/R

(a) Refer to Engine Application Rating (Sales Tech Data Book 1, Vol. 3) for specific application usage of injector size and full load speed combination. No load speed will vary with injector size and governor.
(b) 1980
(c) 1981
(e) 53T uses fuel modulator.

1980 CERTIFIED AUTOMOTIVE ENGINES

ENGINE	INJECTOR	RATED BHP	PEAK TORQUE (LB-FT)
4-53T	5A55 5A60	155 @ 2500 170 @ 2500	379 @ 1800 402 @ 1800
6V-53T	5A50	225 @ 2600	550 @ 1800

1981 CERTIFIED AUTOMOTIVE ENGINES

ENGINE	INJECTOR	RATED BHP	PEAK TORQUE (LB-FT)
4-53T	5A55 5A60	155 @ 2500 170 @ 2500	379 @ 1800 402 @ 1800
6V-53T	5A50	215 @ 2200 223 @ 2500 225 @ 2600	550 @ 1800

ALL ENGINE HORSEPOWER RATINGS ARE BASED ON SAE CONDITIONS

85°F (29.4°C) — AIR INLET TEMPERATURE
29.00 IN. HG. (98.19 kPa) — BAROMETER (DRY)

1982 CERTIFIED AUTOMOTIVE CONFIGURATIONS

FEDERAL

ENGINE FAMILIES	4L-53T	6V-53T
INJECTORS (a)	5A55 5A60	5A50
MAX. FULL LOAD SPEED	2500	2600
MIN. FULL LOAD SPEED	2500	2200
MIN. IDLE SPEED	500	600
GEAR TR. TIMING	STD.	STD.
INJECTOR TIMING	1.496	1.490
THROTTLE DELAY SETTING	.365 (a)	.404 (a)
LINER PORT HGHT.	.84	.84
LINER PART NO.	5132803	5132803
TURBOCHARGER A/R	T04B98 (b) .96 A/R (c)	TV6123 1.20 A/R
TURBOCHARGER P/N	5103905	5104082
BLOWER DR. RATIO	2.49:1	2.49:1
BLOWER PART NO.	5107528L 5107527R	5107523
COMP. RATIO	18.7:1	18.7:1
EXHAUST VALVE P/N	5109925	5109925
CERT. LABEL NO.	14B7-327	14B7-328

(a) 53T uses fuel modulator.
(b) For "RD" configuration optional turbocharger 5106635 & 5106636 are available.
(c) Optional 3LM-353, 2.7 sq. in. 5104803.

1982 CERTIFIED AUTOMOTIVE ENGINES

ENGINE	INJECTOR	RATED BHP	PEAK TORQUE (LB-FT)
4-53T	5A55 5A60	155 @ 2500 170 @ 2500	379 @ 1800 402 @ 1800
6V-53T	5A50	225 @ 2600	550 @ 1800

ALL ENGINE HORSEPOWER RATINGS ARE BASED ON SAE CONDITIONS

85°F (29.4°C) — AIR INLET TEMPERATURE
29.00 IN. HG. (98.19 kPa) — BAROMETER (DRY)

Effective January 1, 1982, California allowed the use of Federal certified engines in *Public Transit Busses* and in *Authorized Emergency Vehicles* as defined in section 165 of the California Vehicle Code.

1983 CERTIFIED AUTOMOTIVE CONFIGURATIONS

FEDERAL

ENGINE FAMILIES	4L-53T	6V-53T
INJECTORS (a)	5A55 5A60	5A50
MAXIMUM FULL LOAD SPEED (a)	2500	2600
MINIMUM FULL LOAD SPEED	2500	2200
MINIMUM IDLE SPEED	500	600
GEAR TRAIN TIMING	STD.	STD.
INJECTOR TIMING	1.496	1.490
MODULATOR SETTING	.365	.404
TURBOCHARGER A/R	T04B98 .96 A/R 3LM-353 2.7 Sq. In.	TV6123 1.20 A/R
TURBOCHARGER PART NO.	5103905 5104803	5104082
BLOWER DRIVE RATIO	2.49:1	2.49:1
BLOWER PART NO.	5107528L 5107527R	5107523
COMPRESSION RATIO	18.7:1	18.7:1
EXHAUST VALVE PART NO.	5109925	5109925
LINER PART NO.	5132803	5132803
LINER PORT HEIGHT	.84	.84
CERT. LABEL NO.	14B7-347	14B7-348

(a) Refer to Engine Application Rating (Sales Tech Data Book 1, Vol. 3) for specific application usage of injector size and full load speed combination. No load speed will vary with injector size and governor.

1983 CERTIFIED AUTOMOTIVE ENGINES

ENGINE	INJECTOR	RATED BHP	PEAK TORQUE (LB-FT)
4-53T	5A55 5A60	155 @ 2500 170 @ 2500	379 @ 1800 402 @ 1800
6V-53T	5A50	225 @ 2600	550 @ 1800

ALL ENGINE HORSEPOWER RATINGS ARE BASED ON SAE CONDITIONS

85°F (29.4°C) — AIR INLET TEMPERATURE
29.00 IN. HG. (98.19 kPa) — BAROMETER (DRY)

Effective January 1, 1982, California allowed the use of Federal certified engines in *Public Transit Busses* and in *Authorized Emergency Vehicles* as defined in section 165 of the California Vehicle Code.

1984 CERTIFIED AUTOMOTIVE CONFIGURATIONS

ENGINE FAMILIES	4L-53T	6V-53T
Injectors (a)	5A55 5A60	5A50
Maximum Full Load Speed (a)	2500	2600
Minimum Full Load Speed	2500	2200
Minimum Idle Speed	500	600
Gear Train Timing	Std.	Std.
Injector Timing	1.496	1.490
Throttle Delay Setting	DNA	DNA
Modulator Setting	.365	.404
Turbocharger A/R	T04B98 .96 A/R 3LM-353 2.7 Sq. In.	TV6123 1.20 A/R
CERT. LABEL NO.	14B7-373	14B7-374

DNA Does not apply.

(a) Refer to Engine Application Rating (Sales Tech Data Book 18SA315) for specific application usage of injector size and full load speed combination. No load speed will vary with injector size and governor.

1984 CERTIFIED AUTOMOTIVE ENGINES			
ENGINE	INJECTOR	RATED BHP	PEAK TORQUE (LB-FT)
4-53T	5A55 5A60	155 @ 2500 170 @ 2500	379 @ 1800 402 @ 1800
6V-53T	5A50	225 @ 2600	550 @ 1800
ALL ENGINE HORSEPOWER RATINGS ARE BASED ON SAE J 1349 CONDITIONS			

Effective January 1, 1982, California allowed the use of Federal certified engines in *Public Transit Busses* and in *Authorized Emergency Vehicles* as defined in section 165 of the California Vehicle Code.

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, increased valve face wear and valve lock damage.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

All of the exhaust valves may be adjusted in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

ENGINES WITH TWO-VALVE CYLINDER HEADS

Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover(s) and remove the cover(s). Discard the gasket(s).

2. Place the governor speed control lever in the *idle speed* position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted.

- **NOTICE:** The hex head of the crankshaft bolt may be used to bar, or turn, the crankshaft. However, the barring operation should always be performed in a clockwise direction. It is very important to make certain that the bolt has not been loosened during the barring operation. Otherwise, serious engine damage may result if the vibration damper or pulley is not securely fastened to the crankshaft.

- **NOTICE:** Barring a left-hand rotating marine engine equipped with a Jabsco raw water pump may result in damage to the rubber impeller if the impeller vanes are forced to rotate against their normal direction of deflection. To avoid damage, detach the cover and remove the impeller before barring the engine. Mark the front of the impeller for easy reinstallation.

- **CAUTION: To reduce the risk of personal injury when barring over or "bumping" the starter, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.**

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place an .011" feeler gage (J 9708-01) between the exhaust valve stem and the rocker arm (Fig. 1). Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .010" feeler gage (J 9708-01 will pass freely between the valve stem and the rocker arm, but the .012" feeler gage will not pass through. Readjust the push rod, if necessary.

8. Adjust and check the remaining exhaust valves in the same manner as above.

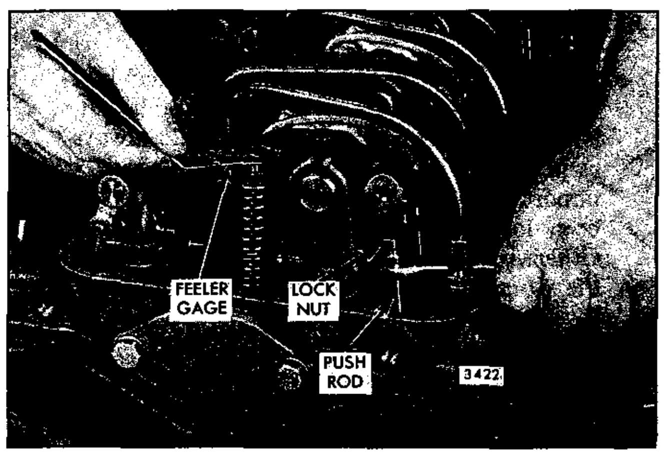


Fig. 1 – Adjusting Valve Clearance (Two Valve Head)

Valve Clearance Adjustment (Hot Engine)

It is *not* necessary to make a final hot engine exhaust valve clearance adjustment after a cold engine adjustment has been performed. However, if a hot engine adjustment is desired, use the following procedure.

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance, when running at full load, may become insufficient.

NOTICE: Since these adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

1. With the engine at normal operating temperature (refer to Section 13.2), set the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .008" gage will pass freely between the end of the valve stem and the rocker arm and the .010" gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).

Check Exhaust Valve Clearance Adjustment

1. With the engine at 100°F (38°C) or less, check the valve clearance.

2. If a .011" feeler gage (ç.004") will pass between the valve stem and the rocker arm bridge, the valve clearance is satisfactory. If necessary, adjust the push rod.

ENGINES WITH FOUR-VALVE CYLINDER HEADS

Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover(s) and remove the cover(s). Discard the gasket(s).

2. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted.

- **NOTICE:** The hex head of the crankshaft bolt may be used to bar, or turn, the crankshaft. However, the barring operation should always be performed in a clockwise direction. It is very important to make certain that the bolt has not been loosened during the barring operation. Otherwise, serious engine damage may result if the vibration damper or pulley is not securely fastened to the crankshaft.

- **NOTICE:** Barring a left-hand rotating marine engine equipped with a Jabsco raw water pump may result in damage to the rubber impeller if the impeller vanes are forced to rotate against their normal direction of deflection. To avoid damage, detach the cover and remove the impeller before barring the engine. Mark the front of the impeller for easy reinstallation.

- **CAUTION: To reduce the risk of personal injury when barring over or "bumping" the starter, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.**

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .026" feeler gage (J 9708-01) between the end of one exhaust valve stem and the rocker arm bridge (Fig. 2). Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .025" feeler gage will pass freely between the end of one valve stem and the rocker arm bridge, but the .027" feeler gage will not pass through. Readjust the push rod, if necessary.

8. Adjust and check the remaining exhaust valves in the same manner as above.

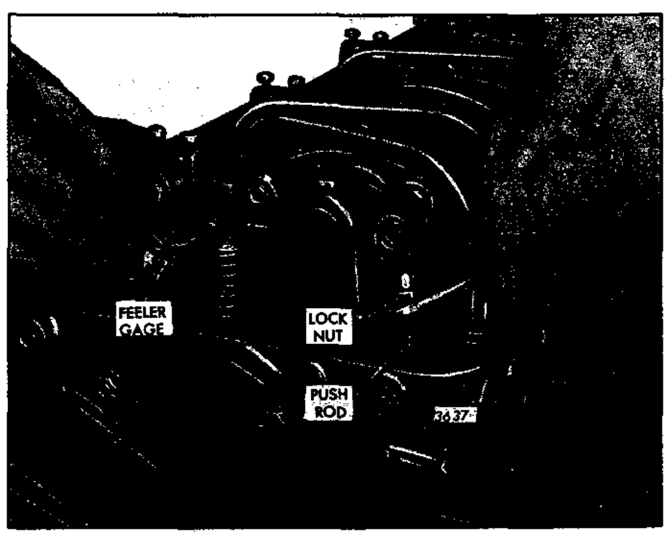


Fig. 2 – Adjusting Valve Clearance (Four Valve Head)

Valve Clearance Adjustment (Hot Engine)

It is *not* necessary to make a final hot engine exhaust valve clearance adjustment after a cold engine adjustment has been performed. However, if a hot engine adjustment is desired, use the following procedure.

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance, when running at full load, may become insufficient.

NOTICE: Since these adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

1. With the engine at normal operating temperature (refer to Section 13.2), set and exhaust valve clearance with feeler gage J 9708–01. At this time, if the valve clearance is correct, the .023" gage will pass freely between the end of one valve stem and the rocker arm bridge, but the .025" feeler gage will not pass through. Readjust the push rod, if necessary.
2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).

Check Exhaust Valve Clearance Adjustment

1. With the engine at 100°F (38°C) or less, check the valve clearance.
2. If a .026" feeler gage (ç.006") will pass between the valve stem and the rocker arm bridge, the valve clearance is satisfactory. If necessary, adjust the push rod.

FUEL INJECTOR TIMING

To time an injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed in firing order sequence during one full revolution of the crankshaft.

Refer to the *General Specifications* at the front of the manual for the engine firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted (Section 14.1), time the fuel injectors as follows:

1. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

2. Rotate the crankshaft, manually or with the starting motor, until the exhaust valves are fully depressed on the particular cylinder to be timed.

- **NOTICE:** The hex head of the crankshaft bolt may be used to bar, or turn, the crankshaft. However, the barring operation should always be performed in a clockwise direction. It is very important to make certain that the bolt has not been loosened during the barring operation. Otherwise, serious engine damage may result if the vibration damper or pulley is not securely fastened to the crankshaft.

- **NOTICE:** Barring a left–hand rotating marine engine equipped with a Jabsco raw water pump may result in damage to the rubber impeller if the impeller vanes are forced to rotate against their normal direction of deflection. To avoid damage, detach the cover and remove the impeller before barring the engine. Mark the front of the impeller for easy reinstallation.

- **CAUTION: To reduce the risk of personal injury when barring over or "bumping" the starter, personnel should keep their hands and clothing away from the engine as there is a remote possibility the engine could start.**

3. Place the small end of the injector timing gage in the hole provided in the top of the injector body with the flat of the gage toward the injector follower (Fig. 1). Refer to the engine option label for the correct timing dimension. Refer to Table 1 or 2 for the correct timing gage (for vehicle engines, refer to Section 14).

4. Loosen the injector rocker arm push rod lock nut.

5. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the push rod and tighten the lock nut. Check the adjustment and, if necessary, readjust the push rod.

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune–up is required, install the valve rocker cover, using a new gasket.

TRUNK PISTONS

Injector	Timing Dimension	Timing Gage	Camshaft Timing	Engine
35	1.484"	J 1242	Standard	53 (2 valve)
35	1.508"	J 8909	Standard	(Reefer Car)
40	1.484"	J 1242	Standard	53, V53
45	1.484"	J 1242	Standard	53, V53
S40	1.460"	J 1853	Standard	53, V53
S45	1.460"	J 1853	Standard	53, V53
S50	1.460"	J 1853	Standard	53, (2 valve)
L40	1.460"	J 1853	Standard	(Lift Truck)
N35	1.460"	J 1853	—	—
N35	1.484"	J 1242	Standard	—
N35	1.508"	J 8909	Standard	Reefer Car
N40	1.460"	J 1853	Standard	53N, V53N
N40	1.460"	J 1853	Standard	—
N45	1.460"	J 1853	Standard	53N, V53N
N45	1.460"	J 1853	Standard	—
N45	1.484"	J 1242	Standard	—
N50	1.460"	J 1853	Standard	53N, V53N
N50	1.460"	J 1853	Standard	—
N60	1.460"	J 1853	—	—
N60	1.460"	J 1853	Standard	SGS*
N65	1.508"	J 8909	Standard	4–53T
N65	1.508"	J 8909	Standard	Industrial & SGS*
N65	1.460"	J 1853	Standard	SGS*
N65	1.508"	J 8909	Standard	Generator
N70	1.460"	J 1853	Standard	Marine
N70	1.460"	J 1853	—	—
N70	1.460"	J 1853	Standard	SGS*
M40	1.460"	J 1853	Standard	SGS*
M55	1.460"	J 1853	Standard	SGS*
M60	1.460"	J 1853	Standard	SGS*
5N65	1.460"	J 1853	Standard	6V–53T
5N65	1.460"	J 1853	Standard	Marine
5N45	1.460"	J 1853	Standard	—
5A50	1.490"	J 29066	Standard	Industrial
5A50	1.484"	J 1242	Standard	6V–53T†
5A55	1.496"	J 9595	Standard	Industrial
5A55	1.484"	J 1242	Standard	3–53T†
5A55	1.484"	J 1242	Standard	6V–53T†
5A60	1.496"	J 9595	Standard	Industrial & SGS*
5A60	1.484"	J 1242	Standard	SGS*
5A60	1.484"	J 1242	Standard	3–53T†

For automotive applications, refer to Section 14.
* Special Gov't. Sale
† With bypass blower.

TABLE 1 – INJECTOR TIMING

CROSS-HEAD PISTONS

Injector	Timing Dimension	Timing Gage	Camshaft Timing	Engine
5C50	1.480"	J 29065	Standard	4-53T 6V-53T
5E50	1.480"	J 29065	Standard	3-53T
5C55	1.480"	J 29065	Standard	4-53T 6V-53T
5E55	1.480"	J 29065	Standard	3-53T
5C60	1.480"	J 29065	Standard	4-53T 6V-53T
5E60	1.480"	J 29065	Standard	3-53T

TABLE 2 - INJECTOR TIMING

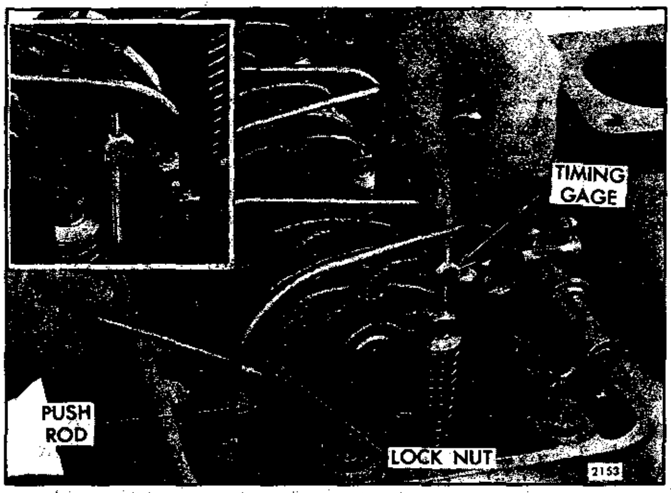


Fig. 1 - Timing Fuel Injector

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

IN-LINE ENGINE

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

NOTICE: Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. On turbocharged engines, the fuel (air box) modulator lever and roller assembly must be positioned free from cam contact. After the adjustments are completed, reconnect and adjust the supplementary governing device, as outlined in Section 14.14.

A 3/4"–16 tapped hole has been added to the SAE No. 2 flywheel housings used on certain 4–53 turbocharged engines. The tapped hole located at the 7:30 o'clock position on the bottom rail accomodates the probe for the digital tachometer J 26791. A 3/4"–16 plug is used to seal this tachometer pick-up hole.

Adjust Governor Gap

With the engine stopped and at operating temperature, adjust the governor gap as follows:

1. Remove the high–speed spring retainer cover.
2. Back out the buffer screw until it extends approximately 5/8" from the locknut.
3. Start the engine and adjust the idle speed screw to obtain an idle speed of 500–600 rpm (Fig. 8). The recommended idle speed is 500–600 rpm, but may vary with special engine applications.
4. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker cover. Discard the gasket.
5. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever. *Do not overspeed the engine.*
6. Check the gap between the low–speed spring cap and the high–speed spring plunger with a feeler gage (Fig. 1). The gap should be .002"–.004". If the gap setting is incorrect, reset the gap adjusting screw.
7. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.

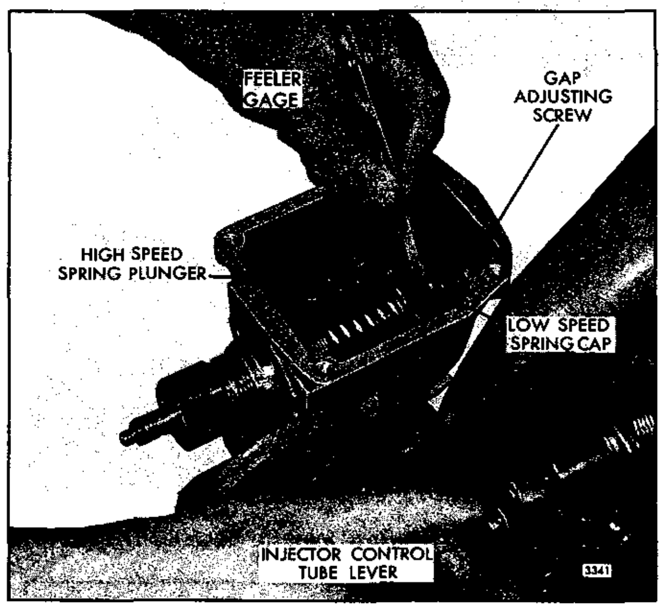


Fig. 1 – Adjusting Governor Gap

8. Recheck the gap with the engine operating between 1100 and 1300 rpm and readjust, if necessary.
9. Install the governor cover. The governor cover should be placed on the housing with the pin of the speed control lever projecting into the slot in the differential lever.
10. Install the screws and lock washers finger tight. Pull the cover away from the engine and tighten the screws. This step will properly locate the cover on the governor housing.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.
2. Governor low–speed gap closed.
3. High–speed spring plunger on the seat in the governor control housing.
4. Injector racks in the *full–fuel* position.

Fig. 2 – Positioning the Rear Injector Rack Control Lever

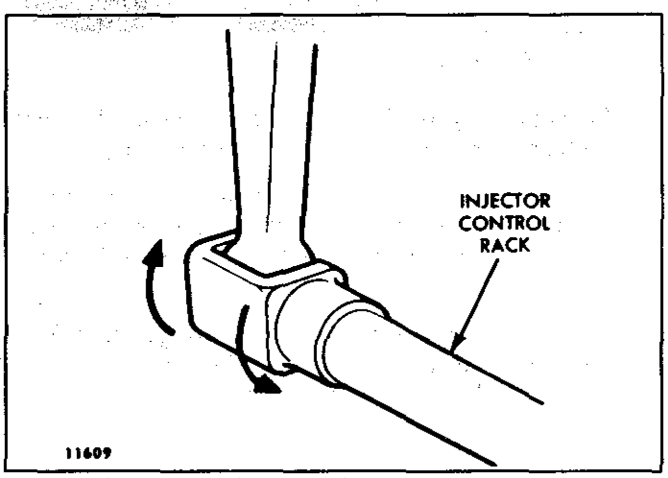


Fig. 3 – Checking Rotating Movement of Injector Control Rack

Adjust the rear injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the speed control lever.

2. Turn the idle speed adjusting screw until 1/2" of the threads (12–14 threads) project from the locknut, when the nut is against the high–speed plunger. This adjustment lowers the tension of the low–speed spring so it can be easily compressed. This permits closing the low–speed gap without bending the fuel rods or causing the *yield mechanism springs to yield or stretch.*

NOTICE: A false fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

3. Back out the buffer screw approximately 5/8", if it has not already been done.

4. Loosen all of the inner and outer injector rack control lever adjusting screws or the adjusting screws and locknuts (Fig. 2). Be sure all of the levers are free on the injector control tube.

5. Move the speed control lever to the full fuel position and hold it in that position with light finger pressure.

Two Screw Assembly

Turn the inner adjusting screw on the rear injector rack control lever down until a slight movement of the control lever is observed or a step–up in effort to turn the screwdriver is noted. This will place the rear injector rack in the *full–fuel* position. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly

Tighten the adjusting screw of the rear injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the rear injector rack in the full–full position.

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adusting screws is 24–36 **lb–in** (3–4 N·m).

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

6. To be sure of the proper rack adjustment, hold the speed control lever in the *full–fuel* position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack when the speed control lever is in the maximum speed position (Fig. 3). Hold the speed control lever in the maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 4).

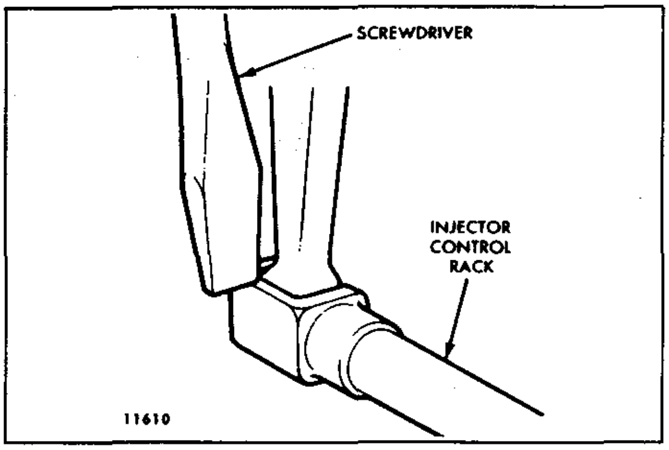


Fig. 4 – Checking Injector Rack "Spring"

If the rack does not return to its original position, it is too loose. To correct this condition with the *Two Screw Assembly,* back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly* loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the speed control lever from the no speed to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step–up in effort required to move the speed control lever to the end of its travel. To correct this condition with the *Two Screw Assembly,* back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly,* loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

7. To adjust the remaining injector rack control levers, remove the clevis pin from the fuel rod and the injector control tube lever. Hold the injector control racks in the *full–fuel* position by means of the lever on the end of the control tube and proceed as follows:

Two Screw Assembly

a. Turn down the inner adjusting screw on the injector rack control lever of the adjacent injector until the injector rack has moved into the *full–fuel* position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

b. Recheck the rear injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while adjusting the adjacent injector. If the rack of the rear injector has become loose, back off the inner adjusting screw slightly on the adjacent injector rack control lever. Tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

c. Position the remaining injector rack control levers as outlined in Steps 6 and 7.

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m).

One Screw and Locknut Assembly

a. Tighten the adjusting screw of the No. 2L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

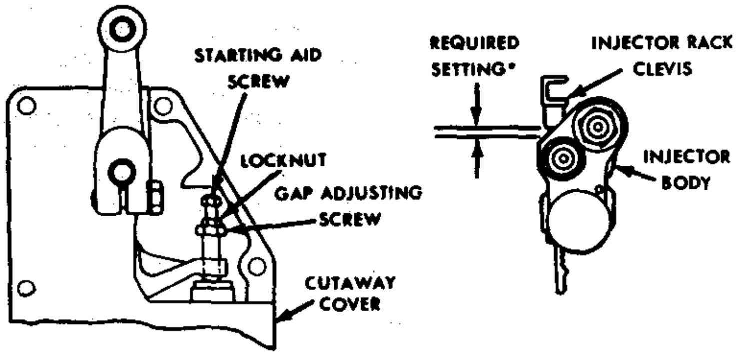
NOTICE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m).

b. Verify the rear injector rack adjustment, as outlined in Step 7. If it does not "spring" back upward, turn the adjacent injector rack adjusting screw counterclockwise slightly until the rear injector rack returns to its *full–fuel* position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both the rear and the adjacent injectors. Turn clockwise or counterclockwise the adjacent injector rack adjusting screw until both the rear and the adjacent injector racks are in the *full–fuel* position when the locknut is securely tightened.

c. Adjust the remaining injectors using the proceedures outlined in Step "b", always verifying proper injector rack adjustment.

8. Connect the fuel rod to the injector control tube lever.

9. Turn the idle speed adjusting screw in until it projects 3/16" from the locknut to permit starting the engine. Tighten the locknut.



INJECTOR	GAGE SETTING*	TOOL NUMBER
5A55	.345"	J 24889
5A60	.345"	J 24889
N55	.345"	J 24889
N60	.345"	J 24889
N65	.385"	J 24882
N70	.385"	J 24882
M60	.345"	J 24889
M70	.385"	J 24882

L-5870

Fig. 5 – Starting Aid Screw Adjustment

10. On *turbocharged engines* adjust the internal starting aid screw, as follows:

The starting aid screw has a locknut and the gap adjusting screw has a self locking patch.

a. Install a cutaway governor cover assembly, on the governor housing (Fig. 5).

b. With the engine *stopped*, place the governor stop lever in the *run* position and the speed control lever in the *idle* position.

c. Hold the gap adjusting screw to keep it from turning and adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the counterbore in the injector body (Fig. 5). Move the gage back and forth along the injector rack until a clearance of 1/64" is noted. The setting is measured at any convenient cylinder. Tighten the locknut on the starting aid screw sufficiently to prevent oil leakage as well as to hold the adjusting screw setting.

d. Check the injector rack clevis–to–body clearance after performing the following:

1. Position the stop lever in the *run* position.
2. Move the speed control lever from the *idle* position to the maximum speed position.
3. Return the speed control lever to the *idle* position.

Movement of the governor speed control lever is to take up clearances in the governor linkage. The clevis–to–body clearance can be increased by backing out the starting aid screw or reduced by turning it farther into the gap adjustment screw.

e. Start the engine and recheck the running gap (.0015") and, if necessary, reset it and reposition the injector racks. Then stop the engine.

f. Remove the cutaway governor cover assembly.

g. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the throttle control shaft assembly in the slot of the differential lever and the dowel pins in the housing in the dowel pin holes of the cover. Tighten the screws.

CAUTION: Before starting an engine after an engine speed control adjustment, or after removal of the engine governor cover and lever assembly, the service technician must determine that the injector racks move to the no–fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.

11. Use a new gasket and reinstall the valve rocker cover.

Adjust Maximum No–Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no–load speed as given on the engine option plate, set the maximum no–load speed as follows:

TYPE A GOVERNOR SPRINGS (Fig. 7):

1. Loosen the locknut (Fig. 6) and back off the high–speed spring retainer approximately five turns.

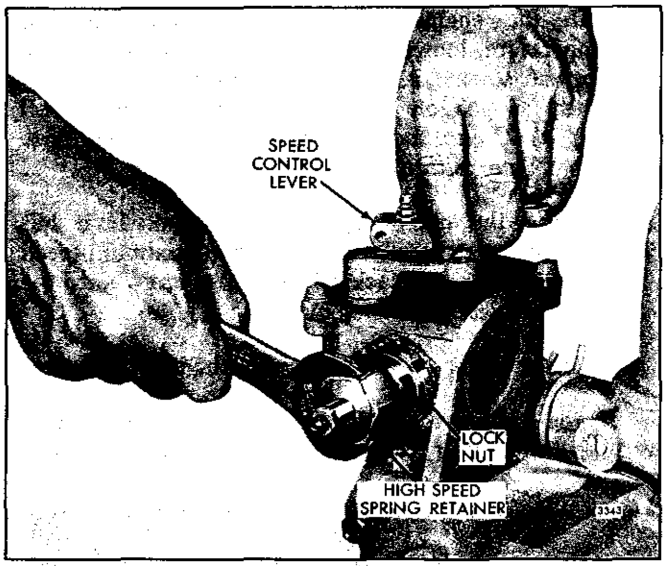


Fig. 6 – Adjusting Maximum No–Load Speed

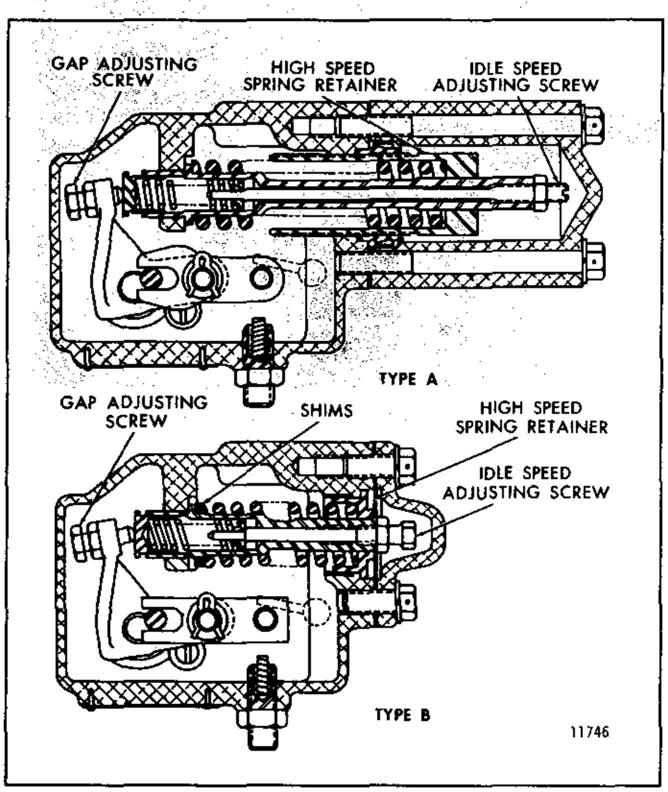


Fig. 7 – Governor Spring Assemblies

2. With the engine at operating temperature and no load on the engine, place the speed control lever in the *full–fuel* position. Turn the high–speed spring retainer IN until the engine is operating at the recommended no–load speed.

   The best method of determining the engine speed is with an accurate tachometer.

3. Hold the high–speed spring retainer and tighten the locknut.

TYPE B GOVERNOR SPRINGS (Fig. 7):

1. Start the engine and after it reaches normal operating temperature, remove the load from the engine.
2. Place the speed control lever in the maximum speed position and note the engine speed.
3. Stop the engine and, if necessary, adjust the no–load speed as follows:
   a. Remove the high–speed spring retainer, high–speed spring and plunger.

      NOTICE: To prevent the low–speed spring and cap from dropping into the governor, be careful not to jar the assembly while it is being removed.

   b. Remove the high–speed spring from the high–speed plunger and add or remove shims as required to establish the desired engine no–load speed. *For each .010" shim added, the engine speed will be increased approximately 10 rpm.*

   c. Install the high–speed spring on the high–speed spring plunger and assemble the spring assembly in the governor housing. Install the spring retainer in the governor housing and tighten it securely.

- **CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the service technician must determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the *stop* posiiton. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.**

   d. Start the engine and recheck the engine no–load speed. Repeat the steps above as necessary to establish the no–load speed.

Adjust Idle Speed

With the maximum no–load speed properly set, adjust the idle speed as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed (Fig. 8).

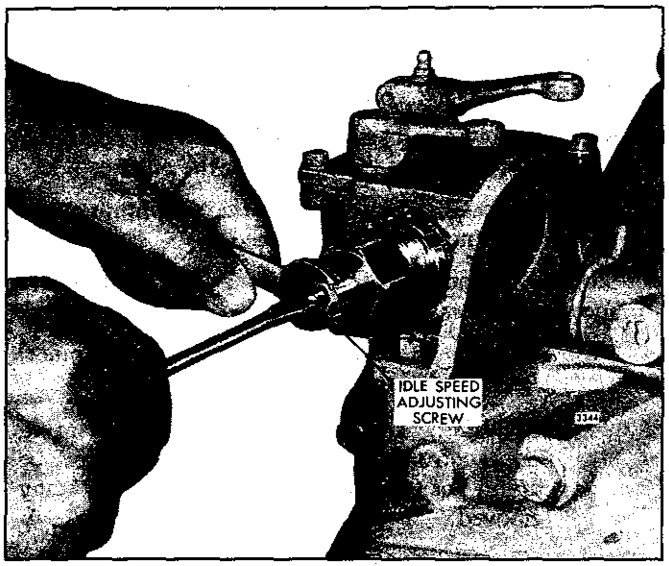


Fig. 8 – Adjusting Engine Idle Speed

The recommended idle speed is 500–600 rpm, but may vary with the particular engine application.

2. Hold the idle speed adjusting screw and tighten the locknut.

3. Install the high–speed spring cover and tighten the two bolts.

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, loosen the locknut and turn the buffer screw in so that it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 9). *Do not increase the engine idle speed more than 15 rpm with the buffer screw.*

2. Recheck the maximum no–load speed. If it has increased more than 25 rpm from the maximum speed attained in Step 1, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the locknut.

If the engine is equipped with a supplementary governing device, refer to Section 14.14 and adjust it at this time.

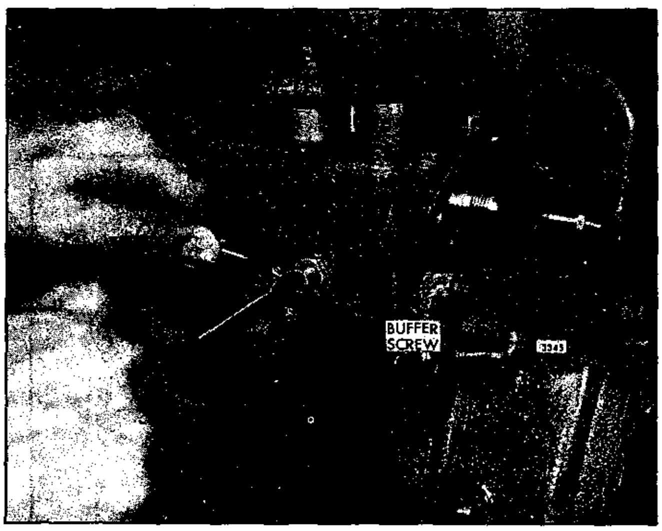


Fig. 9 – Adjusting the Buffer Screw

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT (V-TYPE ENGINE)

6V-53 ENGINE

The limiting speed mechanical governor is mounted at the rear of the engine, between the flywheel housing and the blower (Fig. 1). The governor is driven by the right blower rotor drive gear. The left blower rotor drive gear is driven by a shaft that passes through the governor housing from the engine gear train. There are two types of limiting speed governor assemblies. The difference in the two governors is in the spring mechanism (Fig. 8). One has a long spring mechanism, the other has a short spring mechanism.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. On turbocharged engines, the fuel (air box) modulator lever and roller assembly must be positioned free from cam contact. After the adjustments are completed, reconnect and adjust the supplementary governing device as outlined in Section 14.14.

Adjust Governor Gap

With the engine stopped and at operating temperature, adjust the governor gap as follows:

1. Remove the high-speed spring retainer cover.
2. Back out the buffer screw (Fig. 10) or de-energize the fast idle cylinder until it extends approximately 5/8" from the locknut.

   NOTICE: Do not back the buffer screw out beyond the limits given, or the control link lever may disengage the differential lever.

3. Start the engine and loosen the idle speed adjusting screw locknut. Then adjust the idle screw to obtain the desired idle speed (Fig. 9). Hold the screw and tighten the locknut to hold the adjustment. Governors used in turbocharged engine include a starting aid screw and locknut threaded into the governor gap adjusting screw.
4. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker covers. Discard the gaskets.
5. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever. *Do not overspeed the engine.*
6. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 2). The gap should be .002"-.004". If the gap setting is incorrect, reset the gap adjusting screw.

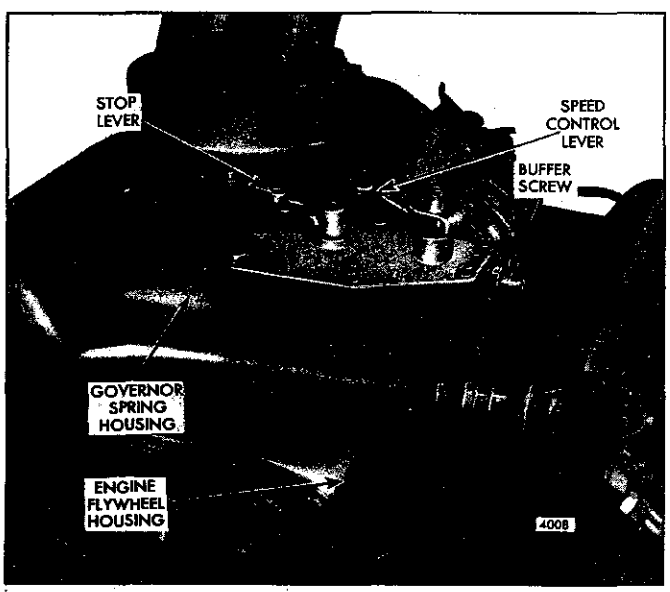


Fig. 1 – Limiting Speed Governor Mounting

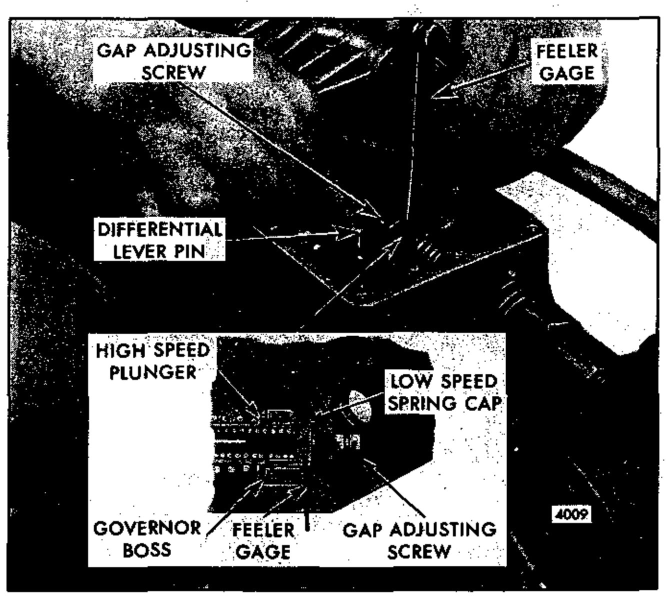


Fig. 2 – Adjusting Governor Gap

7. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.

8. Recheck the gap with the engine operating between 1100 and 1300 rpm and readjust, if necessary.

9. Stop the engine and, using a new gasket reinstall the governor cover. Do not install the governor cover and lever assembly at this time on turbocharged engines as they include an internal starting aid screw and locknut.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the *maximum speed* position.

2. Governor low–speed gap closed.

3. High–speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the *full–fuel* position.

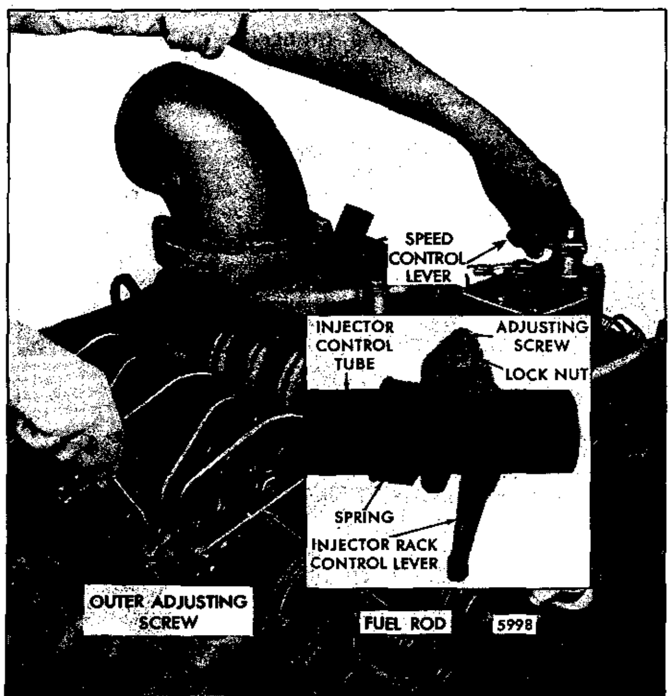


Fig. 3 – Positioning No. 3L Injector Rack Control Lever

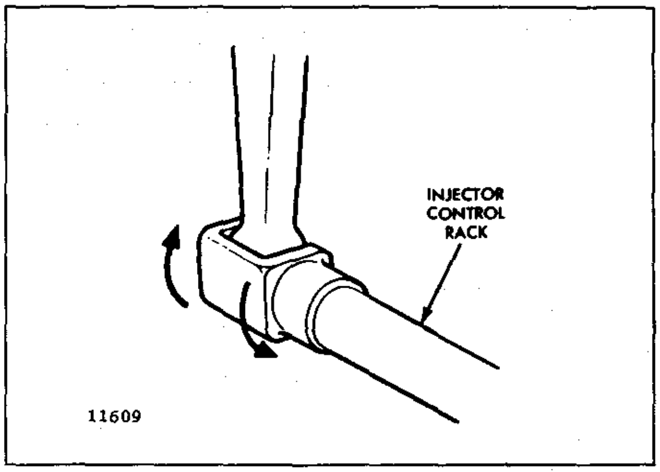


Fig. 4 – Checking Rotating Movement of Injector Control Rack

The letters "R" or "L" indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 3L injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect the linkage attached to the speed control lever.

2. Turn the idle speed adjusting screw until 1/2" of the threads (12–14 threads) project from the locknut when the nut is against the high–speed plunger. This adjustment lowers the tension of the low–speed spring so it can be easily compressed. This permits closing the low–speed gap without bending the fuel rods or causing the *yield mechanism springs to yield or stretch.*

   NOTICE: A false fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

3. Back out the buffer screw approximately 5/8" if it has not already been done.

4. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

5. Loosen all of the inner and outer injector rack control lever adjusting screws or the adjusting screws and locknuts on both injector control tubes (Fig. 3). Be sure all of the injector rack control levers are free on the injector control tubes.

6. Move the speed control lever to the *maximum speed* position and hold it in that position with light finger pressure.

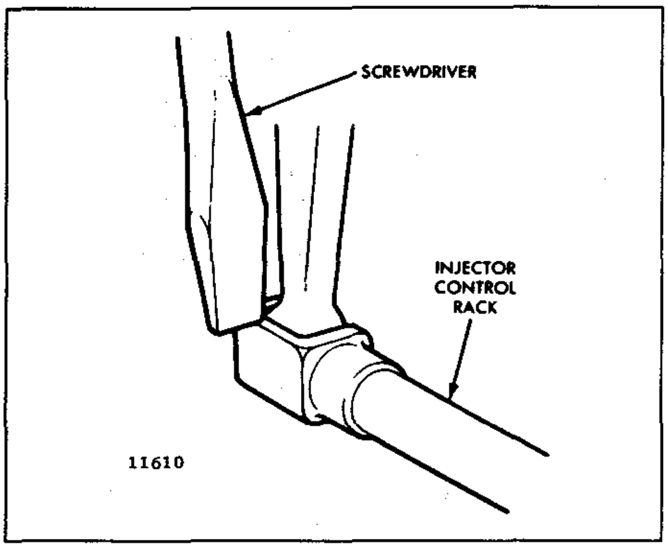


Fig. 5 – Checking Injector Control Rack Spring

Two Screw Assembly

Turn the inner adjusting screw on the No. 3L injector rack control lever down until a slight movement of the control tube lever is observed or a step–up in effort to turn the screwdriver is noted (Fig. 3). This will place the No. 3L injector in the *full–fuel* position.

Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly

Tighten the adjusting screw of the No. 3L injector rack control lever until the injector rack clevis is observed to roll up up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 3L injector rack in the *full–fuel* position.

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m).

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

7. To be sure of the proper rack adjustment, hold the speed control lever in the *maximum speed* position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack when the speed control lever is in the *maximum speed* position (Fig. 4). Hold the speed control lever in the *maximum speed* position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 5).

   If the rack does not return to its original position, it is too loose. To correct this condition with the *Two Screw Assembly,* back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly,* loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

   The setting is too tight if, when moving the speed control lever from the *no–speed* position to the *maximum speed* position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step–up in effort required to move the speed control lever to the end of its travel. To correct this condition with the *Two Screw Assembly,* back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly,* loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

8. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

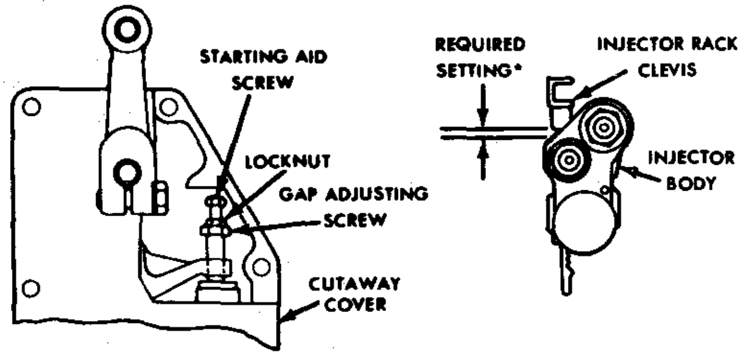
9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 3R injector rack control lever as previously outlined in Step 6 for the No. 3L injector rack control lever.

10. Insert the clevis pin in the fuel rod and the left cylinder bank injector control tube lever. Repeat the check on the No. 3L and 3R injector rack control levers as outlined in Step 7. Check for and eliminate any deflection which may occur at the bend in the fuel rod where it enters the cylinder head.

11. To adjust the remaining injector rack control levers, remove the clevis pin from the fuel rods and the injector control tube levers. Hold the injector control racks in the *full–fuel* position by means of the lever on the end of the control tube and proceed as follows:

    Two Screw Assembly

    a. Turn down the inner adjusting screw of the injector rack control lever until the screw bottoms (injector control rack in the *full–fuel* position).



INJECTOR	GAGE SETTING*	TOOL NUMBER
5A55	.345"	J 24889
5A60	.345"	J 24889
N55	.345"	J 24889
N60	.345"	J 24889
N65	.385"	J 24882
N70	.385"	J 24882
M60	.345"	J 24889
M70	.385"	J 24882

L-5870

Fig. 6 – Starting Aid Screw Adjustment

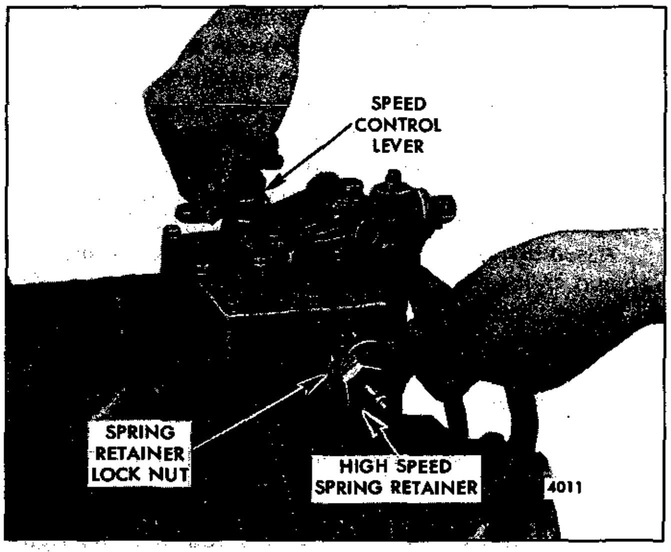


Fig. 7 – Adjusting Maximum No–Load Engine Speed

b. Turn down the outer adjusting screw of the injector rack control lever until it bottoms on the injector control tube.

c. While still holding the control tube lever in the full fuel position, adjust the inner and outer adjusting screws to obtain the same condition as outlined in Step 7. Tighten the screws.

NOTICE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m).

One Screw and Locknut Assembly

a. Tighten the adjusting screw of the No. 2L injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTICE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m).

b. Verify the injector rack adjustment of No. 3L as outlined in Step 7. If No. 3L does not "spring" back upward, turn the No. 2L adjusting screw counterclockwise slightly until the No. 3L injector rack returns to its *full–fuel* position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 3L and No. 2L injectors. Turn clockwise or counterclockwise the No. 2L injector rack adjusting screw until both No. 3L and No. 2L injector racks are in the *full–fuel* position when the locknut is securely tightened.

c. Adjust the remaining injectors using the proceedures outlined in Step "b" always verifying proper injector rack adjustment.

Once the No. 3L and No. 3R injector rack control levers are adjusted, do not try to alter their settings. All adjustments are made on the remaining control racks.

12. When all of the injector rack control levers are adjusted, recheck their settings. With the control tube lever in the *full–fuel* position, check each control rack as in Step 7. All of the control racks must have the same "spring" condition with the control tube lever in the *full–fuel* position.

13. Insert the clevis pin in the fuel rod and the injector control tube levers.

14. Turn the idle speed adjusting screw in until it projects 3/16" from the locknut to permit starting of the engine.

15. On *turbocharged engines* adjust the internal starting aid screw, as follows:

The starting aid screw has a locknut and the gap adjusting screw has a self locking patch.

a. Install a cutaway governor cover assembly, on the governor housing (Fig. 6).

b. With the engine stopped, place the governor stop lever in the *run* position and the speed control lever in the *idle* position.

c. Hold the gap adjusting screw to keep it from turning and adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the counter bore in the injector body (Fig. 6). Move the gage back and forth along the injector rack until a clearance of 1/64" is noted. The setting is measured at the No. 3R injector rack clevis. Tighten the locknut on the starting aid screw sufficiently to prevent oil leakage as well as to hold the adjusting screw setting.

d. Check the injector rack clevis–to–body clearance after performing the following.

   1. Position the stop lever in the *run* position.

   2. Move the speed control lever from the *idle* position to the *maximum speed* position.

   3. Return the speed control lever to the *idle* position.

   Movement of the governor speed control lever is to take up clearances in the governor linkage. The clevis–to–body clearance can be increased by backing out the starting aid screw or reduced by turning it farther into the gap adjustment screw.

e. Start the engine and recheck the running gap (.0015") and, if necessary, reset it and reposition the injector racks. Then stop the engine.

f. Remove the cutaway governor cover assembly.

g. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the throttle control shaft assembly in the slot of the differential lever and thae dowel pins in the housing in the dowel pin holes of the cover. Tighten the screws.

CAUTION: Before starting an engine after an engine speed control adjustment, or after removal of the engine governor cover and lever assembly, the service technician must determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.

16. Use new gaskets and reinstall the valve rocker covers.

Adjust Maximum No–Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no–load speed as given on the engine name plate, set the maximum no–load speed as follows:

TYPE A GOVERNOR SPRINGS (Fig. 8):

1. Loosen the locknut with a spanner wrench and back off the high–speed spring retainer several turns. Then start the engine and increase the speed slowly. If the speed exceeds the required no–load speed before the speed control lever reaches the end of its travel, back off the spring retainer a few additional turns.

2. With the engine at operating temperature and no load on the engine, place the speed control lever in the *maximum speed* position. Turn the high–speed spring retainer in (Fig. 7) until the engine is operating at the recommended no–load speed. Use an accurate hand tachometer to determine the engine speed. The maximum no–load speed varies with the full–load operating speed.

3. Hold the high speed spring retainer and tighten the locknut.

TYPE B GOVERNOR SPRINGS (Fig. 8):

1. Start the engine and, after it reaches normal operating temperature, remove the load from the engine.

2. Place the speed control lever in the *maximum speed* position and note the engine speed.

3. Stop the engine and, if necessary, adjust the no–load speed as follows:

   a. Remove the high–speed spring retainer with tool J 5895 and withdraw the high–speed spring and plunger assembly.

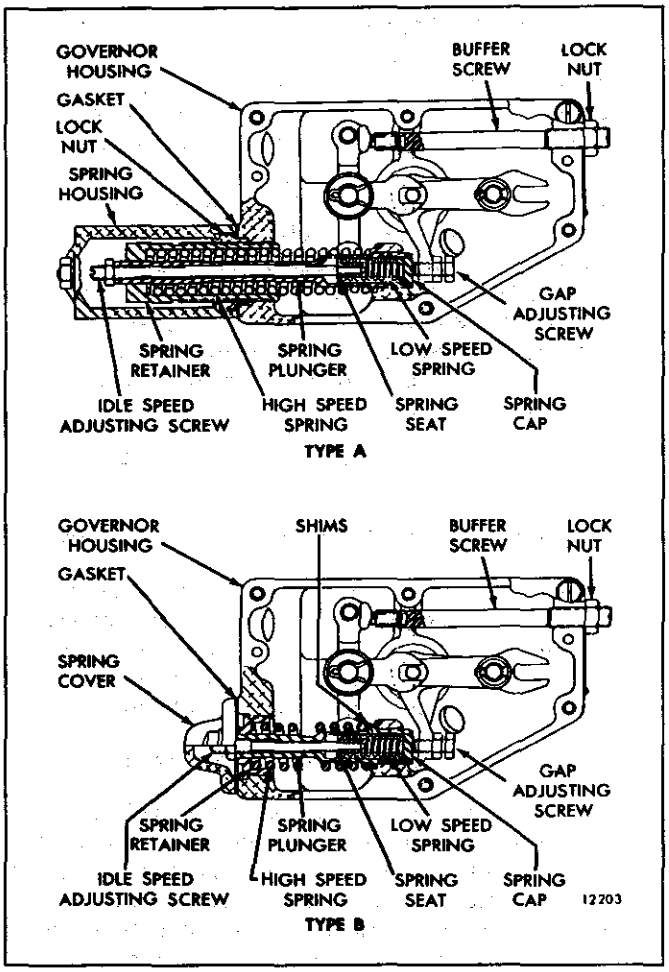


Fig. 8 – Governor Spring Assemblies

NOTICE: To prevent the low–speed spring and cap from dropping into the governor, be careful not to jar the assembly while it is being removed.

b. Remove the high–speed spring from the high–speed spring plunger and add or remove shims as required to establish the desired engine no–load speed. For each .010" in shims added, the engine speed will be increased approximately 10 rpm.

c. Install the high–speed spring on the plunger and install the spring assembly in the governor housing. Tighten the spring retainer securely. The maximum no–load speed varies with the full–load operating speed desired (Table 1).

If the full–load speed is to be 2800 rpm, then the no–load speed setting should be 2940 rpm (2800rpm + 140 rpm) to ensure the governor will move the injector racks into the *full–fuel* position at the desired full–load speed.

Full Load RPM	Maximum Governor Droop RPM
2401-2600	150
2601-2800	140

TABLE 1 – Engine Speed Droop

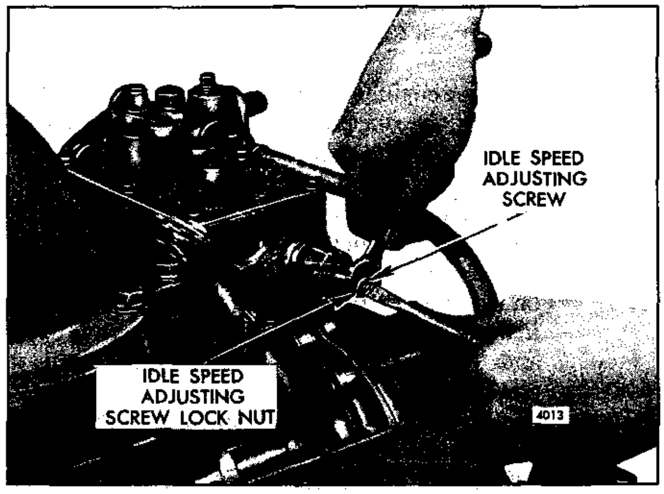


Fig. 9 – Adjusting Engine Idle Speed

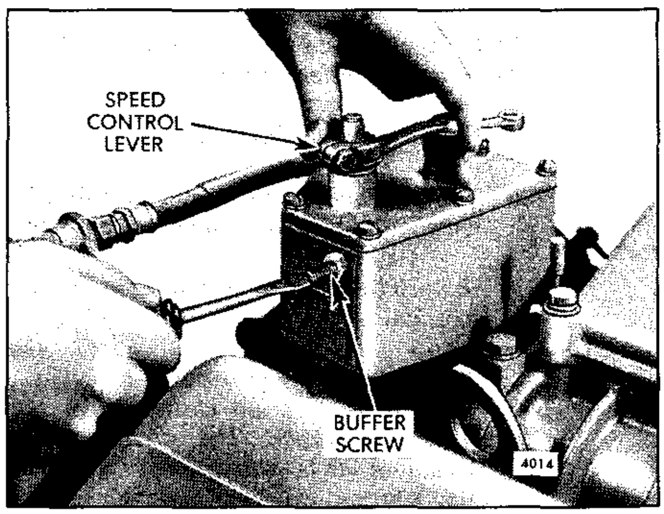


Fig. 10 – Adjusting Buffer Screw

d. Start the engine and recheck the no–load speed. Repeat the procedure, as necessary, to establish the no–load speed required.

Adjust Idle Speed

With the maximum no–load speed properly set, adjust the idle speed as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (Fig. 9) until the engine is operating at approximately 15 rpm below the recommended idle speed. The recommended idle

speed is 500–600 rpm, but may vary with the engine application.

If the engine has a tendency to stall during deceleration, install a new buffer screw. The current buffer screw uses a heavier spring and restricts the travel of the differential lever to the *off (no–fuel)* position.

2. Hold the idle screw and tighten the locknut.
3. Install the high–speed spring retainer cover and tighten the two bolts.

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in so it contacts the differential lever as lightly as possible and still eliminates engine roll (Fig. 10).

NOTICE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no–load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.
3. Hold the buffer screw and tighten the locknut.

After the governor adjustments are completed, adjust any supplementary governing device that may be used as outlined in Section 14.14.

8V–53 ENGINE

The limiting speed mechanical governor assembly is mounted on the front end of the blower (Fig. 11). The governor weight carrier shaft is attached to and driven by the left–hand helix rotor.

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and position the injector rack control levers.

Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device as outlined in Section 14.14.

Adjust Governor Gap

With the engine stopped and at normal operating temperature, set the governor gap as follows:

CAUTION: To avoid personal injury, if the governor gap adjustment is to be made with the engine in the vehicle, it is suggested that the fan assembly be removed due to the closeness of the fan blades to the engine governor.

1. Remove the high–speed spring retainer cover.
2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 17).

NOTICE: Do not back the buffer screw out beyond the limits given, or the control link lever may disengage the differential lever.

3. Start the engine and loosen the idle speed adjusting screw or locknut, if used. Then adjust the idle screw to obtain the desired idle speed (Fig. 16). Hold the screw and tighten the locknut to hold the adjustment.
4. Run the engine until the proper operating temperature is reached, then stop the engine and remove the governor cover, lever assembly and the engine valve rocker covers. Discard the gaskets.
5. Start and run the engine, between 1100 and 1300 rpm, by manual operation of the differential lever. *Do not overspeed the engine.*
6. Check the gap between the low–speed spring cap and the high–speed spring plunger with a feeler gage (Fig. 12). The gap should be .002"–.004". If the gap setting is incorrect, reset the gap adjusting screw.
7. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.

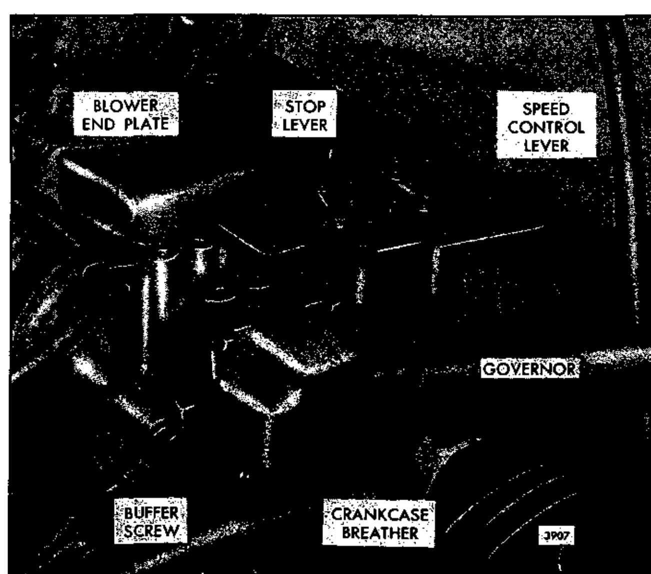


Fig. 11 – Limiting Speed Governor Mounting

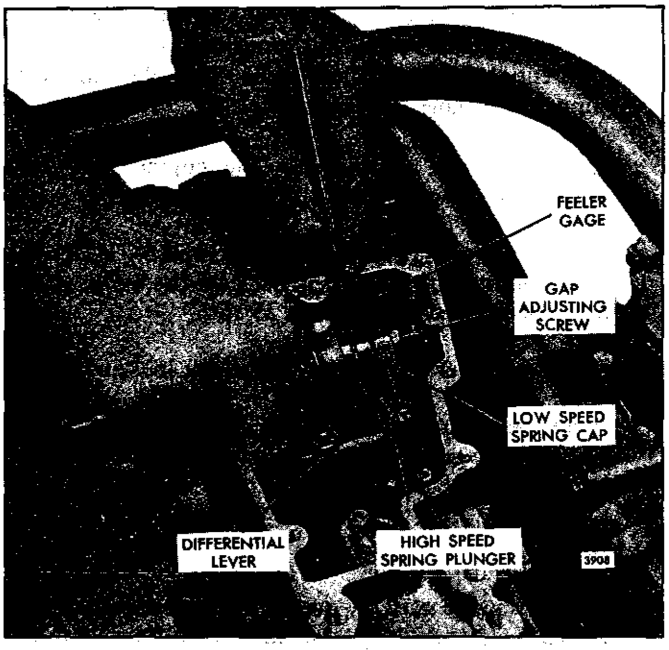


Fig. 12 – Checking Governor Gap

NOTICE: Governors which include a starting aid screw threaded into the end of the gap adjusting screw do not require a locknut as both screws incorporate a nylon patch in lieu of a locknut.

8. Recheck the gap with the engine operating between 1100 and 1300 rpm and readjust if necessary.

9. Stop the engine and, using a new gasket, install the governor cover.

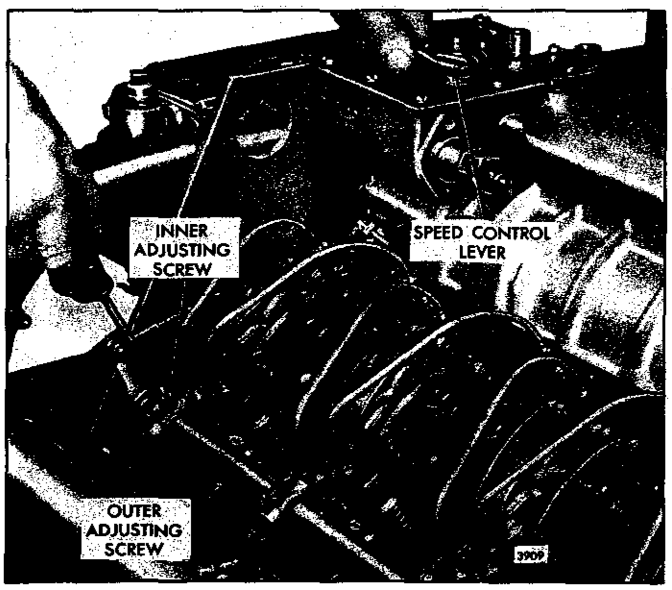


Fig. 13 – Positioning No. 1L Injector Rack Control Lever

10. If a starting aid screw is used, adjust it after the injector rack control levers are positioned.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the *full–fuel* position.
2. Governor low–speed gap closed.
3. High–speed spring plunger on the seat in the governor control housing.
4. Injector fuel control racks in the *full–fuel* position.

The letters "R" or "L" indicate the injector location in the right or left cylinder bank, viewed from the rear of the engine. Cylinders are numbered starting at the front of the engine on each cylinder bank. Adjust the No. 1L injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect the linkage attached to the speed control lever.

2. Turn the idle speed adjusting screw until about 1/2" of the threads (12–14 threads) projects from the locknut when the nut is against the high–speed plunger. This adjustment lowers the tension of the low–speed spring so it can be compressed, while closing the low–speed gap, without bending the fuel rods.

   NOTICE: A false fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

3. If not already done, back out the buffer screw as outlined in Step 2 under *Adjust Governor Gap.*

4. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.

5. Loosen all of the inner and outer injector rack control lever adjusting screws on both injector control tubes. Be sure all of the injector rack control levers are free on the injector control tubes.

6. Move the speed control lever to the *full–fuel* position and hold it in that position with light finger pressure. Turn the inner adjusting screw of the No. 1L injector rack control lever down (Fig. 13) until a slight movement of the control tube lever is observed or a step–up in effort to turn the screwdriver is noted. This will place the No. 1L injector in the *full–fuel* position. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately

tighten both the inner and outer adjusting screws. This should result in placing the governor linkage and the control tube assembly in the same positions they will attain while the engine is running at full load as previously described.

NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m).

7. To be sure of the proper rack adjustment, hold the speed control lever in the *full–fuel* position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack when the speed control lever is in the *full–fuel* position (Fig. 4). Hold the speed control lever in the *full–fuel* position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward (Fig. 5), and when the pressure of the screwdriver is released, the control rack should "spring" back upward.

   The setting is sufficiently tight if the rack returns to its original position. If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw.

   The setting is too tight if, when moving the speed control lever from the *idle speed* to the *maximum speed* position, the injector rack becomes tight before the speed control lever reaches the end of its travel (stop under the governor cover). This will result in a step–up in effort to move the speed control lever to its *maximum speed* position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

8. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.

9. Insert the clevis pin in the fuel rod and the right cylinder bank injector control tube lever and position the No. 1R injector rack control lever as previously outlined in Step 6 for the No. 1L injector rack control lever.

10. Insert the clevis pin in the fuel rod and the left cylinder bank injector control tube lever. Repeat the check on the No. 1L and No. 1R injector rack control levers as outlined in Step 7. Check for and eliminate any deflection which occurs at the bend in the fuel rod where it enters the cylinder head.

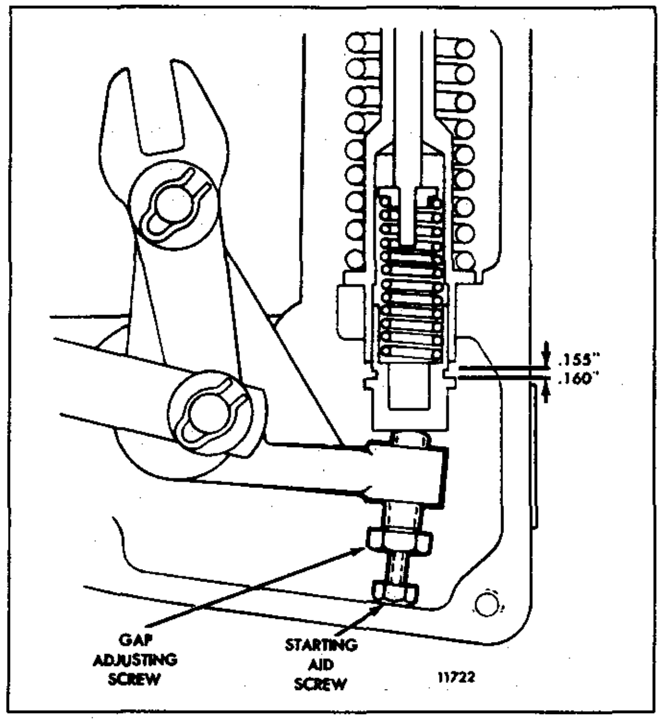


Fig. 14 – Adjust Starting Aid Screw

11. Manually hold the No. 1L injector rack in the *full–fuel* position and turn down the inner adjusting screw of the No. 2L injector rack control lever until the injector rack of the No. 2L injector has moved into the *full–fuel* position. Turn the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

12. Recheck the No. 1L injector rack to be sure it has remained snug on the ball end of the rack control lever while positioning the No. 2L injector rack. If the rack of the No. 1L injector has become loose, back off the inner adjusting screw slightly on the No. 2L injector rack control lever. Tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

13. Position the No. 3L and 4L injector rack control levers as outlined in Steps 11 and 12.

14. Position the No. 2R, 3R and 4R injector racks as outlined above for the left cylinder bank.

15. Turn the idle speed adjusting screw in until it projects 3/16" from the locknut to permit starting of the engine.

- **CAUTION: Before starting an engine after an engine speed control adjustment, or after removal of the engine governor cover and lever assembly, the service technician must**

determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.

16. Use new gaskets and reinstall the valve rocker covers.

Adjust Starting Aid Screw

The internal starting aid screw is threaded into the governor gap adjusting screw (Fig. 13). This screw is adjusted to position the injector racks at less than *full–fuel* when the governor speed control lever is in the *idle* position. The reduced fuel makes starting easier and reduces the amount of smoke on start–up.

NOTICE: The effectiveness of the starting aid screw will be eliminated if the speed control lever is advanced to wide open throttle during starting.

After the normal governor *running* gap of .0015" has been set and the injector racks positioned, adjust the starting aid screw as follows:

1. With the engine stopped, place the governor stop lever in the *run* position and move the speed control lever to the *idle* position.
2. Hold the gap adjusting screw, to keep it from turning, and adjust the starting aid screw to obtain .330" to .360" clearance between the shoulder on the No. 1L injector rack clevis and the injector body, with the head of the starting aid screw against the governor wall.

   With the engine stopped, this adjustment will provide a gap of .155" to .160" between the high–speed spring plunger and the low–speed spring cap (Fig. 14).
3. Move the stop lever to the *stop* position, with the speed control lever still in the *idle* position, and return it to the *run* position.
4. Recheck the injector rack clevis–to–body clearance. Movement of the governor stop lever is to take–up clearances in the governor linkage. The clevis to body clearance can be increased by backing out the starting aid screw or reduced by turning it farther into the gap adjusting screw.
5. Start the engine and recheck the *running* gap (.0015") and, if necessary, reset it. Then stop the engine.

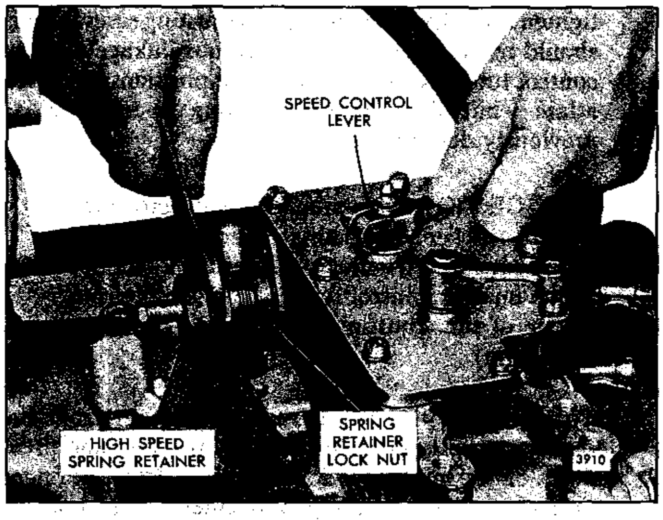


Fig. 15 – Adjusting Maximum No–Load Engine Speed

Fig. 16 – Adjusting Engine Idle Speed

Adjust Maximum No Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no–load speed as given on the engine name plate, set the maximum no–load speed as outlined below.

1. Loosen the locknut with a spanner wrench and back off the high–speed spring retainer several turns. Then start the engine and increase the speed slowly. If the speed exceeds the required no–load speed before the speed control lever reaches the end of its travel, back off the spring retainer a few additional turns.
2. With the engine at operating temperature and no load on the engine, place the speed control lever in the *maximum speed* position. Turn the high–speed spring retainer in (Fig. 14) until the engine is operating at the recommended no–load speed. Use an accurate hand

tachometer to determine the engine speed. The recommended speed droop is 150 rpm for governors with a full–load speed range of 2500–2800 rpm.

3. Hold the spring retainer and tighten the locknut.

Adjust Idle Speed

With the maximum no–load speed properly adjusted, adjust the idle speed as follows:

1. With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (Fig. 16) until the engine is operating at approximately 15 rpm below the recommended idle speed. *The recommended idle speed is 500 to 600 rpm, but may vary with special engine applications.*
2. Hold the idle screw and tighten the locknut.
3. Install the high–speed spring retainer cover and tighten the two bolts.

Adjust Buffer Screw

With the idle speed properly adjusted, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in (Fig. 17) so it contacts the differential lever as lightly as possible and still eliminates engine roll. *Do not increase the engine idle speed more than 15 rpm with the buffer screw.*
2. Recheck the maximum no–load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.
3. Hold the buffer screw and tighten the locknut to retain the adjustment.

After the governor adjustments are completed, adjust any supplementary governing device that may be used as outlined in Section 14.14.

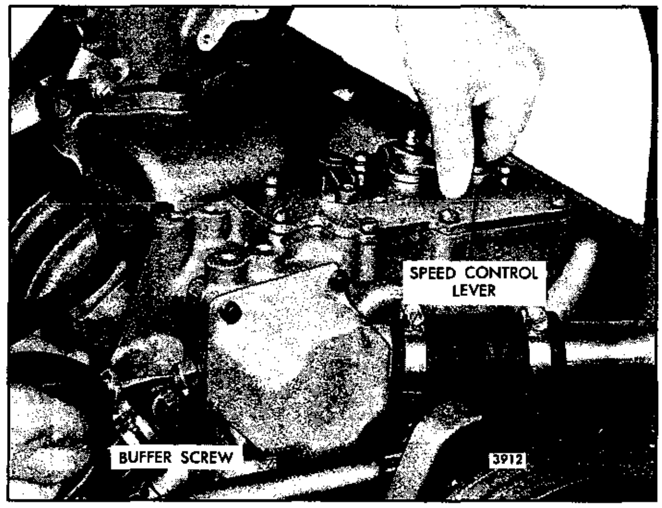


Fig. 17 – Adjusting Buffer Screw

LIMITING SPEED MECHANICAL GOVERNOR ADJUSTMENT (VARIABLE LOW-SPEED)

IN-LINE AND 6V-53 ENGINES

The variable low-speed limiting speed mechanical governor used on In-line and 6V-53 highway vehicle engines is of the double-weight type. It is used where the same engine powers both the vehicle and the auxiliary equipment for unloading bulk products (such as cement, grain or liquids) and a 500 to 1200 rpm idle speed range is desired during auxiliary operation. A service kit is available to convert the short spring pack 6V-53 double weight limiting speed governor assembly to a cable operated variable low-speed limiting speed governor for 500 to 1600 rpm idle speed range auxiliary operations.

During highway operation, the governor functions as a limiting speed governor, controlling the engine idling speed and limiting the maximum operating speed. At the unloading area, the throttle is left in the idle speed position and the speed adjusting handle, on the cable operated governor (Fig. 1), is turned to the speed required within the above range to operate the auxiliary equipment. For the air operated governor (Fig. 2), the engine speed is changed to the speed required by increasing or decreasing the air supply pressure to the governor. The governor, then functions as a variable speed governor, maintaining a constant speed when the load is constantly changing, during the unloading operation. Before resuming highway operations, the speed adjusting handle on the cable operated governor must be turned back to the stop, then turned ahead about one-quarter of a turn. The air operated governor's air supply pressure must be vented before resuming highway operations.

- **CAUTION: Failure to return the device to normal idle speed could result in loss of control of the engine at idle, causing possible personal injury.**

Governor identification is provided by a name plate attached to the governor housing. The letters V.L.S.-L.S. stamped on the name plate denote a variable low-speed limiting speed mechanical governor.

After adjusting the exhaust valves and timing the injectors, adjust the governor and position the injector rack control levers.

Adjust Governor Gap

With the engine at operating temperature, adjust the governor gap as follows:

1. Stop the engine, remove the two bolts and withdraw the spring housing. Discard the gasket.

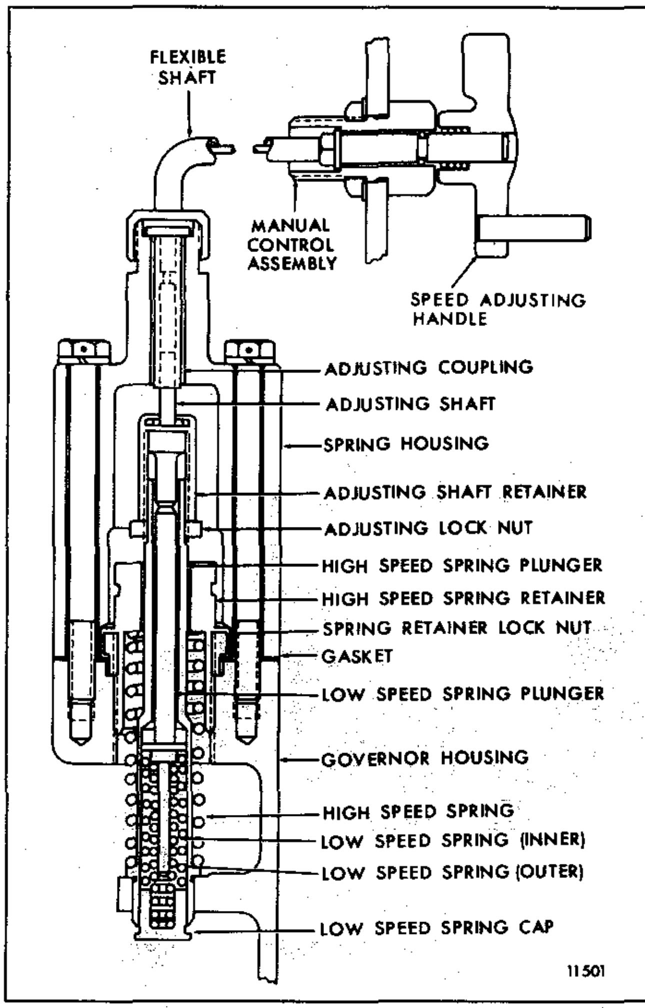


Fig. 1 – Cable Operated Governor Spring Housing and Components

2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

3. For *Cable Operated Governors* make a preliminary idle speed (normal highway idle speed) adjustment as follows (Fig. 1):

   a. Back out the variable low-speed adjusting shaft until the shoulder on the shaft contacts the shaft retainer.

   b. Start the engine. Then, hold the locknut and loosen the low-speed adjusting shaft retainer.

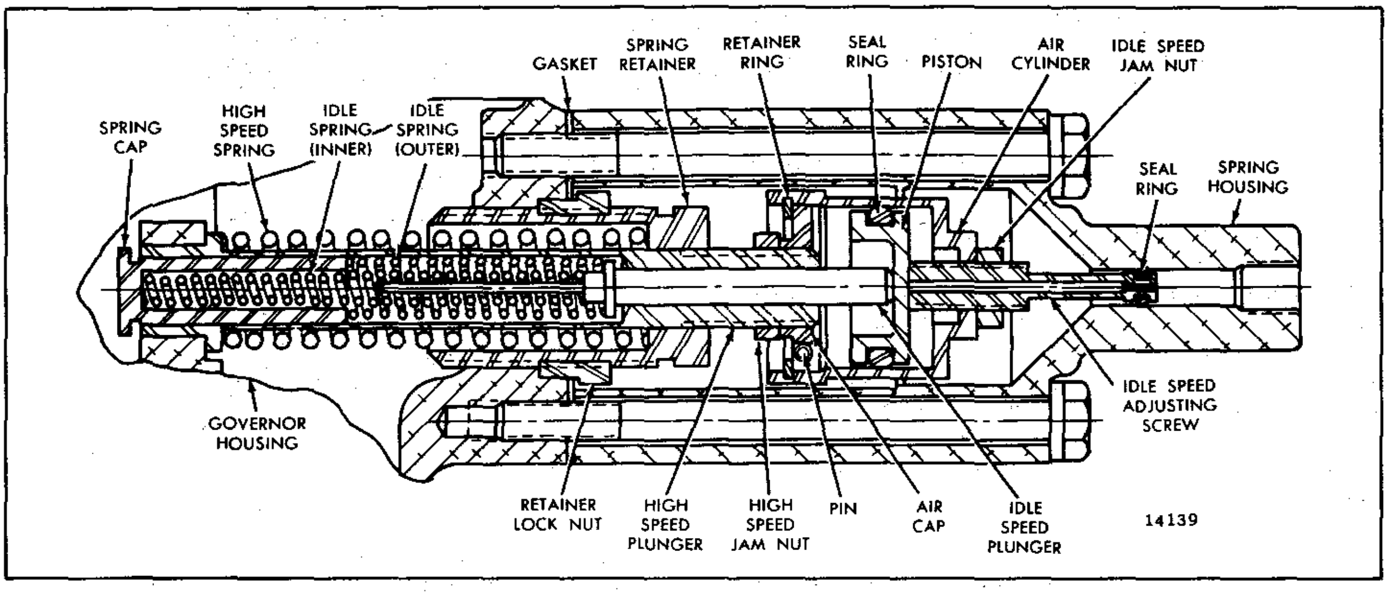


Fig. 2 – Air Operated Governor Spring Housing and Components

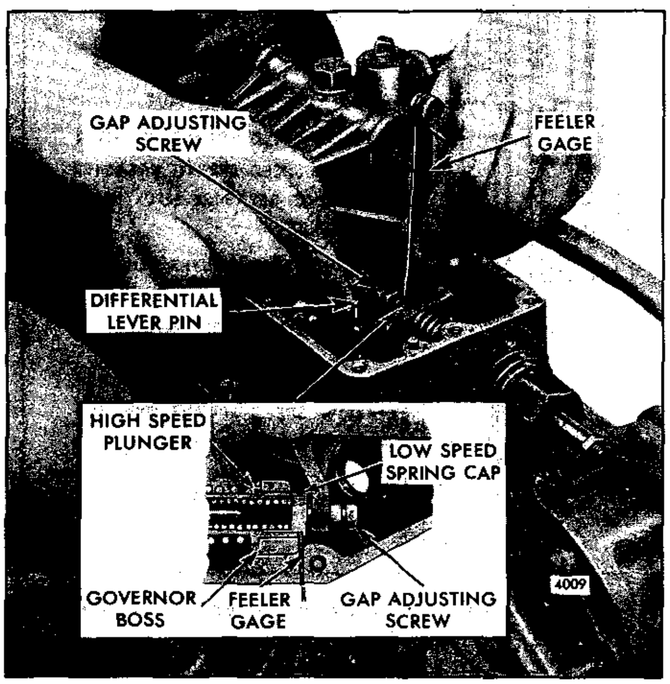


Fig. 3 – Adjusting Governor Gap

c. Adjust the retainer and shaft assembly to obtain the desired idle speed (500 rpm minimum). Then, hold the retainer and tighten the locknut to retain the adjustment.

   It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8").

d. Install the spring housing, using a new gasket. Tighten the attaching bolts.

4. For *Air Operated Governors* make a preliminary idle speed (normal highway idle speed) adjustment as follows (Figure 2):

   Adjust the maximum idle speed.

   a. Loosen the idle speed and high idle speed jam (lock) nuts.

   b. Turn the idle speed adjusting screw clockwise into the air cylinder, until the piston contacts the air cap. The air cylinder should be 2 or 3 threads from its position of maximum engagement with the high–speed spring plunger, to prevent the piston from contacting the high speed plunger before it contacts the air cap. *Do not force the idle speed adjusting screw.*

   c. Start the engine. With the speed control lever in the idle position, turn the air cylinder clockwise to raise the idle speed and counterclockwise to lower the idle speed.

   d. Lock the air cylinder to the high speed plunger with the jam nut in the position which provides the desired maximum idle speed.

   Adjust the minimum idle speed adjustment. *Make this adjustment after the maximum idle speed adjustment is completed.*

   a. Run the engine with the speed control lever in the idle speed position.

   b. Turn the idle speed adjusting screw counterclockwise to lower the idle speed and clockwise to raise the idle speed.

   c. Lock the idle speed adjusting screw with the jam nut, in the position which provides the desired minimum idle speed.

d. Stop the engine and lubricate the bore of the spring housing with engine lubricating oil.

e. Install the spring housing, using a new gasket. Tighten the attaching bolts.

5. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker covers. Discard the gaskets.

6. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever. *Do not overspeed the engine.*

7. Check the gap between the low–speed spring cap and the high–speed spring plunger with a feeler gage (Fig. 1). The gap should be .002"–.004". If the gap setting is incorrect, reset the gap adjusting screw.

8. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.

9. Recheck the gap with the engine operating between 1100 rpm and 1300 rpm and readjust, if necessary.

10. Reinstall the governor cover and lever assembly.

Position Injector Rack Control Levers

Position the injector rack control levers as outlined in Section 14.3.1 or 14.3.2.

- **CAUTION: Before starting an engine after an engine speed control adjustment, or after removal of the engine governor cover and lever assembly, the service technician must determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the *stop* position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.**

Adjust Maximum No–Load Engine Speed

Adjust the maximum no–load engine speed as outlined for the limiting speed mechanical governor in Section 14.3.1 or 14.3.2.

Adjust Idle Speed

Adjust the normal highway idle speed as follows:

With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, hold the locknut and loosen the variable low–speed adjusting shaft retainer. Adjust the retainer and shaft assembly to obtain a minimum of 500 rpm.

It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8").

Adjust Buffer Screw

Adjust the buffer screw as outlined in Section 14.3.1 or 14.3.2.

After the governor tune–up is completed, install the variable low–speed adjuster coupling and spring housing. Center the coupling before securing the spring housing to the governor. Install the flexible shaft and manual control assembly.

LIMITING SPEED MECHANICAL GOVERNOR ADJUSTMENT (FAST IDLE CYLINDER)

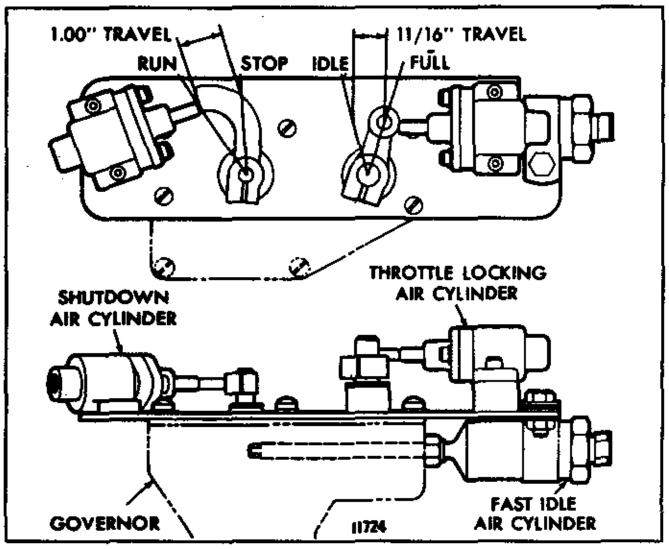


Fig. 1 – Governor with Fast Idle Cylinder

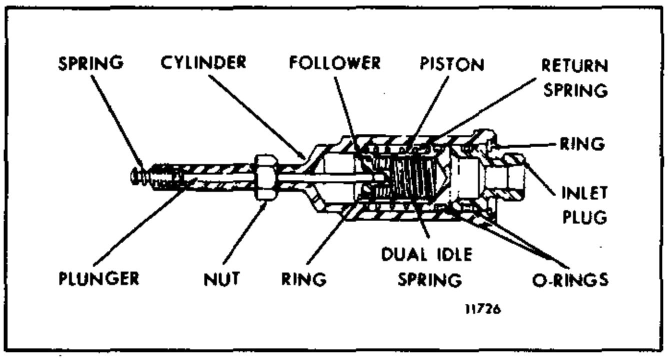


Fig. 2 – Fast Idle Air Cylinder

The limiting speed governor equipped with a fast idle air cylinder is used on vehicle engines where the engine powers both the vehicle and auxiliary equipment.

The fast idle system consists of a fast idle air cylinder installed in place of the buffer screw and a throttle locking air cylinder mounted on a bracket fastened to the governor cover (Fig. 1). An engine shutdown air cylinder, if used, is also mounted on the governor cover.

The fast idle air cylinder and the throttle locking air cylinder are actuated at the same time by air from a common air line.

The engine shutdown air cylinder is connected to a separate air line. The air supply for the fast idle air cylinder is usually controlled by an air valve actuated by an electric solenoid. The fast idle system should be installed so that it will function only when the parking brake system is in operation to make it tamper-proof.

The vehicle accelerator–to–governor throttle linkage is connected to a yield link so the operator cannot overcome the force of the air cylinder holding the speed control lever in the idle position while the engine is operating at the single fixed high idle speed.

Operation

During highway operation, the governor functions as a limiting speed governor.

For operation of auxiliary equipment, the vehicle is stopped and the parking brake set. Then, with the engine running, the low speed switch is placed in the ON position. When the fast idle air cylinder is actuated, the force of the dual idle spring (Fig. 2) is added to the force of the governor low–speed spring, thus increasing the engine idle speed.

The governor now functions as a constant speed governor at the high idle speed setting, maintaining a near constant engine speed regardless of the load within the capacity of the engine. The fast idle system provides a single fixed high idle speed that is not adjustable, except by disassembling the fast idle air cylinder and changing the dual idle spring. As with all mechanical governors, when load is applied, the engine speed will be determined by the governor droop.

Adjust Governor

Adjust the governor as outlined in Section 14.3.2. However, before adjusting the governor gap, back out the de–energized fast idle air cylinder until it will not interfere with the governor adjustments. After the normal idle speed setting is made, adjust the de–energized fast idle air cylinder as follows:

1. Turn in the fast idle cylinder assembly until an increase of idle speed is noted. The increase in idle speed should not exceed 15 rpm. Tighten the fast idle jam nut.

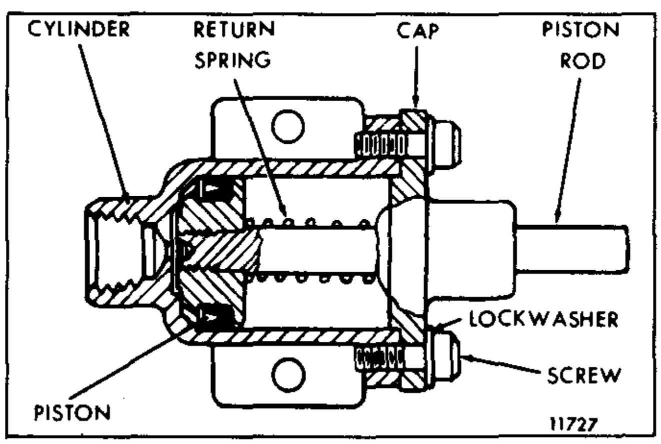


Fig. 3 – Throttle Locking Air Cylinder

2. Lock the governor throttle in the idle position and apply full shop air pressure to the fast idle air cylinder. The engine idle speed must increase 250–800 rpm, depending upon the dual idle spring used.

The throttle locking air cylinder is adjusted on its mounting bracket so it will lock the throttle in the idle position when it is activated, but will not limit the throttle movement when not activated.

VARIABLE SPEED MECHANICAL GOVERNOR (OPEN LINKAGE) AND INJECTOR RACK CONTROL ADJUSTMENT

IN-LINE ENGINES

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor (Fig. 1) and the injector rack control levers.

Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. On turbocharged engines, the fuel (air box) modulator lever and roller assembly must be positioned free from cam contact. After the adjustments are completed, reconnect and adjust the supplementary governing device as outlined in Section 14.14.

Preliminary Governor Adjustments

1. Clean the governor linkage and lubricate the ball joints and bearing surfaces with clean engine oil.

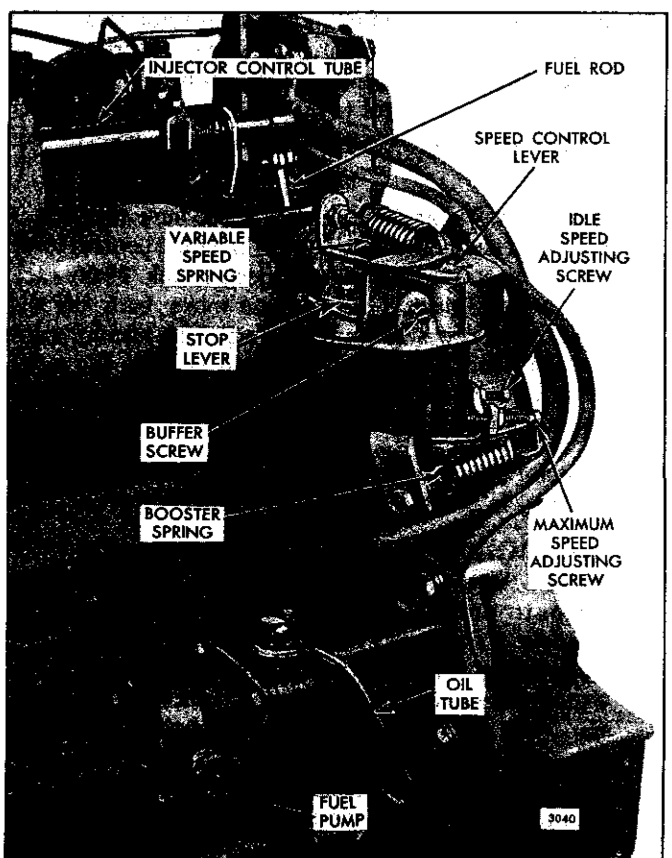


Fig. 1 – Variable Speed Open Linkage Governor Mounted on Engine

2. Back out the buffer screw until it projects 9/16" from the boss on the control housing.

3. Back out the booster spring eyebolt until it is flush with the outer locknut.

Adjust Variable Speed Spring Tension

1. Adjust the variable speed spring eyebolt until 1/8" of the threads project from the outer locknut (Fig. 2). This setting of the eyebolt will produce approximately 7% droop in engine speed from no load to full load.

2. Tighten both locknuts to retain the adjustment.

Position Injector Rack Control Levers

The position of the injector control racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load. Adjust the rear injector rack control lever first to establish a guide for adjusting the remaining levers.

1. Clean and remove the valve rocker cover. Discard the gasket.

Fig. 2 – Adjusting Governor Spring Eyebolt

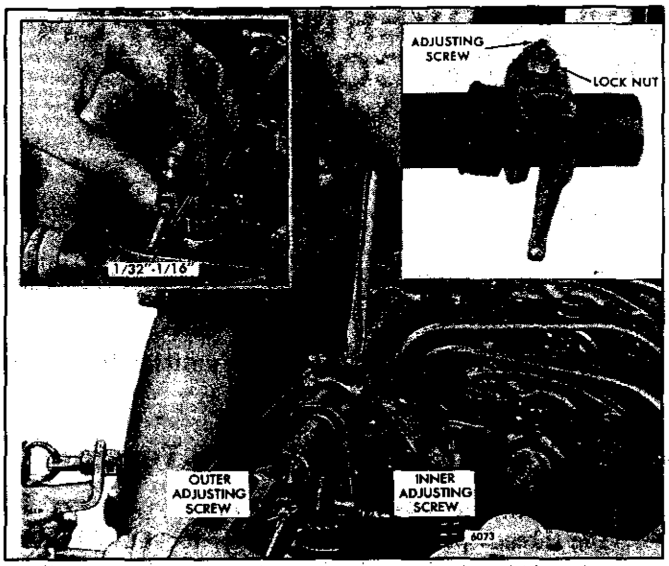


Fig. 3 - Adjusting Injector Rack Control Lever Adjusting Screws

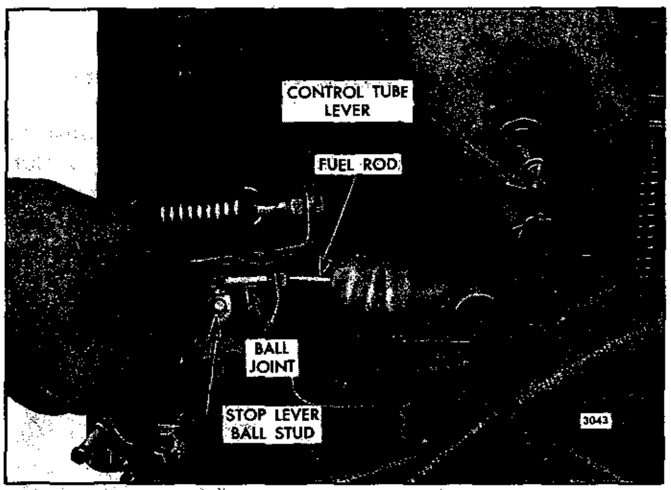


Fig. 4 - Adjusting Fuel Rod Length

2. Disconnect the fuel rod at the stop lever.
3. Loosen all of the injector rack control lever adjusting screws. Be sure all of the injector rack control levers are free on the injector control tube.
4. Move the speed control lever to the *maximum* speed position.
5. Move the rear injector control rack into the *full–fuel* position and note the clearance between the fuel rod and the cylinder head bolt. The clearance should be 1/32" or more. If necessary, readjust the injector rack adjusting screws until a clearance of at least 1/32" to 1/16" exists. Tighten the adjustment screws or screw and locknut (Fig. 3).
6. Loosen the nut which locks the ball joint on the fuel rod. Hold the fuel rod in the *full–fuel* position and adjust the ball joint until it is aligned and will slide on the ball stud on the stop lever (Fig. 4). Position the shutdown cable clip and tighten the fuel rod locknut to retain the adjustment.
7. Check the adjustment by pushing the fuel rod toward the engine and make sure the injector control rack is in the *full–fuel* position. If necessary, readjust the fuel rod. On units having the governor on the opposite side of the control rack, be sure the control rack lever will not contact the rocker cover.
8. Manually hold the rear injector rack in the *full–fuel* position, with the lever on the injector control tube. Turn the adjusting screw of the adjacent injector rack control lever until the injector rack moves into the *full–fuel* position.

   On the *Two Screw Assembly*, turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws. On the *One Screw and Locknut Assembly*, turn the adjusting screw until a slight roll–up on the injector rack clevis is observed or an increase in effort to turn the screwdriver is noted, then securely lock the adjusting screw locknut.

   NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24–36 **lb–in** (3–4 N·m).

9. Recheck the rear injector rack to be sure that it has remained snug on the ball end of the rack control lever while adjusting the adjacent injector rack. If the rack of the rear injector has become loose, back off the adjusting screw slightly on the adjacent injector rack control lever. When the settings are correct, the racks of all injectors must be snug on the ball end of their respective control levers.
10. Position the remaining injector rack control levers as outlined in Steps 8 and 9.

- **CAUTION: Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the service technician must determine that the injector racks move to the *no–fuel* position when the governor stop lever is placed in the *stop* posiiton. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever. An overspeeding engine can result in engine damage which could cause personal injury.**

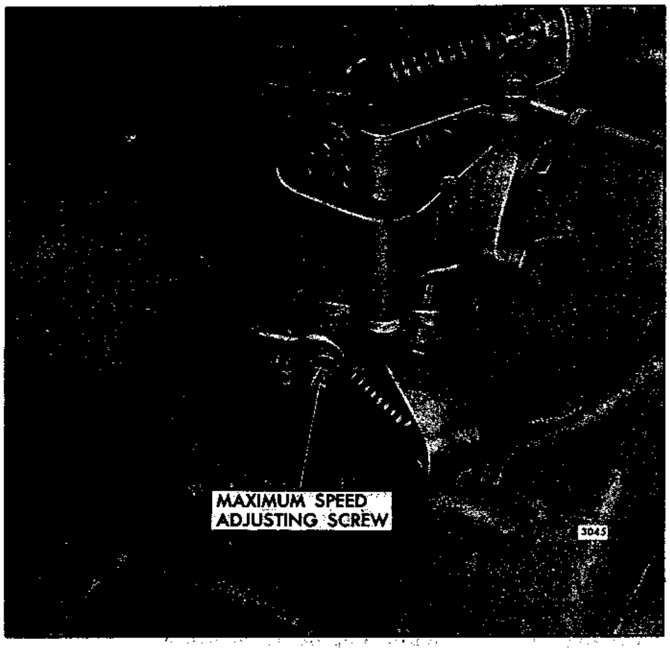


Fig. 5 – Adjusting Maximum No–Load Engine Speed

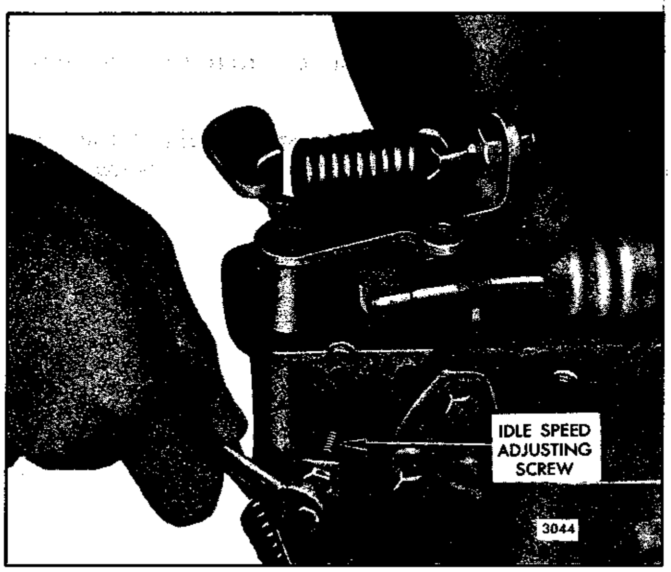


Fig. 6 – Adjusting Idle Speed

Adjust Maximum No–Load Speed

1. With the engine running, move the speed control lever to the maximum speed position. Use an accurate tachometer to determine the no–load speed of the engine. Do not overspeed the engine.

2. Loosen the locknut and adjust the maximum speed adjusting screw (Fig. 6) until the required no–load speed is obtained.

3. Hold the adjusting screw and tighten the locknut.

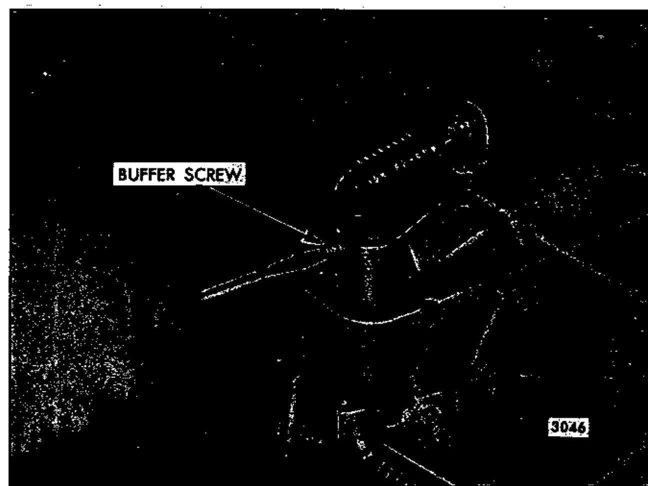


Fig. 7 – Adjusting Buffer Screw

Adjust Engine Idle Speed

1. Make sure the stop lever is in the run position and place the speed control lever in the idle position.

2. With the engine running at normal operating temperature, loosen the locknut and turn the idle speed adjusting screw (Fig. 6) until the engine idles at the recommended speed. The recommended idle speed is 500 rpm. However, the idle speed may vary with special engine applications.

3. Hold the idle speed adjusting screw and tighten the locknut.

Adjust Buffer Screw

1. With the engine running at idle speed, turn the buffer screw in (Fig. 7) so that it contacts the stop lever as lightly as possible and still eliminates engine roll. Do not raise the engine idle speed more than 20 rpm with the buffer screw.

2. Check the maximum no–load speed to make sure it has not increased over 25 rpm by the buffer screw setting.

Adjust Governor Booster Spring

The governor booster spring is used on some engines to reduce the force necessary to move the speed control lever from the idle speed position to the maximum speed position. Adjust the booster spring as follows:

1. Move the speed control lever to the idle speed position.

2. Reduce the tension on the booster spring, if not previously reduced, to the minimum by backing off the outer locknut (Fig. 8) until the end of the booster spring eyebolt is flush with the end of the nut.

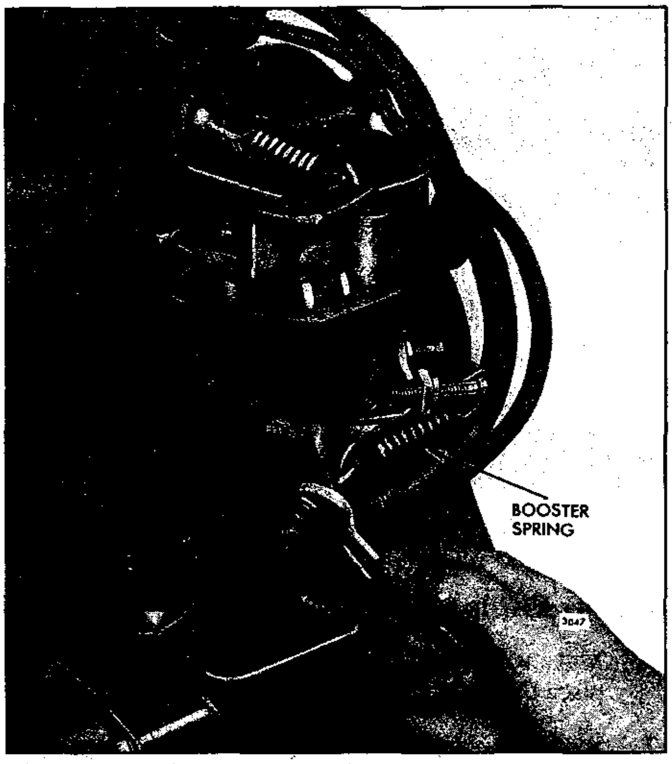


Fig. 8 – Adjusting Booster Spring

3. Adjust the eyebolt in the slot in the bracket so that an imaginary line through the booster spring will align with an imaginary center line through the speed control shaft. Secure the locknuts on the eyebolt to retain the adjustment.

4. Move the speed control lever to the maximum speed position and note the force required. To reduce the force, back off the inner locknut and tighten the outer locknut to increase the tension on the booster spring. Before tightening the locknuts, reposition the booster spring as in Step 3.

The setting is correct when the speed control lever can be moved from the idle speed position to the maximum speed position with a constant force, while the engine is running, and when released it will return to the idle speed position.

Adjust Engine Speed Droop

The adjustment of the spring tension as outlined under *Adjust Variable Speed Spring Tension* will result in approximately 7% droop from the maximum no–load speed to the full–load speed. This is the optimum droop setting for most applications. However, the droop may be changed as necessary, for a particular engine application.

1. Lower the speed droop by increasing the spring tension.

2. Raise the speed droop by decreasing the spring tension.

A change in the variable speed spring tension will change the engine idle speed and maximum no–load speed, which must also be readjusted.