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

IN-LINE ENGINES

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.

Back out the external starting aid screw.

Adjust Governor Gap

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

1. Disconnect any linkage attached to the governor levers.
2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

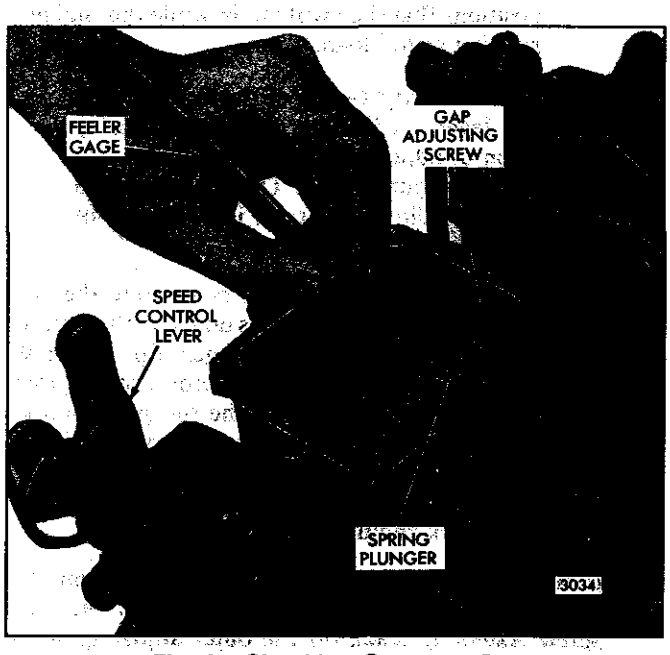


Fig. 1 – Checking Governor Gap

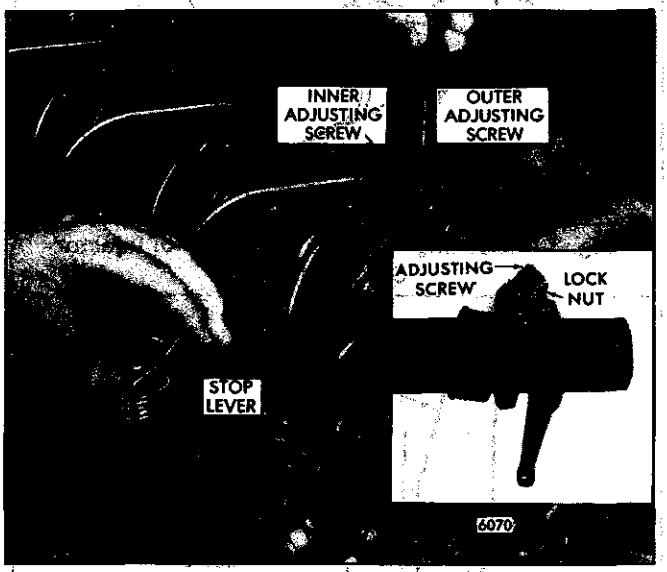


Fig. 2 – Positioning the Rear Injector Rack Control Lever

3. Clean and remove the governor cover and valve rocker cover. Discard the gaskets.
4. Place the speed control lever in the maximum speed position (Fig. 1).
5. Insert a .006" feeler gage between the spring plunger and the plunger guide (Fig. 1). If required, loosen the locknut and turn the gap adjusting screw in or out until a slight drag is noted on the feeler gage.
6. Hold the adjusting screw and tighten the locknut. Check the gap and readjust, if necessary.
7. Use a new gasket and reinstall the governor cover as follows:
   a. Place the cover on the governor housing, with the pin in the throttle shaft assembly entering the slot in the differential lever.
   b. Install the four cover screws and lock washers finger tight.
   c. Pull the cover assembly in a direction away from the engine, to take up the slack, and tighten the cover screws. This step is required since no dowels are used to locate the cover on the housing.

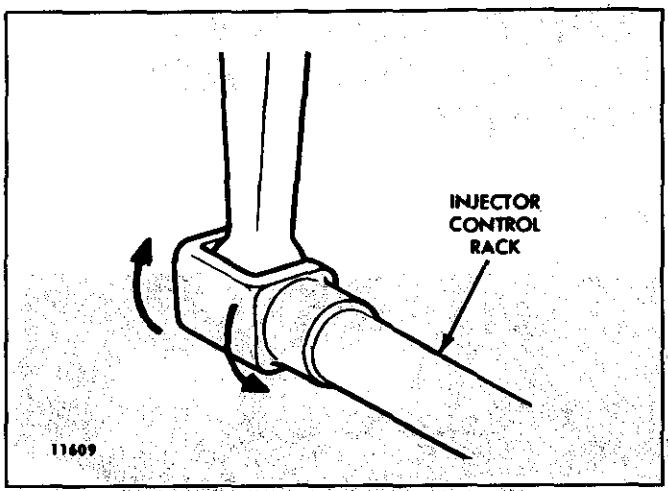


Fig. 3 – Checking Rotating Movement of Injector Control Rack

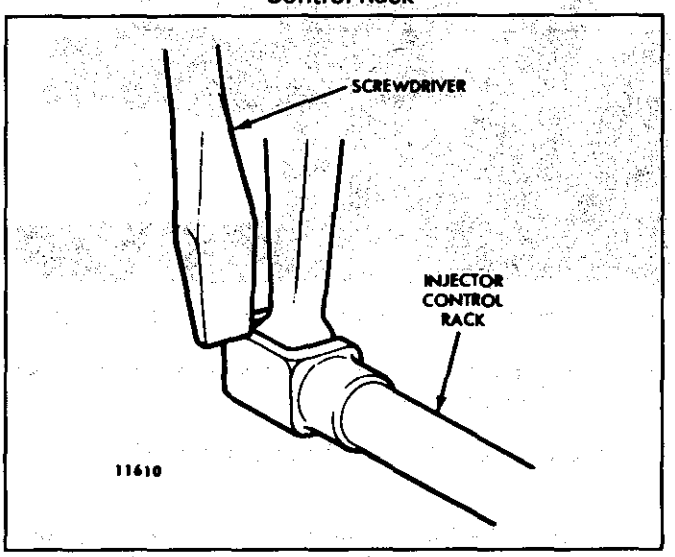


Fig. 4 – Checking Injector Control Rack Spring

Position Injector Rack Control Levers

The position of the injector control rack levers 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 control rack levers with the engine at full load will result in the following:

1. Speed control lever at the *maximum speed* position.
2. Stop lever in the *run* position.
3. Injector fuel control racks in the *full–fuel* position.

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

1. 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.
2. Move the speed control lever to the *maximum speed* position.
3. Move the stop lever to the *run* position and hold it in that position with light finger pressure.

   Two Screw Assembly

   a. Turn the inner adjusting screw of the rear injector rack control lever down until a slight movement of the control tube 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.

   b. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube.

   c. Then alternately tighten both the inner and outer adjusting screws.

   One Screw and Locknut Assembly

   a. 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.

   b. 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–fuel* position.

   This should result in placing the governor linkage and control tube in the respective positions that they will attain while the engine is running at full load.

   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).

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

   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. 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 stop lever from the *stop* to the *run* position, the injector rack becomes tight before the stop lever reaches the end of its travel. This will result in a step–up in effort required to move the stop lever to the *run* position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend).

If the rack is found to be too tight with the *Two Screw Assembly,* back off the inner adjusting screw slightly and tighten the outer adjusting screw. To correct this condition with the *One Screw and Locknut Assemsbly,* loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

5. Manually hold the rear injector control rack in the *full–fuel* position with the lever on the injector 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.

b. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube.

c. Then alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly

a. Tighten the adjusting screw of the adjacent 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.

b. 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).

6. 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 with the *Two Screw Assembly,* back off the inner adjusting screw slightly on the adjacent injector rack control lever and tighten the outer adjusting screw. With the *One Screw and Locknut Assembly,* turn the adjusting screw counterclockwise slightly until the rear injector rack returns to its *full–fuel* position and secure the adjusting screw locknut.

When the settings are correct, the racks of both injectors must be snug on the ball end of their respective control levers.

7. Position the remaining injector rack control levers as outlined in Steps 4, 5 and 6.

8. 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 4. All of the control racks must have the same "spring" condition with the control tube lever in the *full–fuel* position.

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

- **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.**

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

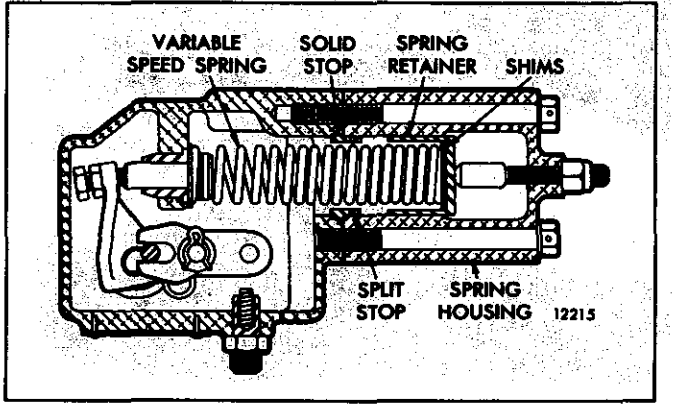


Fig. 5 – Location of Shims and Stops

Adjust Maximum No–Load 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 option plate, the maximum no–load speed may be set as follows:

1. Refer to Fig. 8 and disconnect the booster spring and the stop lever retracting spring.

2. Remove the two attaching bolts and withdraw the variable speed spring housing and the variable speed spring retainer located inside of the housing.

3. Refer to Table 1 and determine the stops or shims required for the desired full–load speed (Fig. 5). Do not use more than four thick and one thin shim. *A split stop can only be used with a solid stop.*

4. Install the variable speed spring retainer and housing and tighten the two bolts.

5. Connect the booster spring and stop lever spring. Start the engine and recheck the maximum no–load speed.

6. If required, add shims to obtain the necessary operating speed. For each .001" in shims added, the operating speed will increase approximately 2 rpm.

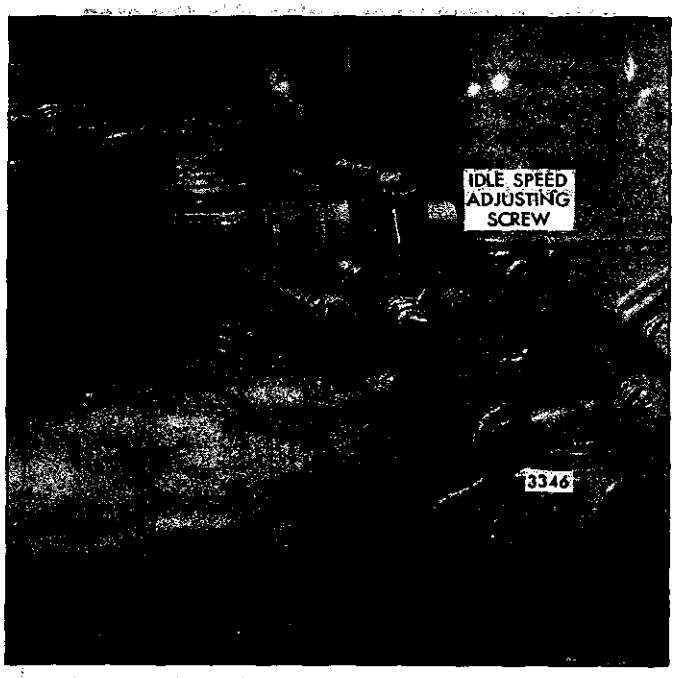


Fig. 6 – Adjusting Idle Speed

Full Load Speed RPM	STOPS		SHIMS
	Solid Ring	Split Ring	
2575-2800	0	0	As Required
2101-2575	1	0	As Required
1701-2100	1	1	As Required
1200-1700	1	2	As Required

TABLE 1

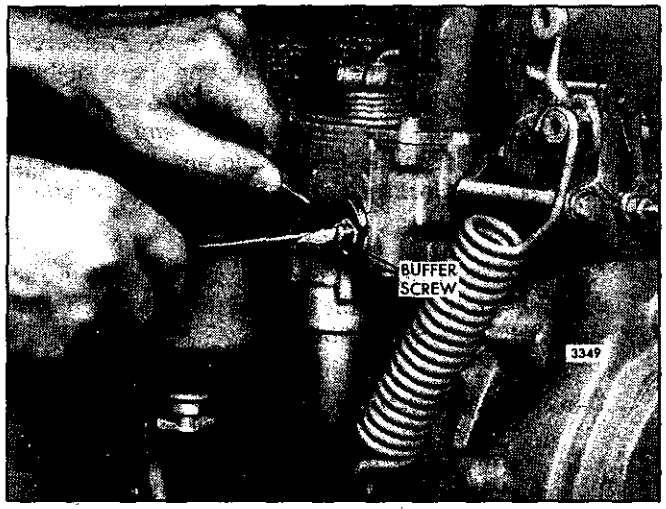


Fig. 7 – Adjusting Buffer Screw

If the maximum no–load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked. Governor stops are used to limit the compression of the governor spring which determines the maximum speed of the engine.

Adjust Idle Speed

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

1. Place the stop lever in the *run* position and the speed control lever in the *idle* position.

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the locknut and turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed (Fig. 6). The recommended idle speed is 550 rpm, but may vary with special engine applications.

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

Adjust Buffer Screw

1. With the engine running at normal operating temperature, turn the buffer screw in (Fig. 7) so that 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. Hold the buffer screw and tighten the locknut.

Adjust Booster Spring

With the engine idle speed set, adjust the booster spring as follows:

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

2. Refer to Fig. 8 and loosen the booster spring retaining nut on the speed control lever. Loosen the locknuts on the eyebolt at the opposite end of the spring.

3. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginary line through the bolt, lever shaft and eyebolt. Hold the bolt and tighten the locknut.

4. Start the engine and move the speed control lever to the *maximum speed* position and release it. The lever should return to the *idle speed* position. If it does not, reduce the booster spring tension. If it does, continue to increase the spring tension until the point is reached where it will not return to idle. Then reduce the spring tension until the lever does return to idle and tighten the locknuts on the eyebolt. This setting will result in the minimum force required to operate the speed control lever.

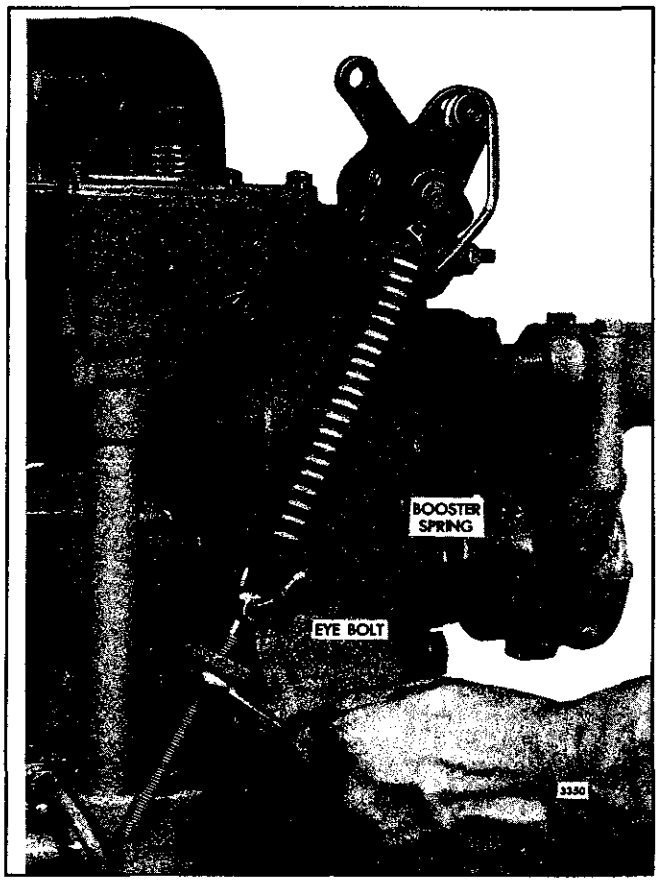
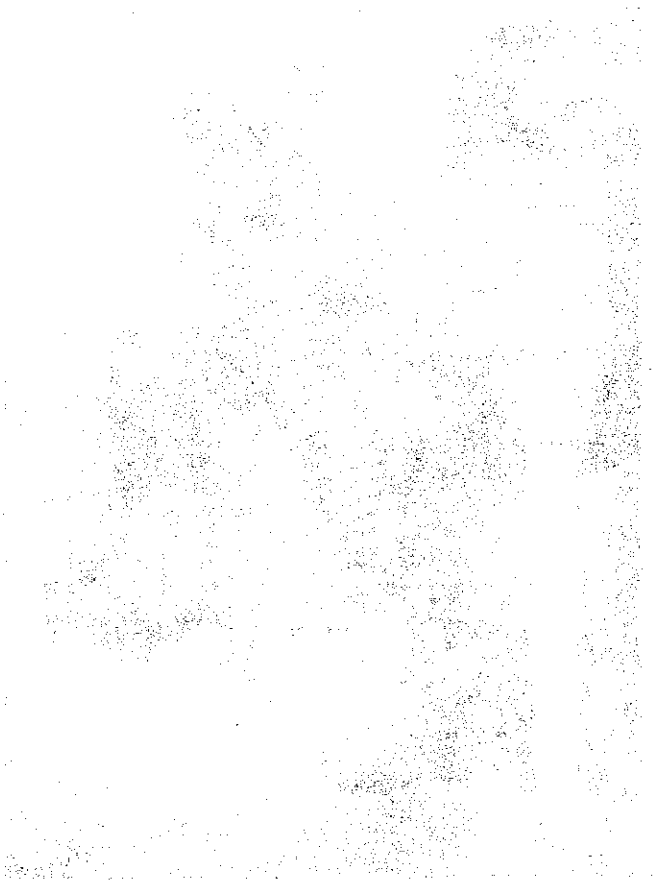


Fig. 8 – Adjusting Booster Spring

5. Connect the linkage to the governor levers.

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



VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

6V–53 ENGINES

The variable speed mechanical governor assembly is mounted at the rear of the 6V engine, between the flywheel housing and the blower (Fig. 1). The governor is driven by the right–hand blower rotor drive gear.

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

NOTICE: 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.

Adjust Governor Gap

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

1. Disconnect any linkage attached to the governor levers.
2. Back out the buffer screw until it extends approximately 5/8" from the lock nut.
3. Clean and remove the governor cover and the valve rocker covers. Discard the gaskets.
4. Place the speed control lever in the maximum speed position.

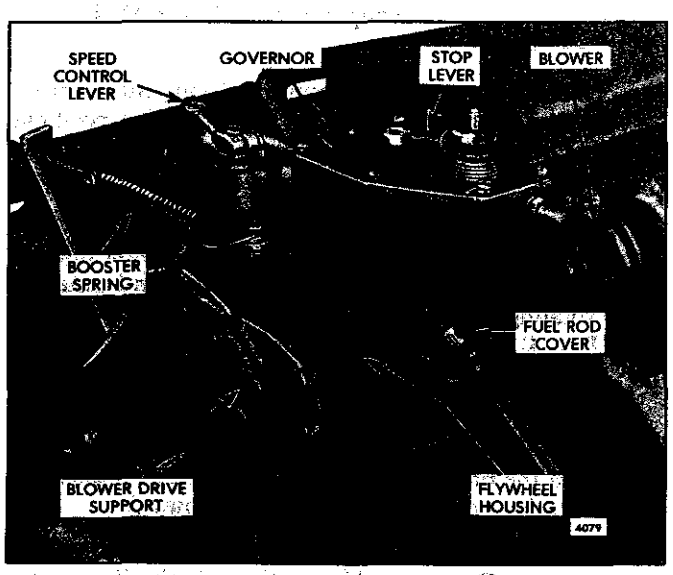


Fig. 1 – Variable Speed Governor Mounting

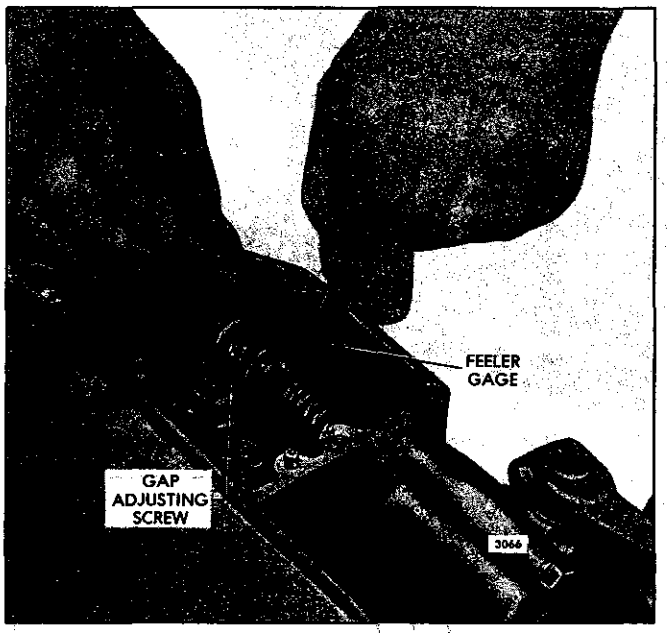


Fig. 2 – Adjusting Governor Gap

5. Insert a .006" feeler gage between the spring plunger and the plunger guide as shown in Fig. 2. If required, loosen the lock nut and turn the adjusting screw in or out until a slight drag is noted on the feeler gage.
6. Hold the adjusting screw and tighten the lock nut. Check the gap and readjust if necessary.
7. Use a new gasket and install the governor cover.

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.

Current engines use spring–loaded injector control tube assemblies which have a yield spring at each injector rack control lever and only one screw and lock nut to keep each injector rack properly positioned. Adjust the single screw and lock nut on each injector rack control lever the same as for the two screw rack control lever.

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. Stop lever in the RUN position.

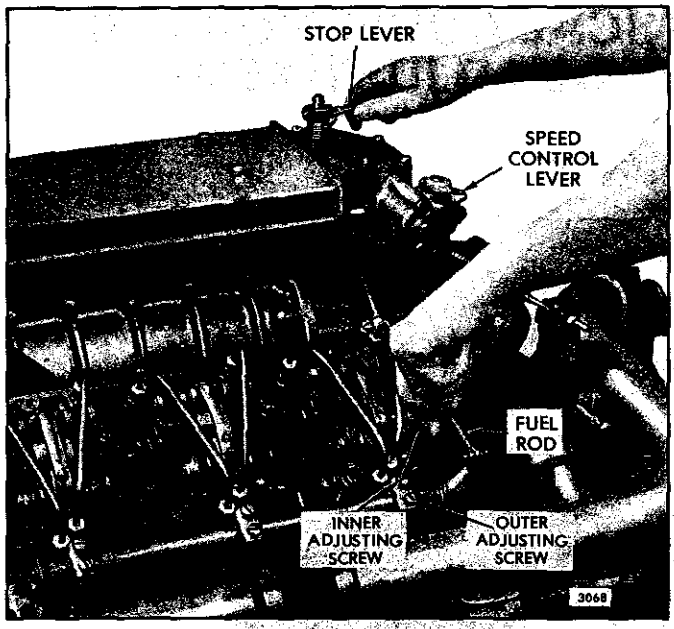


Fig. 3 – Positioning No. 3L Injector Rack Control Lever

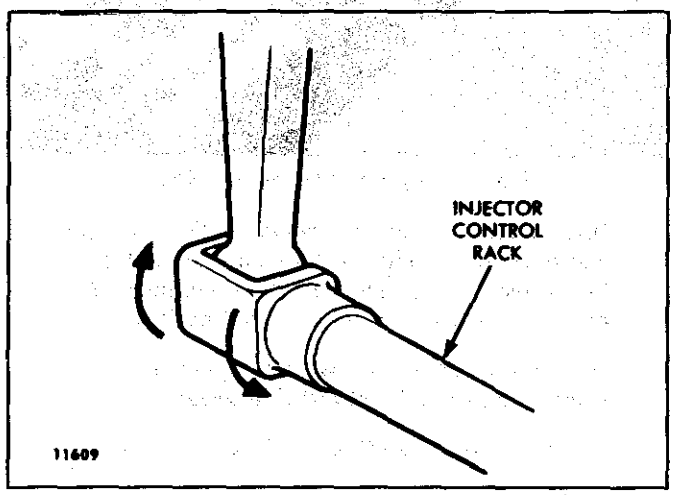


Fig. 4 – Checking Rotating Movement of Injector Control Rack

3. 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 as 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 levers.

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

2. 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.

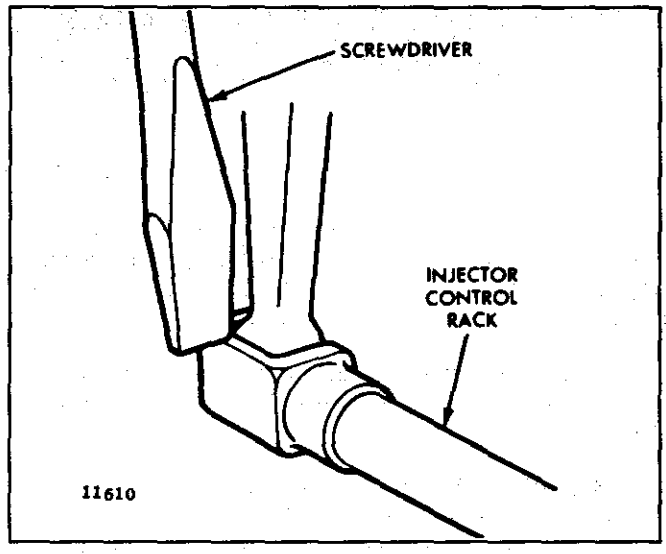


Fig. 5 – Checking Injector Control Rack Spring

3. Move the speed control lever to the maximum speed position.

4. Move the stop lever to the *run* position and hold it in that position with light finger pressure. Turn the inner adjusting screw of the No. 3L injector rack control lever down (Fig. 3) until a slight movement of the control tube is observed, or a step–up in effort to turn the screw driver is noted. This will place the No. 3L injector rack in the *full–fuel* position. 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.

   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 steps should result in placing the governor linkage and control tube in the respective positions that they will attain while the engine is running at full load.

5. To be sure of proper rack adjustment, hold the stop lever in the *run* position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack (Fig. 4).

   Hold the stop lever in the *run* 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.

   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 stop lever from the *stop* to the *run* position, the injector rack becomes tight before the governor stop lever reaches the end of its travel. This will result in a step–up in effort required to move the stop lever to the *run* position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is found to be too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.

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

7. 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 4 for the No. 3L control lever.

8. Insert the clevis pin in the fuel rod and the left bank injector control tube lever. Repeat the check on the 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.

9. 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:

   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).

   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 5. Tighten the screws.

   NOTICE: 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.

10. 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 5. All of the control racks must have the same "spring" condition with the control tube lever in the *full–fuel* position.

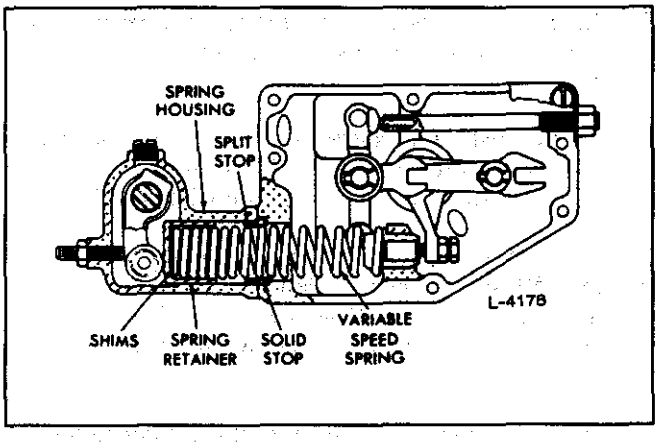


Fig. 6 – Location of Shims and Stops

11. Insert the clevis pin in the fuel rods and the injector control tube levers.

12. Use new gaskets and install the valve rocker covers.

Adjust Maximum No–Load 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, the maximum no–load speed may be set as follows:

Start the engine and after it reaches normal operating temperature, determine the maximum no–load speed of the engine with an accurate tachometer. Then stop the engine and make the following adjustments, if required.

1. Refer to Fig. 9 and disconnect the booster spring and the stop lever retracting spring.

2. Remove the variable speed spring housing and the spring retainer, located inside of the housing from the governor housing.

3. Refer to Table 1 and determine the stops or shims required for the desired full–load speed. A split stop can only be used with a solid stop (Fig. 6).

4. Install the variable speed spring retainer and housing and tighten the two bolts.

Full–Load Speed	Stops		Shims*
	Solid	Split	
1200–2100	1	1	As Required
2100–2500	1	0	As Required
2500–2800	0	0	As Required

*Maximum amount of shims .325"

1 TABLE 1

5. Connect the booster spring and the stop lever spring. Start the engine and recheck the maximum no–load speed.

6. If required, add shims to obtain the necessary operating speed. For each .001" in shims added, the operating speed will increase approximately 2 rpm.

If the maximum no–load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

Governor stops are used to limit the compression of the governor spring, which determines the maximum speed of the engine.

Adjust Idle Speed

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

1. Place the stop lever in the *run* position and the speed control lever in the *idle* position.

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the lock nut and turn the idle speed adjusting screw (Fig. 7) until the engine is operating at approximately 15 rpm below the recommended idle speed. The recommended idle speed is 550 rpm, but may vary with special engine applications.

4. Hold the idle speed adjusting screw and tighten the lock nut.

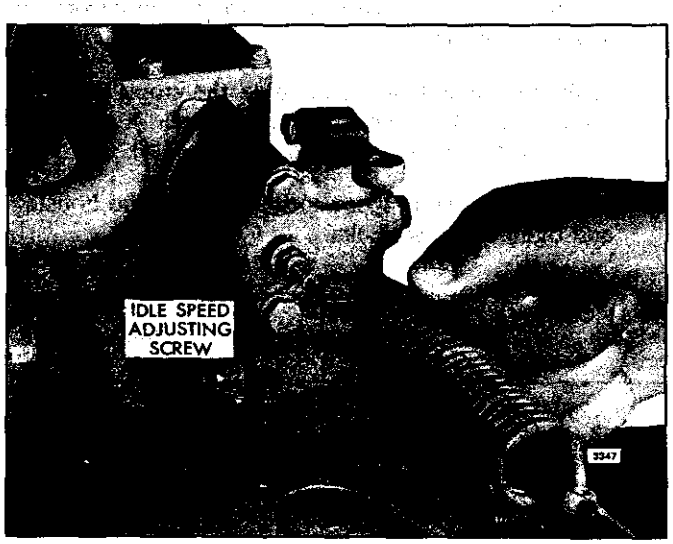


Fig. 7 – Adjusting Idle Speed

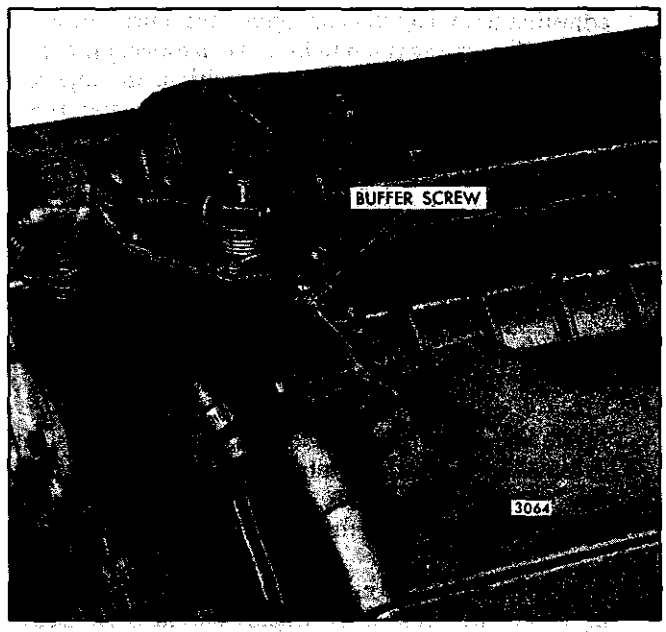


Fig. 8 – Adjusting Buffer Screw

Adjust Buffer Screw

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

1. With the engine running at normal operating temperature, turn the buffer screw in (Fig. 8) so that it contacts the differential lever as lightly as possible and still eliminates engine roll. *Do not raise the engine idle speed more than 15 rpm with the buffer screw.*

2. Hold the buffer screw and tighten the lock nut.

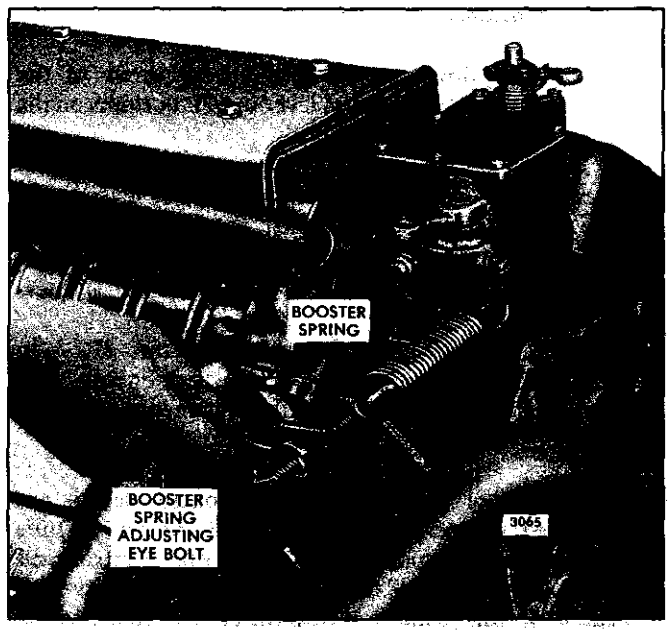


Fig. 9 – Adjusting Booster Spring

Adjust Booster Spring

With the idle speed set, adjust the booster spring as follows:

1. Move the speed control lever to the idle speed position.
2. Refer to Fig. 9 and loosen the booster spring retaining nut on the speed control lever. Loosen the lock nuts on the eye bolt at the opposite end of the booster spring.
3. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginary line through the center of the bolt, lever shaft and eye bolt. Hold the bolt and tighten the lock nut.
4. Start the engine and move the speed control lever to the maximum speed position and release it. The speed control lever should return to the idle position. If it does not, reduce the tension on the booster spring. If the lever does return to the idle position, continue to increase the spring tension until the point is reached that it will not return to idle. Then reduce the tension until it does return to idle and tighten the lock nut on the eye bolt. This setting will result in the minimum force required to operate the speed control lever.
5. Connect the linkage to the governor levers.

8V-53 ENGINES

The variable speed mechanical governor assembly is mounted at the front end of the 8V engine (Fig. 10). After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and 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.

Adjust Governor Gap

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

1. Disconnect any linkage attached to the governor levers.
2. Back out the buffer screw until it extends approximately 5/8" from the lock nut.

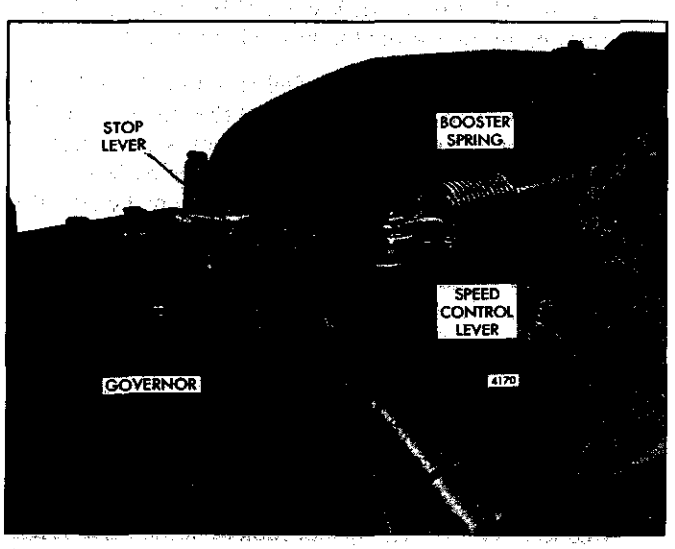


Fig. 10 – Variable Speed Governor Mounting

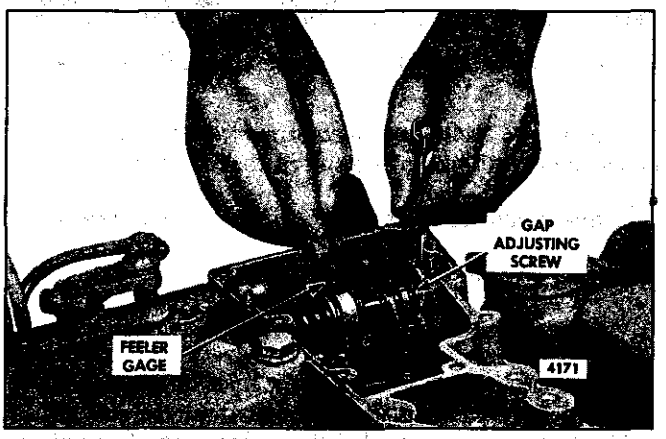


Fig. 11 – Adjusting Governor Gap

3. Clean and remove the governor cover and the valve rocker covers. Discard the gaskets.
4. Place the speed control lever in the maximum speed position.
5. Insert a .006" feeler gage between the spring plunger and the plunger guide as shown in Fig. 11. If required, loosen the lock nut and turn the adjusting screw in or out until a slight drag is noted on the feeler gage.
6. Hold the adjusting screw and tighten the lock nut. Check the gap and readjust, if necessary.
7. Use a new gasket and install the governor cover.

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.

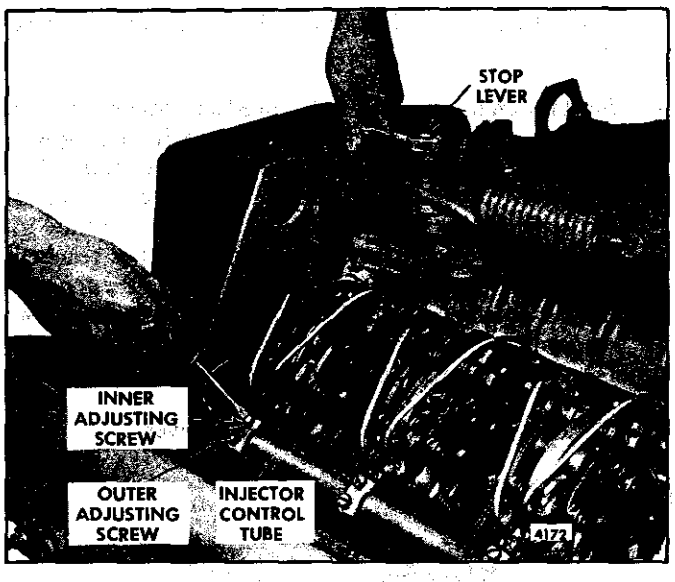


Fig. 12 – Positioning No. 1L Injector Rack Control Lever

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. Stop lever in the RUN position.
3. 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 as 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 levers.

1. Remove the clevis pin from the fuel rod and the right cylinder bank injector control tube lever.
2. 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.
3. Move the speed control lever to the maximum speed position.
4. Move the stop lever to the *run* 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. 12) until a slight movement of the control tube is observed, or a step–up in effort to turn the screwdriver is noted. This will place the No. 1L injector rack in the *full–fuel* position. 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.

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 steps should result in placing the governor linkage and control tube in the respective positions that they will attain while the engine is *running* at full load.

5. To be sure of proper adjustment, hold the stop lever in the *run* position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack (Fig. 4). Hold the stop lever in the *run* 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.

   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 stop lever from the *stop* to the *run* position, the injector rack becomes tight before the governor stop lever reaches the end of its travel. This will result in a step–up in effort required to move the stop lever to the *run* position and a deflection in the fuel rod (fuel rod deflection can be seen at the bend). If the rack is found to be too tight, back off the inner adjusting screw slightly and tighten the outer adjusting screw.
6. Remove the clevis pin from the fuel rod and the left bank injector control tube lever.
7. 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 4 for the No. 1L control lever.
8. Insert the clevis pin in the fuel rod and the left bank injector control tube lever. Repeat the check on the 1L and 1R injector rack control levers as outlined in Step 5. Check for and eliminate any deflection which may occur at the bend in the fuel rod where it enters the cylinder head.
9. Manually hold the No. 1L injector rack in the *full–fuel* position, with the lever on the injector control tube, and turn the inner adjusting screw of the No. 2L injector rack control lever down until the No. 2L injector rack moves into the *full–fuel* position. 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.
10. Recheck the No. 1L injector rack to be sure that 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 and tighten the outer adjusting screw. When the settings are correct, the rack of each injector must be snug on the ball end of its respective control lever.

11. Position the No. 3L and No. 4L injector rack control levers as outlined in Steps 9 and 10.

12. Position the No. 2R, 3R and 4R injector rack control levers as outlined for the left cylinder bank in Steps 9 through 11.

13. Use new gaskets and install the valve rocker covers.

Adjust Maximum No–Load 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, the maximum no–load speed may be set as follows:

NOTICE: The maximum no–load speed must not exceed 150 rpm above the full–load speed.

Start the engine and after it reaches normal operating temperature, determine the maximum no–load speed of the engine with an accurate tachometer. Then stop the engine and make the following adjustments, if required.

1. Refer to Fig. 16 and disconnect the booster spring and the stop lever retracting spring.

2. Remove the variable speed spring housing and the spring retainer, located inside of the housing, from the governor housing.

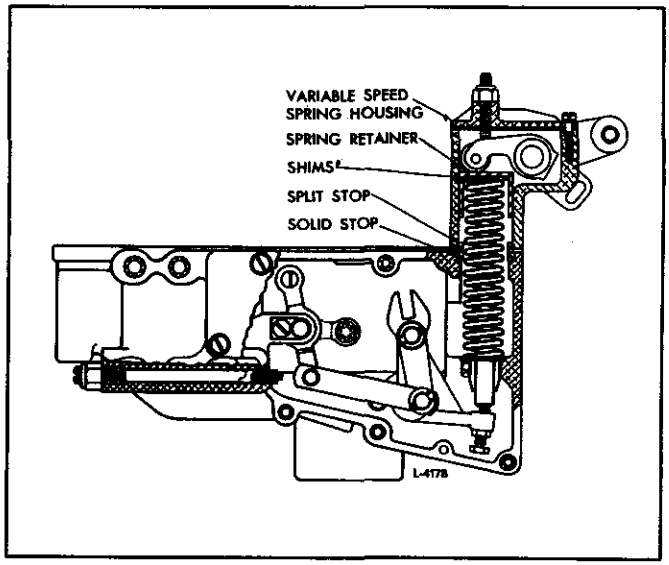


Fig. 13 – Location of Shims and Stops

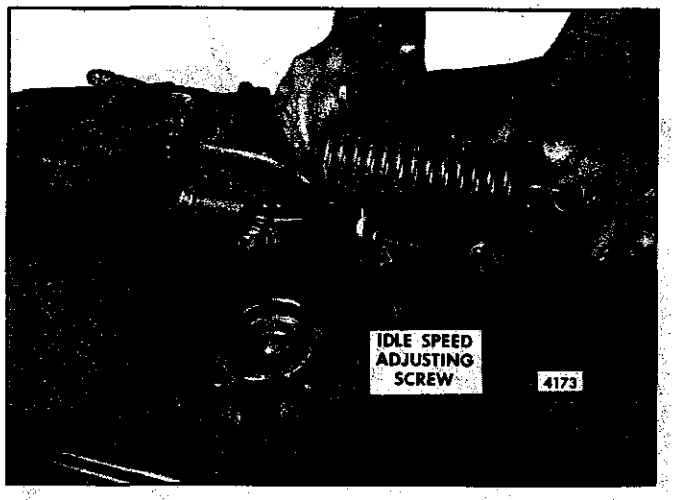


Fig. 14 – Adjusting Idle Speed

3. Refer to Table 1 and determine the stops or shims required for the desired full–load speed. A split stop can only be used with a solid stop (Fig. 13).

4. Install the variable speed spring retainer and housing and tighten the two bolts.

5. Connect the booster spring and the stop lever spring. Start the engine and recheck the maximum no–load speed.

6. If required, add shims to obtain the necessary operating speed. For each .001" in shims added, the operating speed will increase approximately 2 rpm.

If the maximum no–load speed is raised or lowered more than 50 rpm by the installation or removal of shims, recheck the governor gap. If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

Governor stops are used to limit the compression of the governor spring, which determines the maximum speed of the engine.

Adjust Idle Speed

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

1. Place the stop lever in the *run* position and the speed control lever in the *idle* position.

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the lock nut and turn the idle speed adjusting screw (Fig. 14) in or out until the engine idles at 600 rpm.

4. Hold the idle speed adjusting screw and tighten the lock nut.

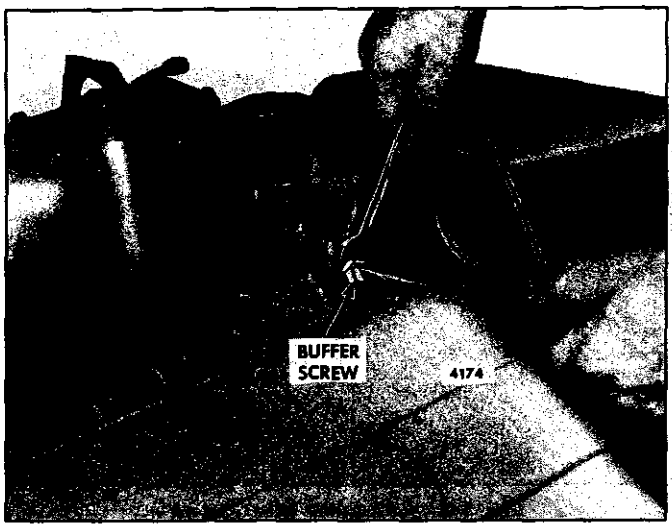


Fig. 15 – Adjusting Buffer Screw

Adjust Buffer Screw

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

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

Adjust Booster Spring

With the engine idle speed set, adjust the booster spring as follows:

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

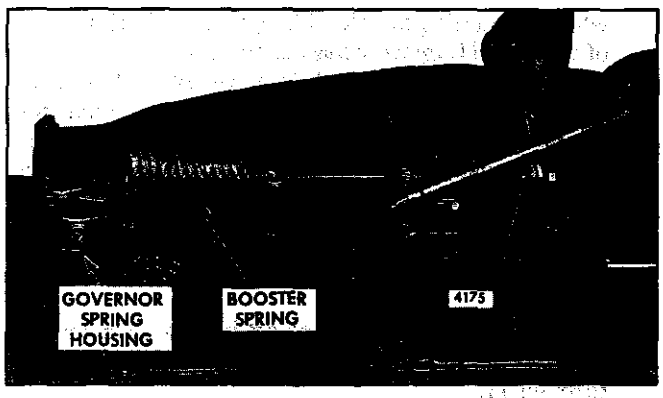


Fig. 16 – Adjusting Booster Spring

2. Refer to Fig. 16 and loosen the booster spring retaining nut on the speed control lever. Loosen the lock nuts on the eye bolt at the other end of the spring.
3. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginary line through the center of the bolt, lever shaft and eye bolt. Hold the bolt and tighten the lock nut.
4. Start the engine and move the speed control lever to the maximum speed position and release it. The speed control lever should return to the idle position. If it does not, reduce the tension on the booster spring. If the lever does return to the idle position, continue to increase the spring tension until the point is reached that it will not return to idle. Then reduce the tension until it does return to idle and tighten the lock nut on the eye bolt. This setting will result in the minimum force required to operate the speed control lever.
5. Connect the linkage to the governor levers.

CONSTANT SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

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

Adjust Governor Gap

1. Stop the engine and disconnect any linkage attached to the speed control lever.
2. Remove the governor cover and lever assembly.
3. Remove the fuel rod from the differential lever and the injector control tube lever.
4. Insert a .006" feeler gage between the spring plunger and the plunger guide as shown in Fig. 1. If required, loosen the lock nut and turn the gap adjusting screw in or out until a slight drag is noted on the feeler gage.
5. Hold the adjusting screw and tighten the lock nut. Check the gap and readjust if necessary.
6. Install the governor cover as follows:
   a. Place the cover on the governor housing, with the pin in the throttle shaft assembly entering the slot in the differential lever.

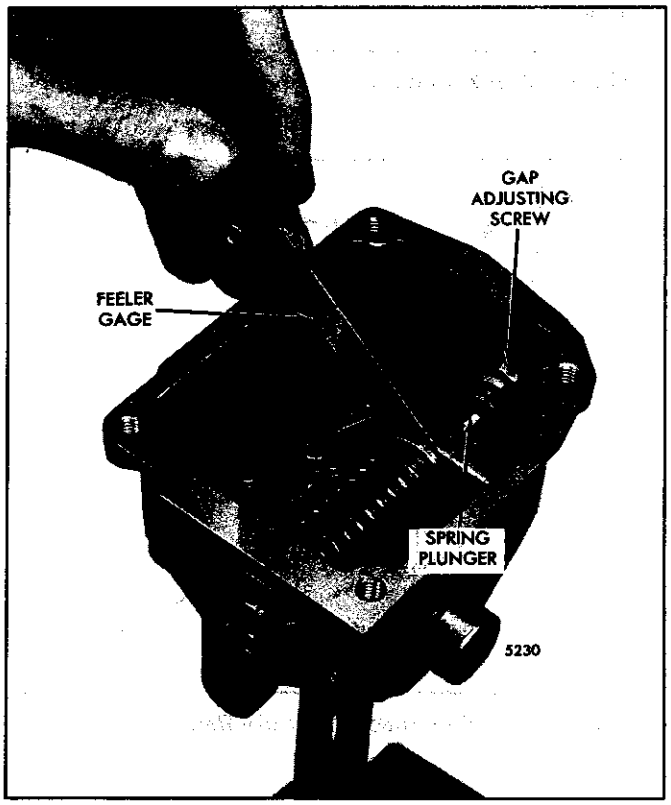


Fig. 1 – Adjusting Governor Gap

   b. Install the four cover screws and lock washers finger tight.
   c. Pull the cover assembly in a direction away from the engine, to take up the slack, and tighten the cover screws. This step is required since no dowels are used to locate the cover on the housing.

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 No. 1 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the control lever.
2. Remove the valve rocker cover.
3. Loosen all of the inner and outer injector rack control lever adjusting screws. Be sure all of the control levers are free on the injector control tube.
4. Move the control lever to the maximum speed position. Turn the inner adjusting screw down until a step–up in effort is noted. This will place the No. 1 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. The recommended torque of the adjusting screws is 24–36 **lb–in.**

   NOTICE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube.

5. To be sure the control lever is properly adjusted, hold the speed control lever in the maximum speed position and press down on the injector rack with a screw driver or finger tip and note the "rotating" movement of the injector control rack (Fig. 2). Hold the speed control lever in the maximum speed position and, using a screw driver, press downward on the injector control rack. The rack should tilt downward (Fig. 3) and when the pressure of the screw driver is released, the control rack should "spring" back upward.
6. If no movement is observed, back off the inner adjusting screw approximately 1/8 of a turn and tighten the outer adjusting screw. If the movement exceeds that specified, back off the outer adjusting screw approximately 1/8 of a turn and tighten the

inner adjusting screw. When the setting is correct, the injector rack will be snug on the pin of the rack control lever and still maintain the movement specified in Step 5.

Performing Steps 4, 5 and 6 will result in placing the governor linkage and control tube assembly in the same positions that they will attain while the engine is running at full load. These positions are:

a. The governor speed control lever is at the maximum speed position.

b. The governor gap is closed.

c. The governor spring plunger is on its seat in the governor control housing.

d. The injector fuel control racks are in the maximum speed position.

7. Remove the clevis pin between the fuel rod and the injector control tube lever.

8. Manually hold the No. 1 injector in the maximum fuel position and turn down the inner adjusting screw of the No. 2 injector until the injector rack has moved into the maximum speed 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.

9. Recheck the No. 1 injector fuel rack to be sure that it has remained snug on the pin of the rack control lever while adjusting the No. 2 injector. If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw on the No. 2 injector rack control lever and tighten the outer adjusting screw. When the settings are correct, the racks of both injectors must be snug on the pins of their respective rack control levers.

10. Position the remaining control rack levers as outlined in Steps 8 and 9.

11. Insert the clevis pin between the fuel rod and the injector control tube lever.

12. Install the valve rocker cover.

Adjust Maximum No–Load 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, the maximum no–load speed may be set as follows:

1. Start and warm up the engine.

2. Run the engine at no–load and observe the engine speed. Be sure the speed control lever is in the run position. *There must be no load on the engine during the maximum no–load speed adjustment.*

3. Observe the engine speed and set it, if necessary, to the recommended speed with shims placed between the operating speed spring and the spring plunger.

Since the engine performance and efficiency will be governed, to a large extent, by the accuracy with which the tune–up adjustments are made, the service technician should always perform these operations carefully.

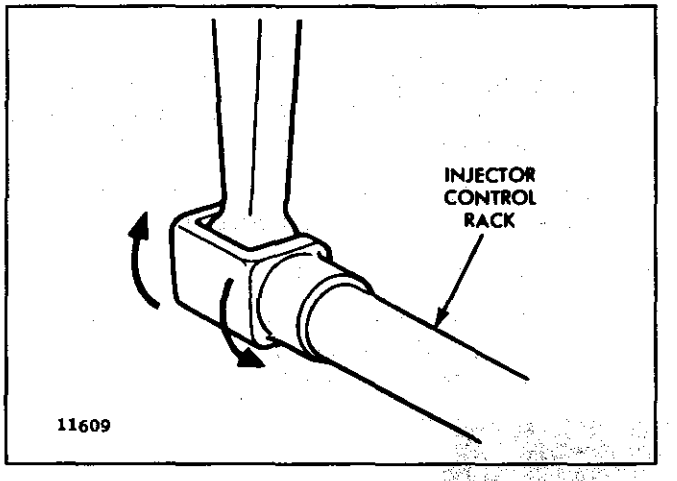


Fig. 2 – Checking Rotating Movement of Injector Control Rack

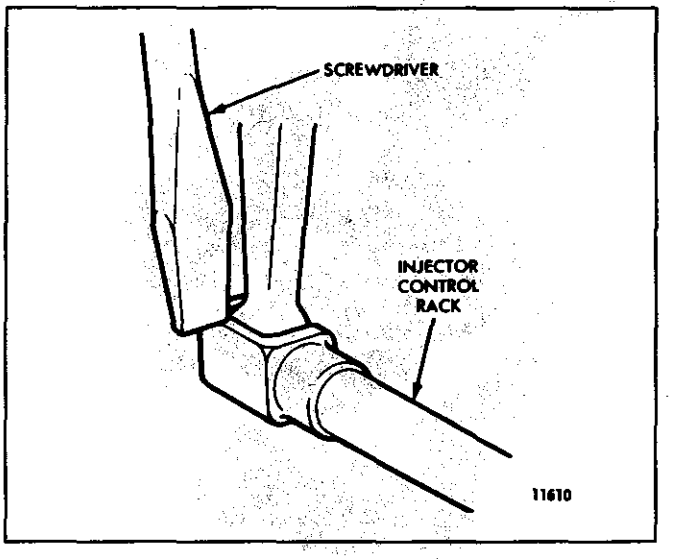


Fig. 3 – Checking Injector Control Rack "Spring"

HYDRAULIC GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

IN-LINE ENGINE

The hydraulic governor is mounted on the 2–53, 3–53 and 4–53 engines (Fig. 1). The terminal lever return spring and the fuel rod are attached to an external terminal shaft lever. The maximum fuel position of the governor load limit is determined by the internal governor terminal lever striking against a boss that projects from the governor cover.

Adjust the hydraulic governor after adjusting the exhaust valve clearance and timing the fuel injectors.

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.

Adjust Fuel Rod And Injector Rack Control Levers

1. Adjust the inner and outer adjusting screws (Fig. 2) on the rear injector rack control lever until both the screws are equal in height and tight on the control tube.

   Some engines use spring-loaded control tube assemblies which have a yield spring at each injector rack control lever and only one screw and locknut to keep each injector rack properly positioned. Adjust the single screw and locknut on each injector rack control lever to a central or middle position.

   Check the clearance between the fuel rod and the cylinder head bolt or the cylinder head casting (below the bolt) for at least 1/16" clearance when the injector rack is in the *full–fuel* position and the rack adjusting screws are tight. If the fuel rod contacts the bolt or the cylinder head casting, readjust the screws to obtain the 1/16" clearance.

   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 on the adjusting screws is 24–36 **lb–in** (3–4 **N·m**).

2. Remove the governor terminal lever return spring.

3. Remove the fuel rod end bearing or ball joint from the terminal shaft lever and the terminal lever from the terminal shaft.

4. Place the terminal lever on the terminal shaft so that the hole for attaching the fuel rod end bearing or ball joint is in line vertically above the terminal lever shaft at one half the arc of travel. Do not tighten the clamping bolt.

5. Hold both the injector rack control tube and the terminal lever in the *full–fuel* position and adjust the length of the fuel rod until the end bearing or ball joint will slide freely into the hole of the terminal lever (Fig. 3). Tighten the locknut, to retain the ball joint or end bearing, and the terminal lever clamping bolt securely.

   It will be necessary to slide the terminal lever partially off of the shaft to attach the fuel rod end bearing or ball joint to the terminal lever.

   On former governors that do not have the load limit screw in the cover, hold the terminal lever in the *full–fuel* position and loosen the inner adjusting screw 1/8 of a turn and tighten the outer adjusting screw 1/8 of a turn to retain the adjustment. This is done to prevent the governor from bottoming the injector racks.

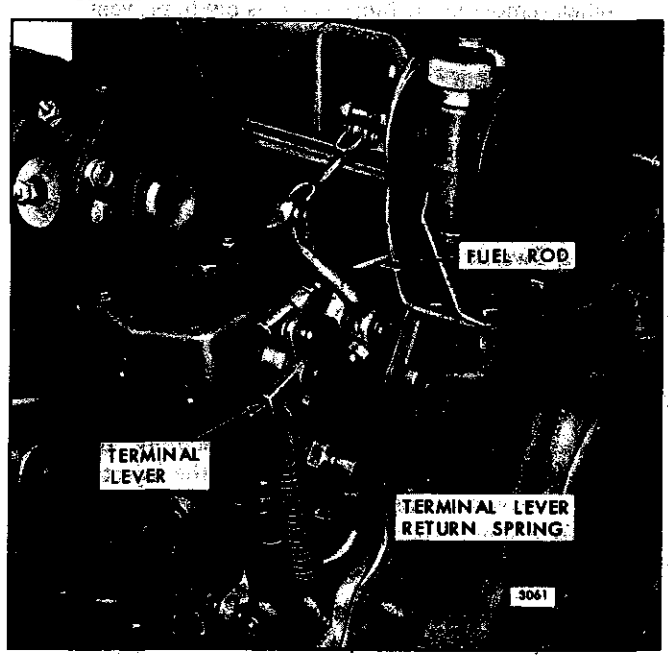


Fig. 1 – Hydraulic Governor Mounting

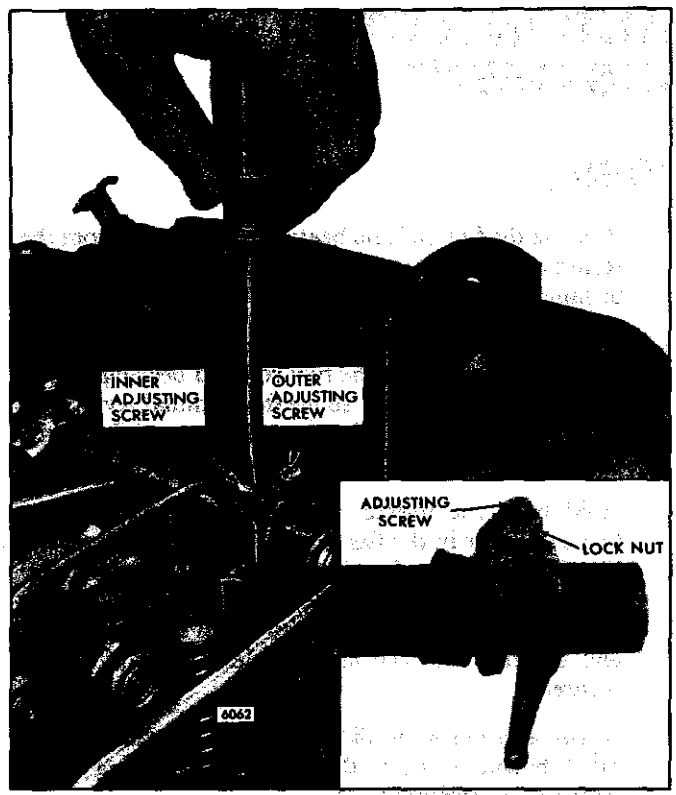


Fig. 2 – Adjusting Height of Rack Control Lever Adjusting Screws

6. Remove the clevis pin between the fuel rod and the injector control tube lever.

NOTICE: Cover the cylinder head oil drain–back hole, located under the control lever, when removing the fuel rod clevis pin to prevent loss of the pin and possible damage to the engine.

7. Manually hold the rear injector in the *full–fuel* position with the lever on the injector control tube. Turn the adjusting screw of the rear injector rack control lever until the injector rack moves into the *full–fuel* position.

On a *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 a *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.

8. Recheck the rear injector fuel rack to be sure that it has remained snug on the ball end of the rack control lever while adjusting the adjacent injector. If the rack of the rear injector has become loose, back off slightly on the adjusting screw 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 rack control levers.

9. Position the remaining rack control levers as outlined in Steps 7 and 8.

10. Insert the clevis pin between the fuel rod and the injector control tube lever.

11. On current governors, that have the load limit screw in the governor cover (refer to Section 2.8.1), hold the terminal lever in the *full–fuel* position and adjust the load limit screw until it just contacts the terminal lever.

Then, advance the load limit screw enough to cause the injector racks to just become loose on the control tube levers. This will allow the terminal lever to reach full travel before the injector racks bottom.

12. Install the terminal lever return spring.

Adjust Speed Droop

The purpose of adjusting the speed droop is to establish a definite engine speed at no load with a given speed at rated full load.

The governor droop is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs, the speed droop should be readjusted.

The best method of determining the engine speed is by the use of an accurate hand tachometer.

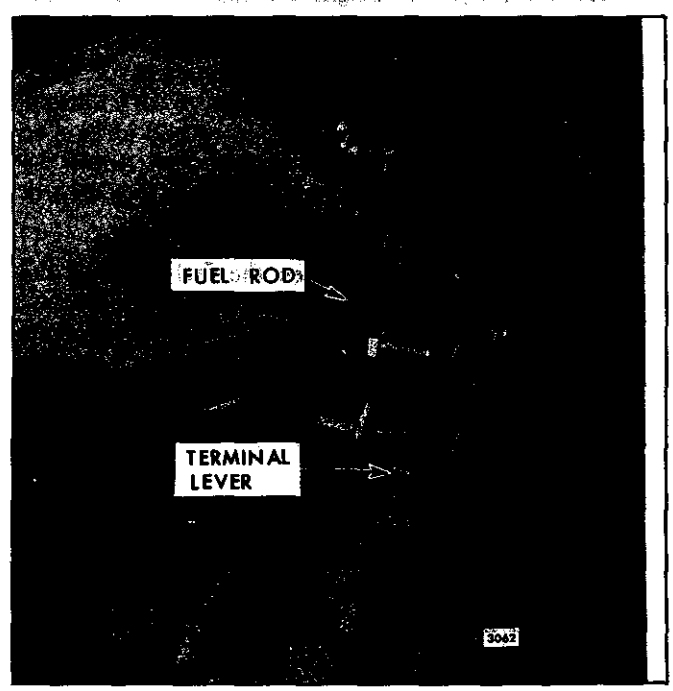


Fig. 3 – Adjusting Length of Fuel Rod

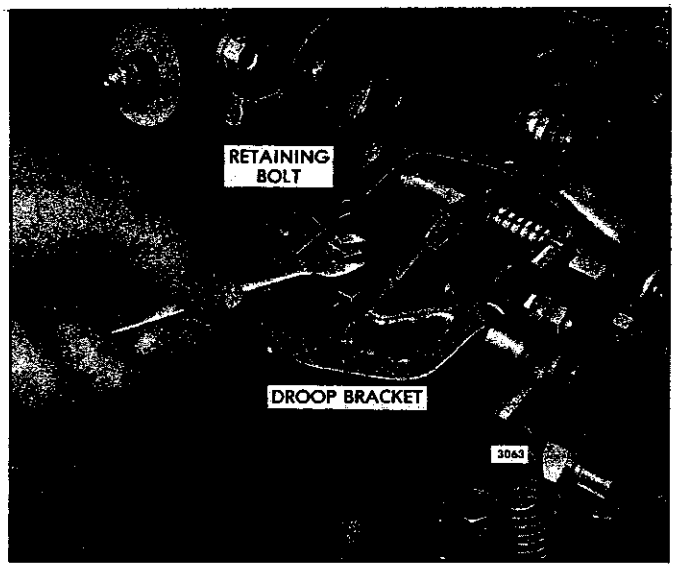


Fig. 4 – Adjusting Droop Bracket

If a full–rated load on the unit can be established and the fuel rod, injector rack control levers and load limit have been adjusted, the speed droop may be adjusted as follows:

1. Start the engine and run it at approximately one–half the rated no–load speed until the lubricating oil temperature stabilizer.

   When the engine lubricating oil is cold, the governor regulation may be erratic. The regulation should become increasingly stable as the temperature of the lubricating oil increases.

2. Stop the engine and remove the governor cover. Discard the gasket.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 5/8" (Fig. 5).

4. Refer to Fig. 4 and loosen the droop adjusting bolt. Move the droop bracket so that the bolt is midway between the ends of the slot in the bracket. Tighten the bolt.

5. With the throttle in the *run* position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full–load speed.

6. Apply the full–rated load on the engine and readjust the engine speed to the correct full–load speed.

Full Load	No-Load
50 cycles 1000 rpm	52.5 cycles 1050 rpm
60 cycles 1200 rpm	62.5 cycles 1250 rpm
50 cycles 1500 rpm	52.5 cycles 1575 rpm
60 cycles 1800 rpm	62.5 cycles 1875 rpm

TABLE 1

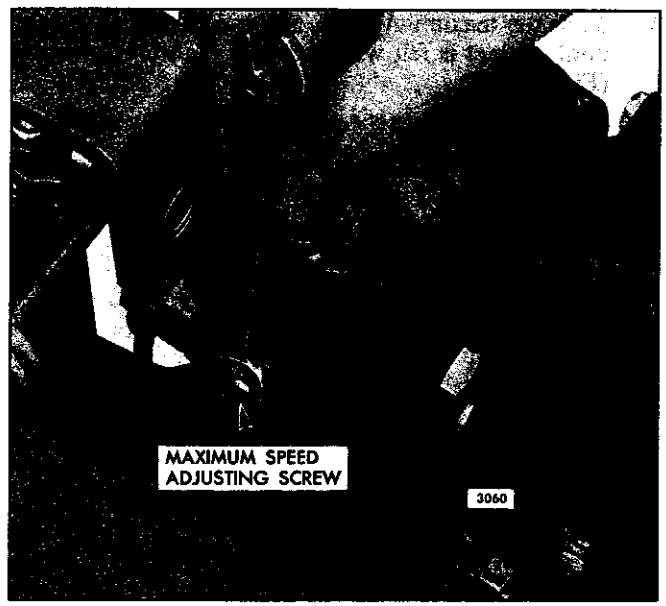


Fig. 5 – Adjusting Maximum Engine Speed

7. Remove the rated load and note the engine speed after the speed stabilizes under no load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full–load speed.

If the speed droop is too high, stop the engine and again loosen the droop bracket retaining bolt and move the droop adjusting bracket *in* toward the engine. Tighten the bolt. To increase the speed droop, move the droop adjusting bracket *out*, away from the engine.

The speed droop in governors which control engines driving generators in parallel must be identical, otherwise the electrical load will not be equally divided.

Adjust the speed droop bracket in each engine governor to obtain the desired variation between the engine no–load and full–load speeds (Table 1).

The recommended speed droop of generator sets operating in parallel is 50 rpm (2–1/2 cycles) for units operating at 1000 and 1200 rpm and 75 rpm (2–1/2 cycles) for units operating at 1500 rpm and 1800 rpm full load. This speed droop recommendation may be varied to suit the individual application.

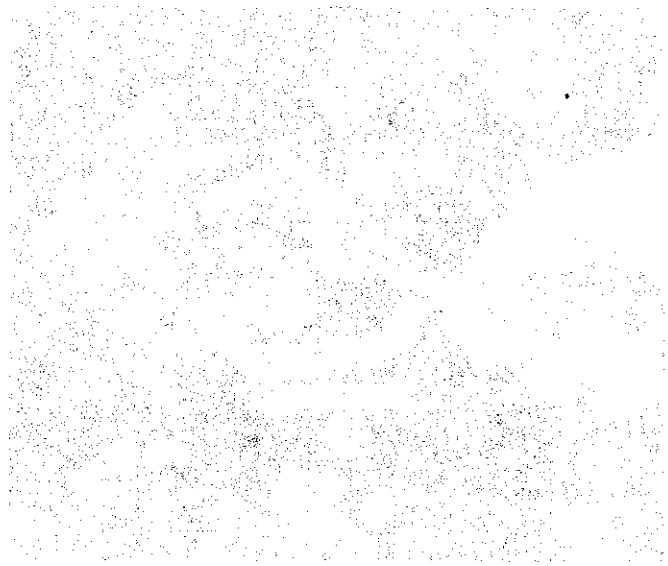
Adjust Maximum No–Load Speed

With the speed droop properly adjusted, set the maximum no–load speed as follows:

1. Loosen the maximum speed adjusting screw locknut and back out the maximum speed adjusting screw 3 turns.

2. With the engine operating at no load, adjust the engine speed until the engine is operating at approximately 8% higher than the rated full–load speed.

3. Turn the maximum speed adjusting screw in lightly until contact is felt with the linkage in the governor (Fig. 5).
4. Hold the maximum speed adjusting screw and tighten the locknut.
5. Use a new gasket and install the governor cover.



SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT

ENGINE LOAD LIMIT DEVICE

Engines with mechanical governors may be equipped with a load limit device to reduce the maximum horsepower (Fig. 1)

This device consists of a load limit screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a load limit lever clamped to the injector control tube.

The load limit device is located between the No. 2 and No. 3 cylinders of a 3–53 or 4–53 engine or between the No. 1 and No. 2 cylinders of *each* cylinder head on a V–type engine. However, when valve rocker covers with a breather are used, the load limit device is installed between the No. 1 and No. 2 cylinders on In–line engines and between the No. 2 and No. 3 cylinders on V–type engines to avoid interference with the rocker cover baffles.

When properly adjusted for the maximum horsepower desired, this device limits the travel of the injector control racks and thereby the fuel ouput of the injectors.

Adjustment

After the engine tune–up is completed, make sure the load limit device is properly installed (Fig. 1). Make sure the counterbores in the adjusting screw plate are up. The rocker arm shaft bracket bolts which fasten the adjusting screw plate to the brackets are tightened to 50–55 lb–ft (68–75 N·m) torque. Then adjust the load limit device, on each cylinder head, as follows:

1. Loosen the load limit screw locknut and remove the screw.
2. Loosen the load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.
3. With the screw out of the plate, adjust the load limit screw locknut so the bottom of the locknut is 7/8" from the bottom of the load limit screw for the initial setting (Fig. 1).
4. Loosen the load limit lever clamp bolts so that the lever is free to turn on the injector rack control tube.
5. Thread the load limit screw into the adjusting screw plate until the locknut *bottoms* against the top of the plate.
6. Hold the injector rack control tube in the *full–fuel* position and place the load limit lever against the bottom of the load limit screw. Then, tighten the load limit lever clamp bolts.
7. Check to ensure that the injector racks will just go into the *full–fuel* position – readjust the load limit lever, if necessary.
8. Hold the load limit screw to keep it from turning, then *set* the locknut until the distance between the bottom of the locknut and the top of the adjusting screw plate corresponds to the dimension (or number of turns) stamped on the plate. Each full turn of the screw equals .042", or .007" for each flat on the hexagon head.

   If the plate is not stamped, adjust the load limit screw while operating the engine on a dynamometer test stand and note the number of turns required to obtain the desired horsepower. Then, stamp the plate accordingly.
9. Thread the load limit screw into the plate until the locknut *bottoms* against the top of the plate. Be sure the nut turns with the screw.
10. Hold the load limit screw to keep it from turning, then tighten the lock nut to secure the setting.

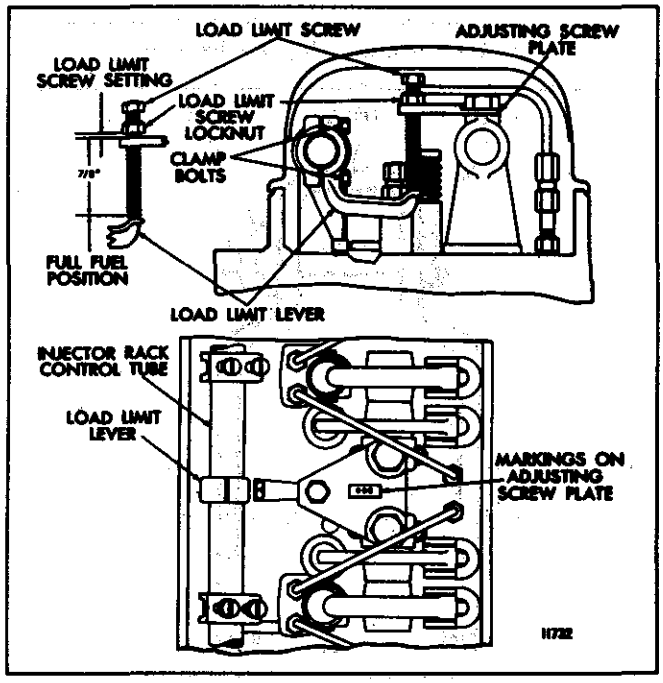


Fig. 1 – Engine Load Limit Device

THROTTLE DELAY MECHANISM

The throttle delay mechanism is used to retard *full-fuel* injection when the engine is accelerated. This reduces exhaust smoke and also helps to improve fuel economy.

The throttle delay mechanism (Fig. 2) is installed between the No. 1 and No. 2 cylinders on 3–53 engines, between the No. 2 and No. 3 cylinders on 4–53 engines, or between the No. 1 and No. 2 cylinders on the right-bank cylinder head of V-type engines. It consists of a special rocker arm shaft bracket (which incorporates the throttle delay cylinder), a piston, throttle delay lever, connecting link, orifice plug, ball check valve and U-bolt.

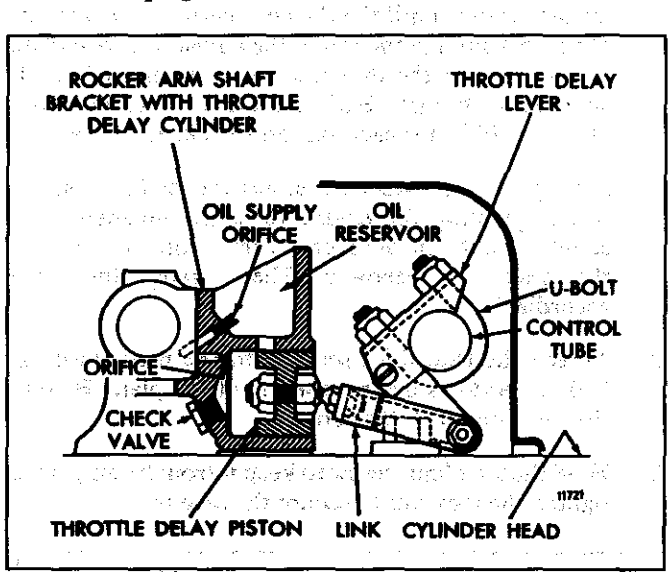


Fig. 2 – Throttle Delay Mechanism

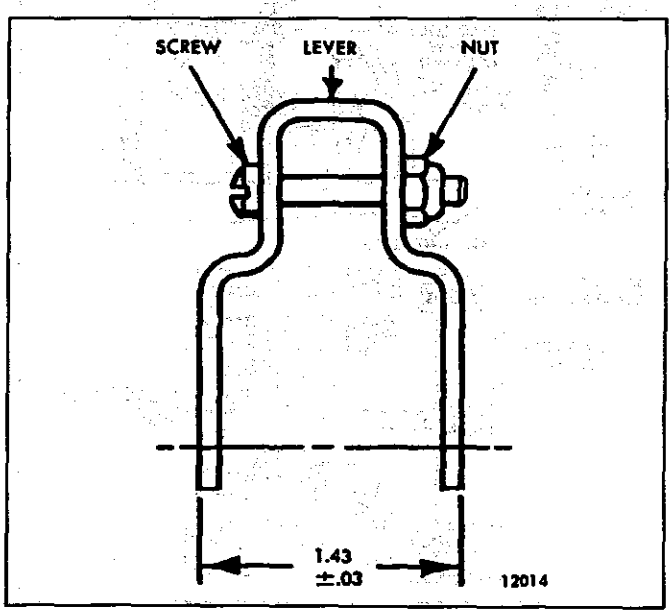


Fig. 3 – Current Throttle Delay Lever Assembly

Effective with turbocharged engines built January, 1980 10–32 x 1 1/8" screws and 10–32 locknuts are used in the lever assembly rather than 8–32 screws and locknuts. Also, 10–32 x 3/4" screws and 10–32 locknuts are used at each leg of the lever assembly, rather than 8–32 screws and nuts. The screw holes in the lever were enlarged to accommodate the 10–32 screws (Fig. 3).

DO NOT use a 10–32 locknut on an 8–32 screw. An 8–32 nut must be used with an 8–32 screw and a 10–32 nut used with a 10–32 screw.

Effective February, 1975, a new throttle delay lever is used on the 4 and 6V–53 engines (Fig. 3). The lever assembly consists of a throttle delay lever (not serviced separately), an 8–32 x 1 1/8" screw and a stop nut.

NOTICE: Install the throttle delay lever assembly on the injector control tube with the legs inward (Fig. 2). A backward installation (legs outward) can result in a binding condition between the lever and the valve cover and possible loss of injector fuel control. Adjust the lever to obtain a leg width of 1.43" ± .03" (Fig. 3) to prevent binding.

Prior to May, 1973, the throttle delay lever assembly was the same as the current lever assembly, except that the lever was serviced separately and no adjustment dimension was specified.

Effective May, 1973 and until February, 1975, the throttle delay lever was used with an 8–32 x 1.20" long spacer and an 8–32 x 2 1/2" screw instead of the two shorter 8–32 x 3/4" screws at each leg of the lever. Also, the 1 1/8" long adjusting screw was eliminated. The single 2 1/2" long screw and spacer was discontinued because it was found that the spacer could hit the cylinder head bolt, preventing the fuel injectors from reaching full rack position.

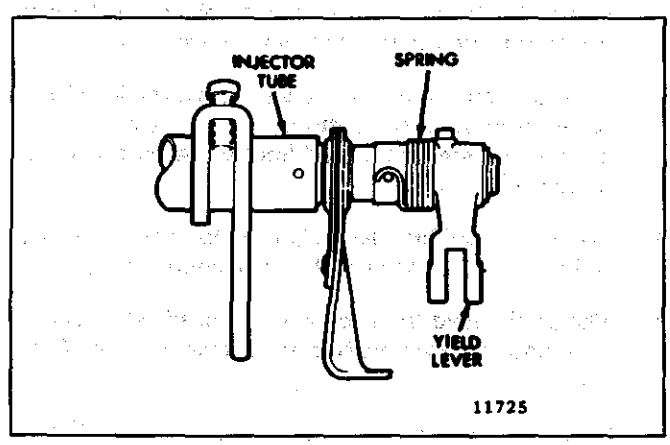


Fig. 4 – Throttle Delay Yield Lever (In-line Engine)

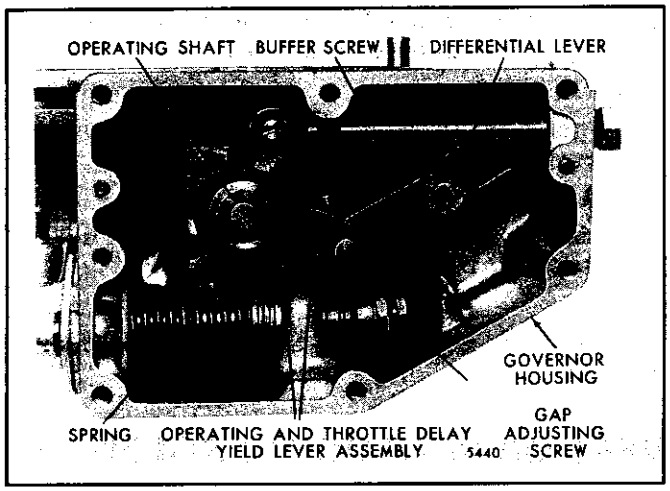


Fig. 5 – Throttle Delay Yield Lever (6V–53 Engine)

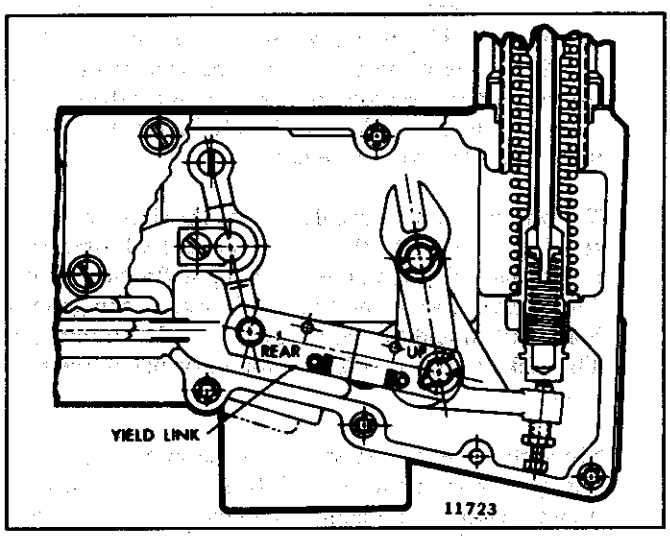


Fig. 6 – Throttle Delay Yield Link (8V–53 Engine)

Former engines can be updated by replacing the 1.20" long spacer and 2 1/2" screw with the shorter 3/4" screws and nuts at each leg of the throttle delay lever. Add the 1 1/8" long screw and nut to the lever.

Adjust the current throttle delay lever assembly (Fig. 3) by loosening or tightening the screw and nut in the lever to obtain a width of 1.43" ± .03" between the lever legs.

NOTICE: This dimension is required to prevent the lever from binding with the link.

A yield lever and spring assembly replaces the standard lever and pin assembly on the rear end of the injector control tube on In–line engines (Fig. 4). A yield lever replaces the standard operating lever in the governor of the 6V–53 engine (Fig. 5) and a yield link replaces the standard operating lever link in the 8V–53 governor (Fig. 6).

Operation

Oil is supplied to a reservoir above the throttle delay cylinder through an orifice plug in the drilled oil passage in the rocker arm shaft bracket (Fig. 2). As the injector racks are moved toward the *no–fuel* position, free movement of the throttle delay piston is assured by air drawn into the cylinder through the ball check valve. Further movement of the piston uncovers an opening which permits oil from the reservoir to enter the cylinder and displace the air. When the engine is accelerated, movement of the injector racks toward the *full–fuel* position is momentarily retarded while the piston expels the oil from the cylinder through an orifice. To permit full accelerator travel, regardless of the retarded injector rack position, a spring–loaded yield lever or link assembly replaces the standard operating lever connecting link to the governor.

Inspection

To inspect the check valve, fill the throttle delay cylinder with diesel fuel oil and watch for check valve leakage while moving the engine throttle from the idle position to the *full–fuel* position. If more than a drop of leakage occurs, replace the check valve.

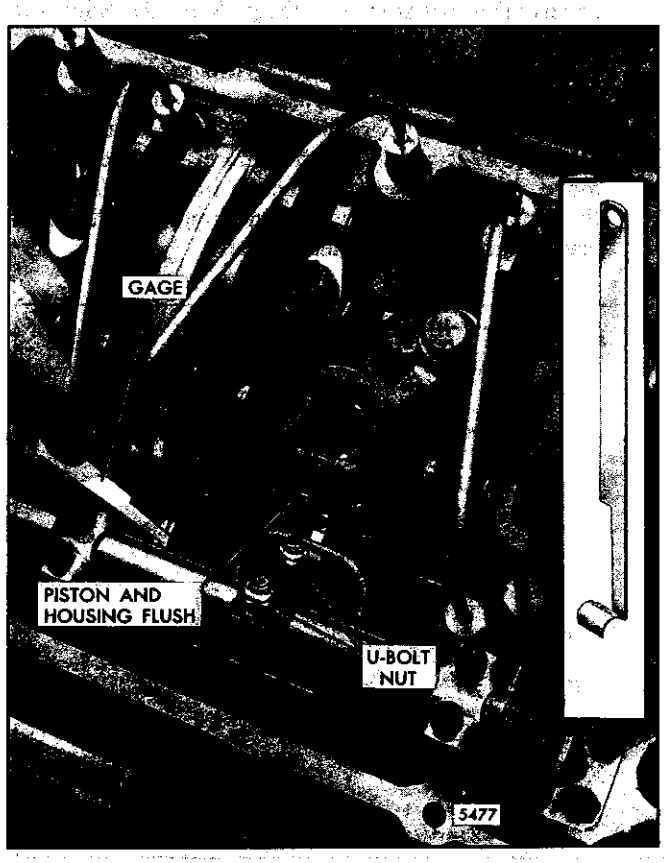


Fig. 7 – Adjusting Throttle Delay Cylinder

Adjustment

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U–bolt which clamps the lever to the injector control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be readjusted. With the engine stopped, proceed as follows:

1. Refer to Fig. 7 and insert gage J 23190 (.454" setting) between the injector body and the shoulder on the injector rack. Then exert a light pressure on the injector control tube in the direction of full fuel.
2. Align the throttle delay piston so it is flush with the edge of the throttle delay cylinder.
3. Tighten the U–bolt on the injector control tube and remove the gage.
4. Move the injector rack from the *no–fuel* to the *full–fuel* position to make sure it does not bind.

Refer to *Engine Tune–Up* in Section 15.1 for maintenance.

ADJUSTMENT OF MECHANICAL GOVERNOR SHUTDOWN SOLENOID

When a governor shutdown solenoid is used on an engine equipped with a mechanical governor, the governor stop lever must be properly adjusted to match the shutdown solenoid plunger travel.

The solenoid plunger can be properly aligned to the governor stop lever as follows:

1. Remove the bolt connecting the rod end eye (variable speed governor) or the right angle clip (limiting speed governor) to the stop lever (Figs. 8 and 9). Align and clamp the lever to the shutdown shaft in such a way that, at its mid–travel position, it is perpendicular to the solenoid plunger. This assures that the linkage will travel as straight as possible. The solenoid plunger has available 1/2" travel which is more than adequate to move the injector control racks from the *full–fuel* to the complete *no–fuel* position and shutdown will occur prior to attaining complete travel.
2. With the stop lever in the *run* position, adjust the rod end eye or right angle clip for minimum engagement on the solenoid plunger when the connecting bolt is installed. The oversize hole in the eye or clip will thereby permit the solenoid to start closing the air gap, with a resultant build–up of pull–in force prior to initiating stop lever movement.
3. The bolt through the rod end eye or the right angle clip should be locked to the stop lever and adjusted to a height that will permit the eye or clip to float vertically. The clearance above and below the eye or clip and the bolt head should be approximately 1/32" minimum. The locknut can be either on top of or below the stop lever.
4. Move the lever to the *stop* position and observe the plunger for any possible bind. If necessary, loosen the mounting bolts and realign the solenoid to provide free plunger motion.

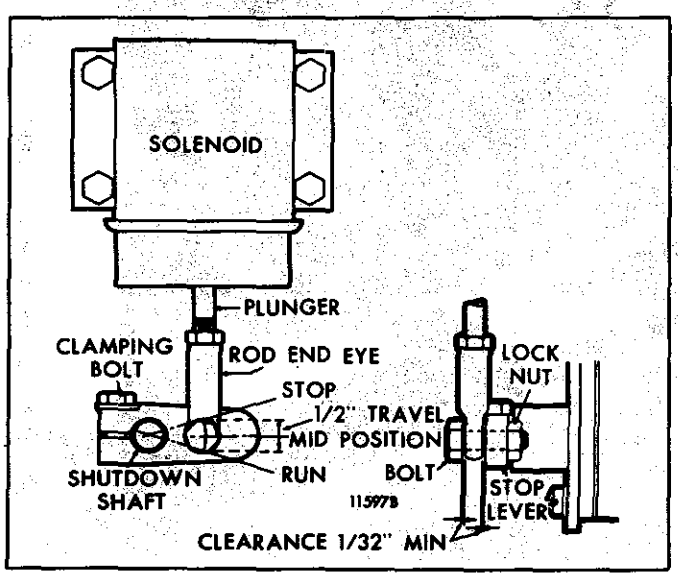


Fig. 8 – Typical Variable Speed Governor Lever Position

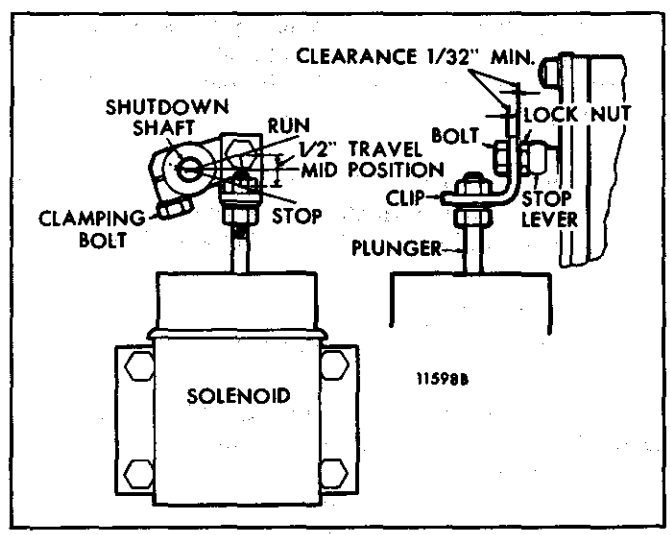


Fig. 9 – Typical Limiting Speed Governor Lever Position

FUEL MODULATOR

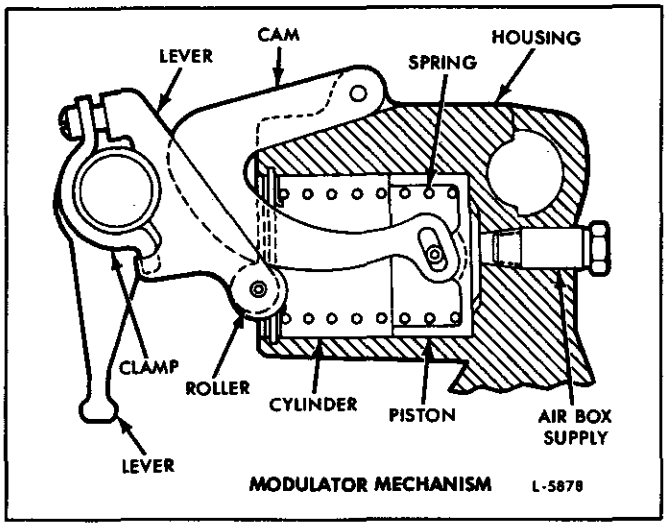


Fig. 10 – Typical Fuel Modulator Assembly

The fuel modulator, used on turbocharged engines, maintains the proper fuel to air ratio in the lower speed ranges where the mechanical governor would normally act to provide maximum injector output. It operates in such a manner that, although the engine throttle may be moved into the full–speed position, the injector racks cannot advance to the *full–fuel* position until the turbine speed is sufficient to provide proper combustion.

The fuel modulator will reduce exhaust smoke and also will help to improve fuel economy. The modulator mechanism is installed between the No. 1 and No. 2 cylinders.

A fuel modulator consists of a cast housing containing a cylinder, piston, cam and calibrated spring mounted on the cylinder head (Table 1). A lever and roller which controls the injector rack is connected to the injector control tube. Tubes run from the air box to the housing to supply pressure to actuate the piston.

FUEL MODULATING SPRING IDENTIFICATION

COLOR CODE	LOAD	RATE
Pink Stripe	5.61 ± 1.5 Lbs. @ 1.125 Length	6.00 Lbs. Per Inch.
Green Stripe	26.9 ± 1.34 Lbs. @ .65 Length	18.25 Lbs. Per Inch.
None	28.25 ± 1.4 Lbs. @ .65 Length	16.25 Lbs. Per Inch.

TABLE 1

The modulator tells the fuel system how much fuel the engine can efficiently use based on air box pressure. Increased air box pressure forces the piston and cam out of the cylinder bore allowing the rack to move toward full fuel. The spring is calibrated to the individual engine model air box pressure characteristics.

Whenever the fuel injector rack control levers are adjusted, the fuel (air box) modulator lever and roller assembly must first be positioned free of cam contact. This is done by loosening the clamp screw.

Inspection

At major repair or overhaul, inspect the roller and piston outer diameter and the cylinder bore inner diameter for wear. Also, inspect the operating surface, the lever roller, the roller pins at the cam pivot and the cam attachment to the piston.

The piston outer diamter must not be less than 1.6555" and the cylinder bore inner diameter must not be more than 1.6605".

Adjust Fuel Modulator

After completing the injector rack control lever and governor adjustment, adjust the fuel modulator, as follows:

1. With the engine stopped, insert the proper gage between the injector body and the shoulder on the injector rack of the No. 2 injector which is adjacent to the modulator (Table 2).
2. Position the governor speed control lever in the maximum speed position and the governor run stop lever in the *run* position.
3. Rotate the air box modulator lever assembly and clamp on the injector control tube until the lever roller contacts the modulator cam with sufficient force to take up the pin clearance (Fig. 10).
4. Check to make sure only the roller contacts the cam and not the lever stamping. Tighten the lever and clamp screw. After tightening, check to make sure that the gage is still in contact with the injector body and the shoulder on the injector rack of the No. 2 injector.
5. Remove the gage from between the injector body and the shoulder on the injector rack.

TOOL NO.	DIM.	USAGE
J35586	.200	53T with crosshead pistons improved cold weather starting
J26646	.290	3, 4-53T Off-Highway, Industrial (except 4-53T with N65 injectors)
J28779	.365	4-53T Truck with 5A55 injectors and 4-53T Off-Highway Industrial with N65 injectors
J28778	.385	4-53T Truck with 5A60 injectors (except California)
J9509C	.404	4-53T Truck with 5A60 injectors (California only)
J9509C	.404	4-53T Truck with N65 injectors
J9509C	.404	6V-53T Truck, Off-Highway, Industrial
J28779	.365	6V-53T Marine

TABLE 2

SECTION 15

PREVENTIVE MAINTENANCE – TROUBLESHOOTING – STORAGE

CONTENTS

LUBRICATION AND PREVENTIVE MAINTENANCE

The *Lubrication and Preventive Maintenance Schedule* is intended as a guide for establishing a preventive maintenance schedule. The suggestions and recommendations for preventive maintenance should be followed as closely as possible to obtain long life and best performance from a Detroit Diesel engine. The intervals indicated on the Charts are time or miles (in thousands) of actual operation.

MAINTENANCE SCHEDULE EXPLANATION

The time or mileage increments shown apply only to the maintenance function described. These functions should be coordinated with other regularly scheduled maintenance such as chassis lubrication.

The daily instructions pertain to routine or daily starting of an engine and not to a new engine or one that has not been operated for a considerable period of time. For new or stored engines, carry out the instructions given under *Preparation for Starting Engine First Time* under *Operating Instructions* in Section 13.1.

EMISSION CONTROL MAINTENANCE SERVICE CHART (VEHICLE ENGINES)

DAILY											
1. — Lubricating Oil		Ⓘ									
2. — Fuel Tank		Ⓘ									
3. — Fuel Lines and Flexible Hoses		Ⓘ									
4. — Cooling System		Ⓘ									
5. — Turbocharger		Ⓘ									
3000 MILE INTERVALS											
6. — Battery		Ⓘ									
7. — Tachometer Drive		Ⓘ									
4000-6000 MILE INTERVALS											
8. — Air Cleaner (oil bath)		Ⓘ									
9. — Drive Belts		Ⓘ									
10. — Air Compressor		Ⓘ									
11. — Throttle Control		Ⓘ									
15,000 MILE INTERVALS											
(2.) — Fuel Tank		Ⓘ									
(8.) — Air Cleaner (oil bath)		Ⓘ									
25,000 MILE INTERVALS											
12. — Lubricating Oil Filter		Ⓡ									
6 MONTHS OR	**MONTHS**	**6**	**12**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
10,000 MILE INTERVALS	**MILES (1000)**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
13. — Fuel Filter		Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ
14. — Coolant Filter and Water Pump		Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ
15. — Starting Motor		Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ
(2.) — Fuel Tank			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
(4.) — Cooling System (hoses)			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
(10.) — Air Compressor			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
16. — Air System			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
17. — Exhaust System			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
18. — Air Box Drain Tube				Ⓘ			Ⓘ			Ⓘ	
19. — Emergency Shutdown			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
20. — Engine (steam clean)			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
21. — Radiator			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
22. — Shutter Operation			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
23. — Oil Pressure			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
24. — Governor						Ⓘ					Ⓘ
25. — Fuel Injector & Valve Clearance						Ⓘ					Ⓘ
26. — Throttle Delay						Ⓘ					Ⓘ
27. — Generator or Alternator*											
28. — Engine & Transmission Mounts							Ⓘ				
29. — Crankcase Pressure							Ⓘ				
30. — Air Box Check Valves											Ⓘ
(1.) — Lubricating Oil*											
31. — Fan Hub*											

ANNUALLY	
(3.) — Fuel Lines and Flexible Hoses	Ⓘ
(4.) — Cooling System	Ⓘ
(8.) — Air Cleaners	Ⓘ
32. — Thermostats & Seals	Ⓘ
33. — Blower Screen	Ⓘ
34. — Crankcase Breather	Ⓘ
35. — Fan (thermo-modulated)	Ⓘ
AS REQUIRED	
36. — Engine Tune-Up	

Ⓘ = INSPECT, CORRECT OR REPLACE (IF NECESSARY)

Ⓡ = REPLACE

* = SEE ITEM

INDUSTRIAL OFF HIGHWAY AND MARINE#	HRS.	TIME INTERVALS									
		8	50	100	150	200	300	500	700	1,000	2,000
	MILES DLY.	240	1,500	3,000	4,500	6,000	9,000	15,000	20,000	30,000	60,000
1. — Lubricating Oil	x				x						
2. — Fuel Tank	x							x	x		
3. — Fuel Lines/Flexible Hoses	x							x		x	
4. — Cooling System*	x								x	x	
5. — Turbocharger	x										
6. — Battery				x							
7. — Tachometer Drive				x							
8. — Air Cleaners		x					x				
9. — Drive Belts		x				x					
10. — Air Compressor						x			x		
11. — Throttle and Clutch Controls						x					
12. — Lubricating Oil Filter*								x		x	
13. — Fuel Strainer and Filter*							x				
14. — Coolant Filter/Water Pump*								x			
15. — Starting Motor*											
16. — Air System									x		
17. — Exhaust System									x		
18. — Air Box Drain Tube										x	
19. — Emergency Shutdown									x		
21. — Radiator									x		
22. — Shutter Operation									x		
23. — Oil Pressure									x		
24. — Overspeed Governor								x			
26. — Throttle Delay*											
27. — Alternator*											
28. — Engine/Transmission Mounts											x
29. — Crankcase Pressure											x
30. — Air Box Check Valves*											
31. — Fan Hub*									x		
32. — Thermostats and Seals									x		
33. — Blower Screen										x	
34. — Crankcase Breather										x	
36. — Engine Tune-Up*											
37. — Heat Exchanger Electrodes*											
38. — Raw Water Pump*	x										
39. — Power Generator*											
40. — Power Take-Off*											
41. — Marine Gear*	x										
42. — Torqmatic Converter*											
43. — Hydrostarter System*											
44. — Blower Bypass Valve*											

* See Item
\# Marine Engine Time Intervals May Differ. See Item.

Item 1 – Lubricating Oil

Check the lubricating oil level with the engine stopped. If the engine has just been stopped, wait approximately twenty (20) minutes to allow the oil to drain back to the oil pan. Add the proper grade oil, as required, to maintain the correct level on the dipstick (refer to Section 13.3).

NOTICE: Oil may be blown out through the crankcase breather if the crankcase is overfilled.

Make a visual check for oil leaks around the filters and the external oil lines.

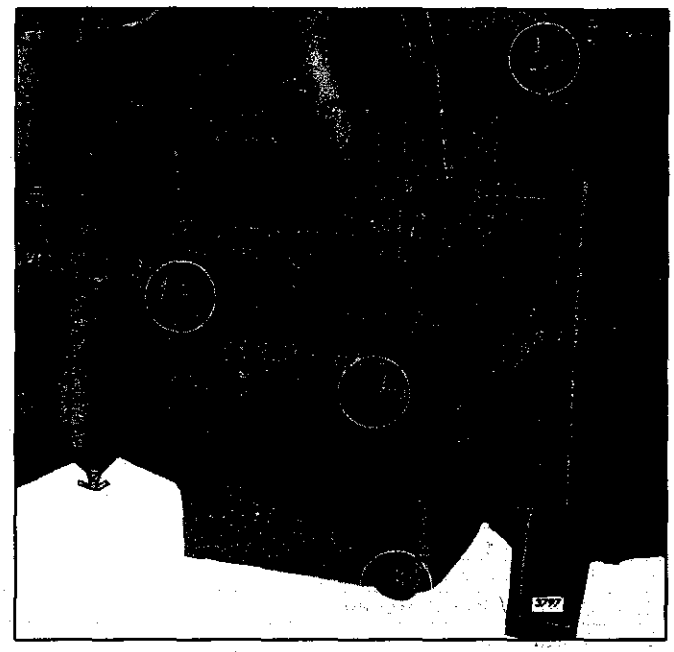
Change the lubricating oil at the intervals shown in the Chart. See Section 13.3 for drain intervals when using high sulfur fuel (above 0.50 mass percent).

When using high TBN/ash oils, a rule of thumb for oil change intervals is to drain the oil when the TBN drops to one–half of the new oil TBN. *Since lubricant composition varies from brand to brand the time and rate of TBN reduction will vary.* These differences manifested by the various high TBN/ash oils will influence the drain interval.

The drain interval may be established on the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the used oil sample analysis) until the most practical oil change period has been determined.

If the lubricating oil is drained immediately after an engine has been run for some time, most of the sediment will be in suspension and will drain readily. Select the proper grade of oil in accordance with the instructions given in the *Lubrication Specifications* in Section 13.3

ENGINE OIL CHANGE INTERVALS	
Service Application	Max. Engine Oil Change Interval Diesel Fuel Sulfur Content 0 to 0.50% by Wt. Max.
City Transit Coaches	6,000 Miles
Pickup Delivery Truck Service (Stop–and–go short distance)	12,000 Miles
Industrial, Agricultural & Marine	150 Hours
Stationary Units: — Full Time — Stand By	500 Hours or 1 Month 150 Hours or 1 Year



Items 1 and 12

Item 2 – Fuel Tanks

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the *Fuel Specifications* in Section 13.3.

Open the drain at the bottom of the fuel tank every 500 hours or 15,000 miles to drain off any water and/or sediment.

Every 12 months or 20,000 miles (700 hours) tighten all fuel tank mountings and brackets. At the same time, check the seal in the fuel tank cap, the breather hole in the cap and the condition of the crossover fuel line. Repair or replace the parts, as necessary.

Diesel Fuel Contamination

The most common form of diesel fuel contamination is water. Water is harmful to the fuel system in itself, but it also promotes the growth of microbiological organisms (microbes). These microbes clog fuel filters with a "slime" and restrict fuel flow.

Water can be introduced into the fuel supply through poor maintenance (loose or open fuel tank caps), contaminated fuel supply or condensation.

Condensation is particularly prevalent on units which stand idle for extended periods of time, such as marine units. Ambient temperature changes cause condensation in partially filled fuel tanks.

Water accumulation can be controlled by mixing isopropyl alcohol (dry gas) into the fuel oil at a ratio of one pint (.5 liter) per 125 gallons (473 liters) fuel (or 0.10% by volume).

Marine units in storage are particularly susceptible to microbe growth. The microbes live in the fuel–water interface. They need both liquids to survive. These microbes find excellent growth conditions in the dark, quiet, non–turbulent nature of the fuel tank.

Microbe growth can be eliminated through the use of commercially available biocides. There are two basic types on the market:

1. The water soluble type treats *only the tank* where it is introduced. Microbe growth can start again if fuel is transferred from a treated to an untreated tank.
2. The diesel fuel soluble type, such as "Biobor" manufactured by U.S. Borax or equilvalent, treats *the fuel* itself, and therefore, the entire fuel system.

Marine units or any other application going into storage should be treated as follows: Add the biocide according to the manufacturer's instructions. This operation is most effective when performed as the tank is being filled. Add dry gas in the correct proportions.

If the fuel tanks were previously filled, add the chemicals and stir with a clean rod.

Item 3 – Fuel Lines and Flexible Hoses

Make a visual check for fuel leaks at the crossover lines and at the fuel tank suction and return lines. Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tanks.

The performance of engine and auxiliary equipment is greatly dependent on the ability of flexible hoses to transfer lubricating oil, air, coolant and fuel oil. Diligent maintenance of hoses is an important step in ensuring efficient, economical and safe operation of the engine and related equipment.

Check hoses daily as part of the pre–start up inspection. Examine hoses for leaks and check all fittings, clamps and ties carefully. Make sure that hoses are not resting on or touching shafts, couplings, heated surfaces including exhaust manifolds, any sharp edges or other obviously hazardous areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can fatigue with age. To ensure continued proper support, inspect fasteners frequently and tighten or replace them, as necessary.

Leaks

Investigate leaks immediately to determine if fittings have loosened or cracked or if hoses have ruptured or worn through. Take corrective action immediately. Leaks are not only potentially detrimental to machine operation, but they also result in added expense caused by the need to replace lost fluids.

CAUTION: Personal injury and/or property damage may result from fire due to the leakage of flammable fluids such as fuel or lube oil.

Service Life

A hose has a finite service life. The service life of a hose is determined by the temperature and pressure of the air or fluid within it, its time in service, its mounting, the ambient temperatures, amount of flexing and vibration it is subject to. With this in mind, all hoses should be thoroughly inspected at least every 500 operating hours (1,000 hours for the fire–resistant fuel and lube hoses and heat–insulating turbo/exhaust system blanket) and/or annually. Look for cover damage or indications of damaged, twisted, worn, crimped, brittle, cracked or leaking lines. Hoses having the outer cover worn through or damaged metal reinforcement should be considered unfit for further service.

All hoses in or out of machinery should be replaced during major overhaul and/or after a maximum of five years service.

NOTICE: The new hose assemblies do not require automatic replacement after five years service or at major overhaul.

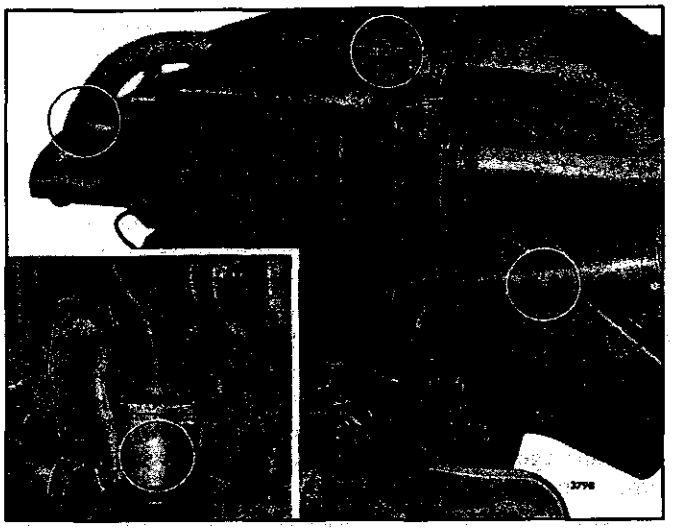
Item 4 – Cooling System

CAUTION: Do not remove the pressure control cap from the radiator or heat exchanger or attempt to drain the coolant until the engine has cooled. Once the engine has cooled, use extreme care when removing the cap. The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding) from the hot liquid.

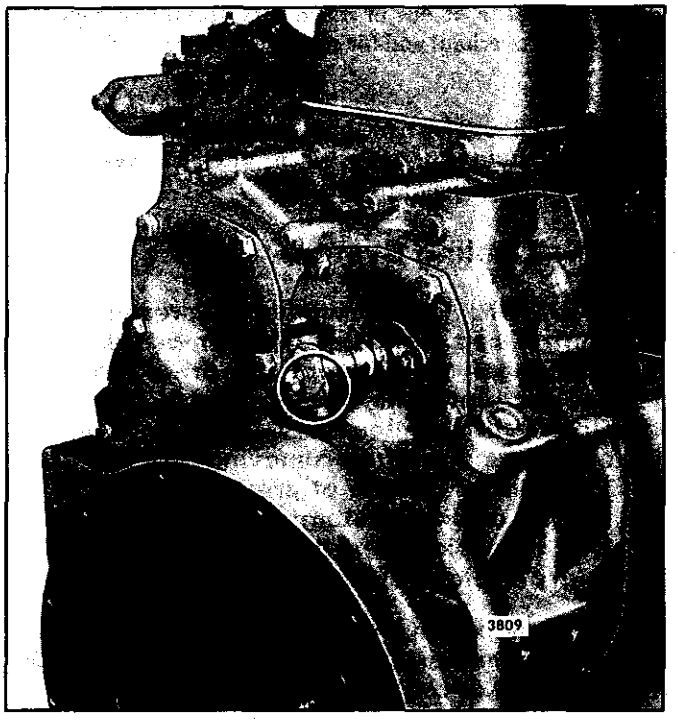
Check the coolant level daily and maintain it near the top of the heat exchanger tank or make sure it covers the radiator tubes. Add coolant, as necessary. *Do not overfill.*

Make a visual check for cooling system leaks. Check for an accumulation of coolant beneath the vehicle during periods when the engine is running and when the engine is stopped.

In order to assure the integrity of the cooling system, it is recommended that a periodic cooling system pressure check be performed. Pressurize the cooling system (15–20 psi or 103–138 kPa) using radiator cap and cooling system tester J 24460–01. Do not exceed 20 psi (138 kPa). Any measurable drop in pressure may indicate an external/internal leak. Whenever the oil pan is removed, the cooling system should be pressure checked as a means of identifying any incipient coolant leaks.



Item 4 and 14



Item 7

• 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 throughly 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 Section 13.3). Add required inhibitors. After filling, run engine until thermostat(s) open and top off to recommended *full* level. Reinstall fill/pressure cap.

Inspect all of the cooling system hoses at least once every 700 hours or 20,000 miles to make sure the clamps are tight and properly seated on the hoses and to check for signs of deterioration. Replace the hoses, if necessary.

Item 5 – Turbocharger

CAUTION: To eliminate the possibility of personal injury when air inlet piping is removed, do not operate an engine with a turbocharger unless the compressor inlet guard assembly or turbo inlet shield (J 26554–A) is installed.

• Visually inspect the mountings, intake and exhaust ducting and connections for leaks daily. Check the oil inlet and outlet lines for leaks or restrictions to oil flow. Check for unusual noise or vibration and, if excessive, stop the engine and do not operate until the cause is determined.

The exhaust manifold retaining nuts, exhaust flange clamp, and other manifold connections should also be checked for leakage and tightened, if necessary.

Check heat–insulating exhaust system blankets for damage daily. Torn, matted, crushed, oil–soaked, or otherwise damaged insulation blankets *must* be replaced immediately.

Item 6 – Battery

Check the "eye" of maintenance–free batteries for charge. If lead–acid or low maintenance batteries are used, check the specific gravity of the electrolyte in each cell every 100 hours or 3,000 miles. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's recommendations.

Item 7 – Tachometer Drive

Lubricate the tachometer drive every 100 hours or 3,000 miles with an all purpose grease at the grease fitting. At temperatures above 30°F (–1°C), use a No. 2 grade grease. Use a No. 1 grade grease below this temperature.

Item 8 – Air Cleaner

Under no engine operating conditions should the air inlet restriction exceed 25 inches of water (6.2 kPa) for non–turbocharged engines or 20 inches of water (5.0 kPa) for turbocharged engines. A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.

Oil Bath

Remove the dirty oil and sludge from the oil bath type air cleaner cups and center tubes every 8 hours (every 6,000 miles for highway vehicle engines), or less if operating

conditions warrant. Wash the cups and elements in clean fuel oil and refill the cups to the level mark with the same grade and viscosity *heavy–duty* oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions. If heavy rain or snow has been encountered, check the air cleaner for an accumulation of water.

Remove and steam clean the air cleaner element and baffle annually.

It is recommended that the body and fixed element in the heavy–duty oil bath type air cleaner be serviced every 500 hours or 15,000 miles or as conditions warrant.

Dry Type

Dry type air cleaner elements (Donaldson, Farr, etc.) used in on–highway applications should be discarded and replaced with new elements after one year of service, after 100,000 miles (Donaldson's recommended mileage interval) or when the maximum allowable air intake restriction has been reached (see Section 13.2), whichever comes first. No attempt should be made to clean or reuse on–highway elements after these intervals.

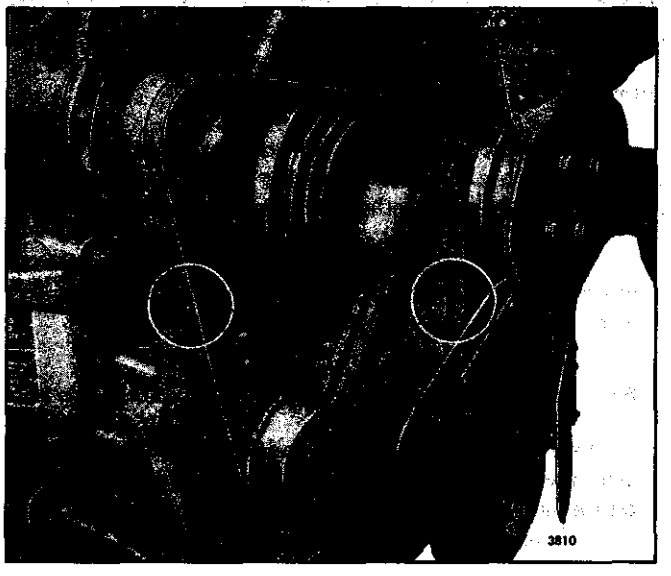
Dry type elements used in off–highway applications should be discarded and replaced with new elements after one year of service or when the maximum allowable air intake restriction has been reached (see Section 13.2), whichever comes first. In cases where the air cleaner manufacturer recommends cleaning or washing off–highway elements, the maximum service life is still one year or maximum restriction. Cleaning, washing and inspection must be done per the manufacturer's recommendations. Inspection and replacement of the cover gaskets must also be done per the manufacturer's recommendations.

Item 9 – Drive Belts

New standard V–belts will stretch after the first few hours of operation. Run the engine for 15 *seconds* to seat the belts, then readjust the tension. Check the belts and tighten the fan drive, pump drive, battery–charging alternator and other accessory drive belts after 1/2 hour or 15 miles and again after 8 hours or 240 miles of operation. Thereafter, check the tension of the drive belts every 200 hours or 6,000 miles and adjust, if necessary. Belts should be neither too tight nor too loose. Belts which are too tight impose excess loads on the crankshaft, fan and/or alternator bearings, shortening both belt and bearing life. Excessively overtightened belts can result in crankshaft breakage. A loose belt will slip.

Replace all belts in a set when one is worn. Single belts of similar size should not be used as a substitute for a matched belt set; premature belt wear can result because of belt length variation. All belts in a matched belt set are within .032" of their specified center distances.

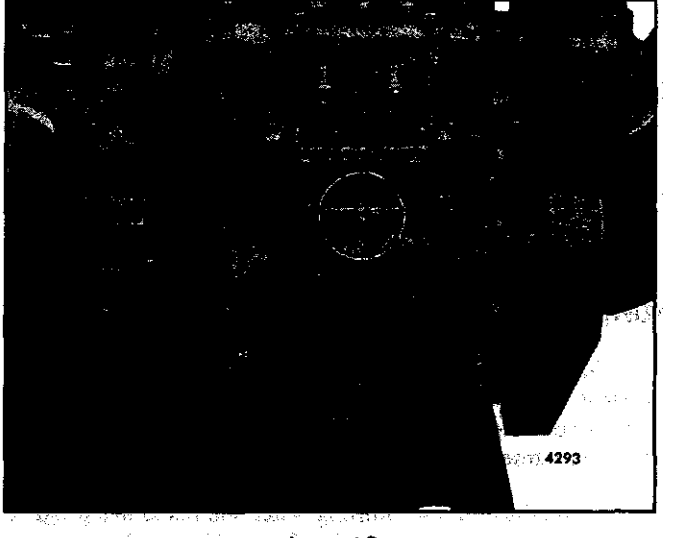
Adjust the belt tension so that a firm push with the thumb, at a point midway between the two pulleys, will depress the belt 1/2" to 3/4". If belt tension gage J 23600–B or equivalent is available, adjust the belt tension, as outlined in the Chart. When installing or adjusting an accessory drive belt, be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot.



Item 9

Model	Fan Drive		Alternator Drive		
	2 or 3 belts	Single belt	Two 3/8" or 1/2" belts	One 1/2" belt	One Wide belt
3, 4-53	40-50	—	40-50	50-70	40-50
6, 8V-53	60-80	80-100	40-50	50-70	40-50
All	For 3-point or triangular drive use a tension of 90-120.				

BELT TENSION CHART (lbs/belt)



Item 10

Item 10 – Air Compressor

Remove and wash all of the polyurethane sponge strainer parts every 5000 miles (150 operating hours). The strainer element should be cleaned or replaced. If the element is cleaned, it should be washed in a commercial solvent or a detergent and water solution. The element should be saturated in clean engine oil, then squeezed dry before replacing it in the strainer. Be sure to replace the air strainer gasket if the entire air strainer is removed from the compressor intake.

For replacement of the air strainer element, contact the nearest Bendix Westinghouse or Midland–Ross dealer; replace with the polyurethane element, if available.

Every 12 months or 20,000 miles tighten the air compressor mounting bolts. If the air compressor is belt driven, check the belts for proper tension.

Item 11 – Throttle and Clutch Controls

Every 200 hours or 6,000 miles lubricate the throttle control mechanism. Use an all purpose grease (No. 2 grade) at temperatures + 30°F (–1°C) and above. At temperatures below this use a No. 1 grade grease.

Lubricate all other control mechanisms, as required, with engine oil.

Item 12 – Lubricating Oil Filter

Install new oil filter elements and gaskets each time the engine oil is changed. See Section 13.3 for filters and recommended intervals.

Make a visual check of all lubricating oil lines for wear and chafing. If any indication of wear is evident, replace the oil lines and correct the cause.

When the engine is equipped with a turbocharger, pre–lubricate it as outlined under *Install Turbocharger* in Section 3.5.

If the engine is equipped with a governor oil filter, change the element every 1,000 hours or 30,000 miles.

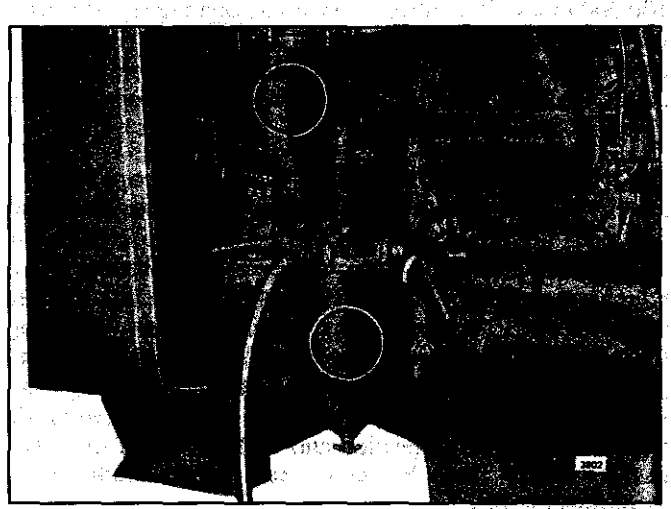
Check for oil leaks after starting the engine.

Item 13 – Fuel Strainer and Filter

Install new elements every 6 months or 10,000 miles (vehicle engines) and 300 hours or 9,000 miles (non–vehicle engines) or when plugging is indicated. See Section 13.3 for filter recommendations.

A method of determining when elements are plugged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury (20.3 kPa). At normal operating speed the fuel pressure is 45–70 psi (310–483 kPa). Change the fuel filter elements whenever the inlet restriction at the fuel pump reaches 12 inches of mercury (41 kPa) at normal operating speeds and whenever the fuel pressure at the inlet manifold falls below 45 psi (310 kPa).

NOTICE: *To improve starting, have replacement filters filled with fuel and ready to install immediately after used filters are removed. This will prevent possible fuel siphoning, causing fuel system aeration. If the engine fails to start after replacement of the fuel filter element(s), the fuel system will require priming with tool J 5956, or equivalent.*



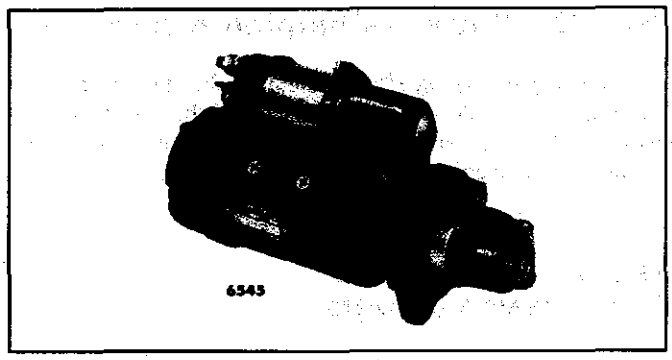
Item 13

Item 14 – Coolant Filter and Water Pump

If the cooling system is protected by a coolant filter and conditioner, the filter element should be changed every 6 months or 10,000 miles (vehicle engines) and 500 hours or 15,000 miles (non–vehicle engines). Select the proper coolant filter element in accordance with the instructions given under *Coolant Specifications* in Section 13.3. Use a new filter cover gasket when installing the filter element. After replacing the filter and cover gasket, start the engine and check for leaks.

Inspect the water pump drain hole every 6 months for plugging. If plugged, clean out the drain hole with a tool made from a front crankshaft seal or equivalent.

Replace the water pump seal after it has been in service for 200,000 miles or 6,000 hours.



Item 15

Item 15 – Starting Motor

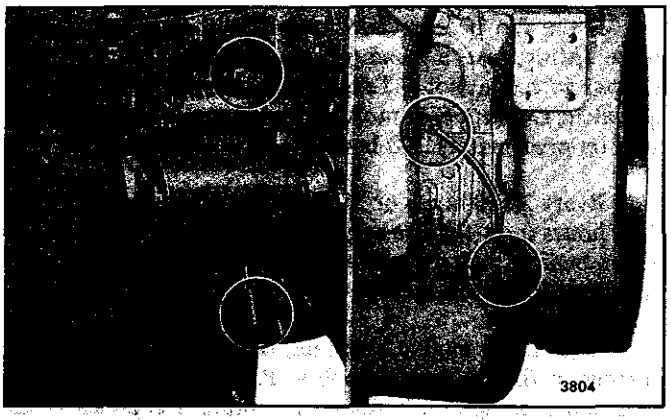
The electrical starting motor is permanently lubricated at the time of manufacture. No further lubrication is required. Follow starter manufacturer's recommendations if disassembly or overhaul is required.

Item 16 – Air System

Check all of the connections in the air system to be sure they are tight. Check all hoses for punctures or other damage and replace, if necessary.

Item 17 – Exhaust System

Check the exhaust manifold retaining nuts, exhaust flange clamp and other connections for tightness. Check for proper operation of the exhaust pipe rain cap, if one is used.



Item 18

Item 18 – Air Box Drain Tube

With the engine running, check for flow of air from the air box drain tubes every 1,000 hours or 30,000 miles. If the tubes are clogged, remove, clean and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent.

If the engine is equipped with an air box drain tank, drain the sediment periodically.

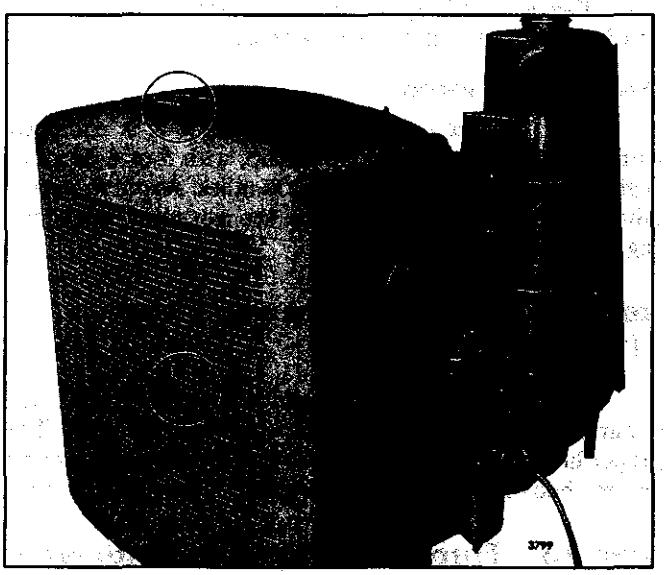
Item 19 – Emergency Shutdown

With the engine running at idle speed, check the operation of the emergency shutdown every 700 hours or 20,000 miles. Reset the air shutdown valve in the *open* position after the check has been made.

Item 20 – Engine (Steam Clean)

Steam clean the engine and engine compartment.

NOTICE: Do not apply steam or solvent directly to the battery-charging alternator, starting motor or electrical components as damage to electrical equipment may result.



Item 21

Item 21 – Radiator

Inspect the exterior of the radiator core every 12 months or 20,000 miles (700 hours) and, if necessary, clean it with a quality grease solvent such as mineral spirits and dry it with compressed air.

CAUTION: To avoid personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Do not use fuel oil, kerosene or gasoline. It may be necessary to clean the radiator more frequently if the engine is being operated in extremely dusty or dirty areas.

Item 22 – Shutter Operation

Check the operation of the shutters and clean the linkage and controls.

Item 23 – Oil Pressure

Under normal operation, oil pressure is noted each time the engine is started. In the event the engine is equipped with warning lights rather than pressure indicators, the pressure should be checked and recorded every 700 hours or 20,000 miles.

Item 24 – Governor

Check and record the engine idle speed and no–load speed. Adjust as necessary.

An idle speed lower than recommended will cause the engine to be accelerated from a speed lower than the speed at which the engine was certified.

A no–load speed higher than recommended will result in a full–load speed higher than rated and higher than the speed at which the engine was certified.

Overspeed Governor

Lubricate the overspeed governor, if it is equipped with a hinge–type cap oiler or oil cup, with 5 or 6 drops of engine oil every 500 hours or 15,000 miles. Avoid excessive lubrication and do not lubricate the governor while the engine is running.

Item 25 – Fuel Injectors and Valve Clearance

Check the injector timing and exhaust valve clearance as outlined in Section 14.2 and 14.1 every 50,000 miles. The proper height adjustment between the injector follower and injector body is of primary importance to emission control.

Item 26 – Throttle Delay/Fuel Modulator

Inspect and adjust, if necessary, every 30 months or 50,000 miles.

The **Throttle Delay** system limits the amount of fuel injected during acceleration by limiting the rate of injector rack movement with a hydraulic cylinder. The initial location of this cylinder must be set with the proper gage to achieve the appropriate time delay (Section 14.14).

Inspect the check valve by filling the throttle delay cylinder with diesel fuel and watching for valve leakage while moving the throttle from the idle to the *full–fuel* position.

On the **Fuel Modulator**, inspect the roller and piston outer diameter and the cylinder bore inner diameter for wear and free operation. Also, inspect the operating surface of the lower roller, the roller pins at the cam pivot and the cam attachment to the piston. Replace parts, as required.

The fuel modulator must be set with the proper gage to achieve the correct fuel–to–air ratio (Section 14.14).

Item 27 – Battery–Charging Alternator

Battery–charging alternators are lubricated at time of manufacture and do not require further lubrication. Check terminals for corrosion and loose connections. Check for damaged or frayed insulation. Repair or replace wiring as required.

Item 28 – Engine and Transmission Mounts

Check the engine and transmission mounting bolts and the condition of the mounting pads every 2,000 hours or 60,000 miles. Tighten and repair as necessary.

Item 29 – Crankcase Pressure

Check and record the crankcase pressure every 2,000 hours or 60,000 miles (refer to Section 15.2).

Item 30 – Air Box Check Valves

Every 100,000 miles or approximately 3,000 hours remove the air box check valves, clean them in solvent and blow out the lines with compressed air. Inspect for leaks after servicing.

CAUTION: To avoid personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Item 31 – Fan Hub

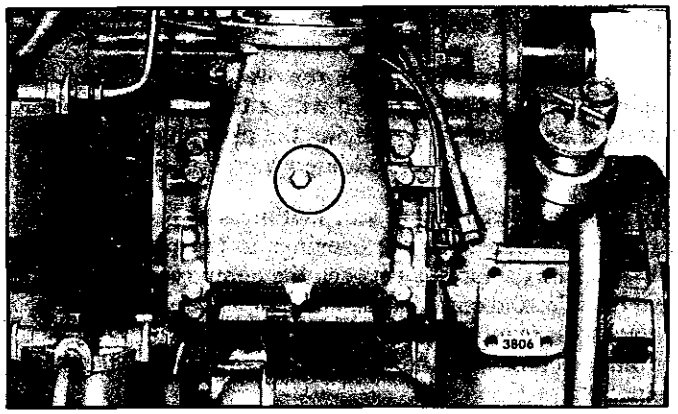
If the fan bearing hub assembly is provided with a grease fitting, use a hand grease gun and lubricate the bearings with one shot of Texaco Premium RB grease, or an equivalent Lithium base multi–purpose grease, every 20,000 miles (approximately 700 hours).

Every 2,500 hours or 75,000 miles (vehicle engines) or 4,000 hours (non–vehicle engines) clean, inspect and repack the fan bearing hub assembly with the above recommended grease (refer to Section 5.4).

At a major engine overhaul, remove and discard the bearings in the fan hub assembly. Pack the hub assembly, using new bearings, with Texaco Premium RB grease or an equivalent Lithium base multi–purpose grease.

Item 32 – Thermostats and Seals

Check the thermostats (see Section 5.2.1) and seals at 5,000 hours (non–highway engines), 200,000 miles (highway engines) or once a year (preferably at the time the cooling system is prepared for winter operation). The thermostats and seals should *always* be replaced at overhaul.



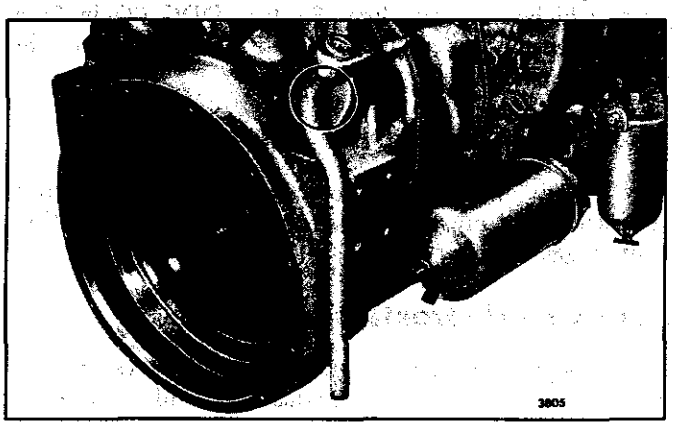
Item 33

Item 33 – Blower Screen

Inspect the blower screen and gasket assembly annually (vehicle engines) or every 1,000 hours or 30,000 miles (non–vehicle engines) and, if necessary, clean the screen in fuel oil and dry it with compressed air.

CAUTION: To avoid personal injury, wear adequate eye protection and do not exceed 40 psi (276 kPa) air pressure.

Install the screen and gasket assembly with the screen side of the assembly toward the blower. Inspect for evidence of blower seal leakage.



Item 34

Item 34 – Crankcase Breather

Remove the externally mounted crankcase breather assembly annually (vehicle engines) or every 1,000 hours or 30,000 miles (non–vehicle engines) and wash the steel mesh pad in clean fuel oil. This cleaning period may be reduced or lengthened according to severity of service.

Clean the breather cap, mounted on the valve rocker cover, in clean fuel oil every time the engine oil is changed.

Item 35 – Fan (Thermo–Modulated)

DRIVE FLUID LEVEL – Check the fan drive fluid level to avoid improper operation and damage to the drive components.

Current modulated fan drive housings have an inspection plug for checking the fluid level. Formerly partial disassembly of the drive was necessary to make the fluid level check. Former units can be updated by installing a current drive housing which includes the fluid inspection plug and a grease fitting for lubricating the bearing.

1. Check the fan drive fluid level after the unit has been idle for at least 1/2 hour.
2. Turn the fan drive so that the inspection plug is 3/4" below the horizontal center line, then allow the silicone fluid to drain down an additional five (5) minutes.
3. Remove the inspection plug. If fluid begins to flow from the inspection hole, the drive has sufficient fluid. Replace the inspection plug.
4. If the fluid does not flow from the hole, proceed as follows:
   a. Rotate the fan drive downward and observe when the fluid begins to flow from the hole. If it is necessary to lower the drain hole more than 2" below the horizontal center line, the fan drive should be removed from the engine, disassembled and inspected for possible damage to the components.
   b. Turn the fan drive back so the inspection hole is 3/4" below the horizontal center line and add fluid until the overflow point is reached. Replace the inspection plug.

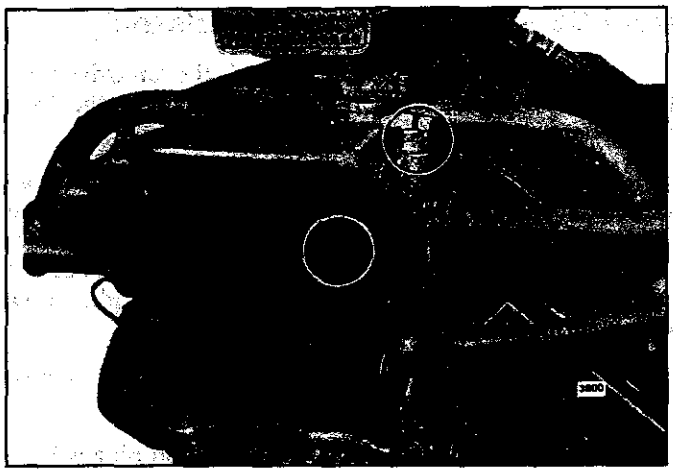
Use only the manufacturer's Special 20 Cenistroke fluid.

DRIVE BEARING LUBRICATION – The fan drive bearing should be lubricated with a Medium Consistency Silicone Grease (Dow Corning No. 44, or equivalent).

The bearing on current fan assemblies is lubricated through a grease fitting in the drive housing hub. Lubrication of the bearing in former assemblies requires the removal of the fan assembly and partial disassembly. The former assemblies can be updated to include a grease fitting by installing the current housing.

Item 36 – Engine Tune–Up

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 mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

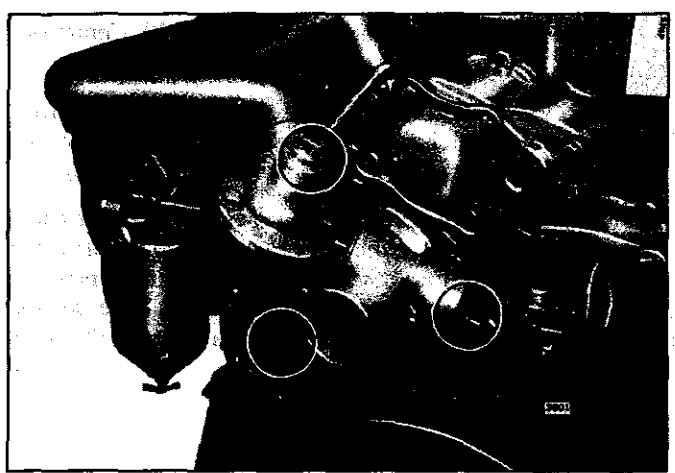


Item 37

Item 37 – Heat Exchanger Electrodes and Core

Heat exchanger electrodes ("zincs") should be removed and checked initially every 60 days, then as required or annually. Electrodes are generally found in the heat exchanger assembly, the raw water pump elbows, and the engine/marine gear auxiliary coolers. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a used electrode, strike it sharply against a hard surface; a weakened electrode will break.

Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1,000 hours and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, contact a *Detroit Diesel Service Outlet.*



Item 38

Item 38 – Raw Water Pump

Check the prime on the raw water pump daily. The engine should not be operated with a dry pump. Prime the pump, if necessary, by removing the pipe plug provided in the pump inlet elbow and adding water. Reinstall the plug.

• A raw water pump seal malfunction is indicated by leakage of water from the openings in the pump housing. These openings, located between the pump mounting flange and the inlet and outlet ports, must remain open at all times. Leaky seals require replacement. The raw water pump body or liner should also be checked for cracks or wear and replaced.

Item 39 – Power Generator

Follow the power generator manufacturer's lubrication and preventive maintenance recommendations at his suggested intervals.

Item 40 – Power Takeoff

Follow the power take–off manufacturer's lubrication and preventive maintenance recommendations at his suggested intervals.

Item 41 – Marine Gear

• Check marine gear oil level daily. Replace Allison marine gear lube oil and filter every 150 hours or every two years, whichever comes first. Replace DDC (Twin Disc) marine gear lube oil every 1,000 hours or every six months, whichever comes first.

• Item 42 – Torqmatic Converter

Follow the Torqmatic converter manufacturer's lubrication and preventive maintenance recommendations at his suggested intervals.

Item 43 – Hydrostarter System

If engine is equipped with a hydrostarter system, refer to Section 12.6.1 for lubrication and preventive maintenance.

• Item 44 – Blower Bypass Valve

Every 100,000 miles or approximately 3,000 hours, remove the bypass blower valve and clean it in solvent, if necessary. Inspect for free operation of the valve and any scoring of the piston, piston guide or sleeve assembly. Repair or replace, as required.

TROUBLESHOOTING

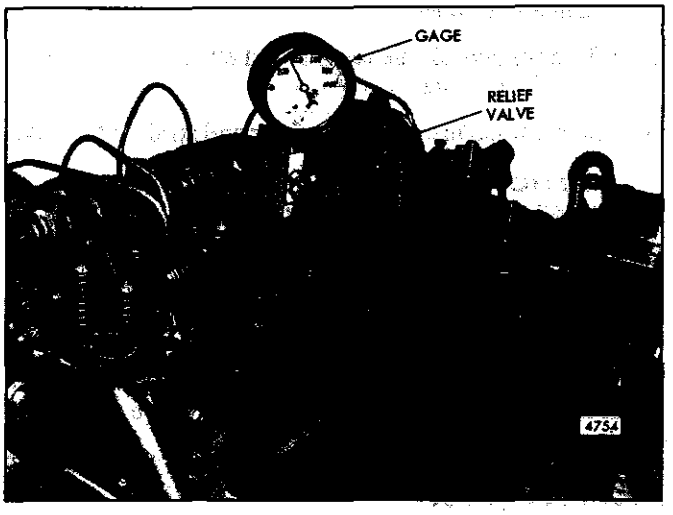


Fig. 1 – Checking Compression Pressure

Certain abnormal conditions which sometimes interfere with satisfactory engine operation, together with methods of determining the cause of such conditions, are covered on the following pages.

Satisfactory engine operation depends primarily on:

1. An adequate supply of air compressed to a sufficiently high compression pressure.
2. The injection of the proper amount of fuel at the right time.

Lack of power, uneven running, excessive vibration, stalling at idle speed and hard starting may be caused by either low compression, faulty injection in one or more cylinders, or lack of sufficient air.

Since proper compression, fuel injection and the proper amount of air are important to good engine performance, detailed procedures for their investigation are given below.

Locating a Misfiring Cylinder

1. Start the engine and run it at part load until it reaches normal operating temperature.
2. Stop the engine and remove the valve rocker cover(s).
3. Check the valve clearance (refer to Section 14.1).
4. Start the engine. Then hold an injector follower down with a screw driver to prevent operation of the injector. If the cylinder has been misfiring, there will be no noticeable difference in the sound and operation of the engine. If the cylinder has been firing properly, there will be a noticeable difference in the sound and operation when the injector follower is held down. This is similar to short–circuiting a spark plug in a gasoline engine.
5. If the cylinder is firing properly, repeat the procedure on the other cylinders until the faulty one has been located.
6. If the cylinder is misfiring, check the following:
   a. Check the injector timing (refer to Section 14.2).
   b. Check the compression pressure.
   c. Install a new injector.
   d. If the cylinder still misfires, remove the cam follower (refer to Section 1.2.1) and check for a worn cam roller, camshaft lobe, bent push rod or worn rocker arm bushing.

Checking Compression Pressure

Compression pressure is affected by altitude as shown in Table 1.

Check the compression pressure as follows:

1. Start the engine and run it at approximately one–half rated load until normal operating temperature is reached.
2. Stop the engine and remove the fuel pipes from the injector and fuel connectors of the No. 1 cylinder.
3. Remove the injector and install adaptor J 7915–02 and pressure gage and hose assembly J 6692 (Fig. 1).
4. Use a spare fuel pipe to fabricate a jumper connection between the fuel inlet and return manifold connectors. This will permit fuel from the inlet manifold to flow directly to the return manifold.
5. Start the engine and run it at a 600 rpm. Observe and record the compression pressure indicated on the gage. *Do not crank the engine with the starting motor to obtain the compression pressure.*

Minimum Compression Pressure at 600 rpm				Altitude Above Sea Level	
Std. Engine		"N" Engine			
psi	kPa	psi	kPa	Feet	Meters
430	2 963	540	3 721	500	152
400	2 756	500	3 445	2,500	762
370	2 549	465	3 204	5,000	1 524
340	2 343	430	2 963	7,500	2 286
315	2 170	395	2 722	10,000	3 048

TABLE 1

Cylinder	Gage Reading	
	psi	kPa
1	525	3 617
2	520	3 583
3	485	3 342
4	515	3 548

TABLE 2

6. Perform Steps 2 through 5 on each cylinder. The compression pressure in any one cylinder at a given altitude above sea level should not be less than the minimum shown in Table 1. In additon, the variation in compression pressures between cylinders must not exceed 25 psi (172 kPa) at 600 rpm.

   If the compression pressure readings were as shown in Table 2, it would be evident that No. 3 cylinder should be examined and the cause of the low compression pressure be determined and corrected.

   The pressures in Table 2 are for an "N" engine operating at an altitude near sea level. Note that all of the cylinder pressures are above the low limit for satisfactory engine operation. Nevertheless, the No. 3 cylinder compression pressure indicates that something unusual has occurred and that a localized pressure leak has developed.

   Low compression pressure may result from any one of several causes:

   A. Piston rings may be stuck or broken. To determine the condition of the rings, remove the air box cover and inspect them by pressing on the rings with a blunt tool. A broken or stuck ring will not have a "spring–like" action.

   B. Compression pressure may be leaking past the cylinder head gasket, the valve seats, the injector tube or a hole in the piston.

Engine Out of Fuel

The problem in restarting an engine after it has run out of fuel stems from the fact that after the fuel is exhausted from the fuel tank, fuel is then pumped from the primary fuel strainer and sometimes partially removed from the secondary fuel filter before the fuel supply becomes insufficient to sustain engine firing. Consequently, these components must be refilled with fuel and the fuel pipes rid of air in order for the system to provide adequate fuel for the injectors.

When an engine has run out of fuel, there is a definite procedure to follow for restarting it:

1. Fill the fuel tank with the recommended grade of fuel oil. If only partial filling of the tank is possible, add a minimum of ten gallons (38 litres) of fuel.
2. Remove the fuel strainer shell and element from the strainer cover and fill the shell with fuel oil. Install the shell and element.
3. Remove and fill the fuel filter shell and element with fuel oil as in Step 2.
4. Start the engine. Check the filter and strainer for leaks.

   NOTICE: In some instances, it may be necessary to remove a valve rocker cover and loosen a fuel pipe nut to bleed trapped air from the fuel system. Be sure the fuel pipe is retightened securely before replacing the rocker cover.

Primer J 5956 may be used to prime the entire fuel system. Remove the filler plug in the fuel filter cover and install the primer. Prime the system. Remove the primer and install the filler plug.

Fuel Flow Test

The proper flow of fuel is required for satisfactory engine operation. Check the condition of the fuel pump, fuel strainer and fuel filter as outlined in Section 2.0 under *TroubleShooting.*

Crankcase Pressure

The crankcase pressure indicates the amount of air passing between the oil control rings and the cylinder liners into the crankcase, most of which is clean air from the air box. A slight pressure in the crankcase is desirable to prevent the entrance of dust. A loss of engine lubricating oil through the breather tube, crankcase ventilator or dipstick hole in the cylinder block is indicative of excessive crankcase pressure.

The causes of high crankcase pressure may be traced to excessive blow–by due to worn piston rings, a hole or crack in a piston crown, loose piston pin retainers, worn blower oil seals, defective blower, cylinder head or end plate gaskets, or excessive exhaust back pressure. Also, the breather tube or crankcase ventilator should be checked for obstructions.

Check the crankcase pressure with a manometer connected to the oil level dipstick opening in the cylinder block. Check the readings obtained at various engine speeds with the *Engine Operating Conditions* in Section 13.2. *The dipstick adaptor must not be below the level of the oil when checking the crankcase pressure.*

Exhaust Back Pressure

A slight pressure in the exhaust system is normal. However, excessive exhaust back pressure seriously affects engine operation. It may cause an increase in the air box pressure with a resultant loss of efficiency of the blower. This means less air for scavenging which results in poor combustion and higher temperatures.

Causes of high exhaust back pressure are usually a result of an inadequate or improper type of muffler, an

exhaust pipe which is too long or too small in diameter, an excessive number of sharp bends in the exhaust system, or obstructions such as excessive carbon formation or foreign matter in the exhaust system.

Check the exhaust back pressure, measured in inches of mercury, with a manometer. Connect the manometer to the exhaust manifold (except on turbocharged engines) by removing the 1/8" pipe plug which is provided for that purpose. If no opening is provided, drill an 11/32" hole in the exhaust manifold companion flange and tap the hole to accommodate a 1/8" pipe plug.

On turbocharged engines, check the exhaust back pressure in the exhaust piping 6" to 12" from the turbine outlet (Fig. 1, Section 13.2). The tapped hole must be in a comparatively straight pipe area for an accurate measurement.

Check the readings obtained at various speeds (at no–load) with the *Engine Operating Conditions* in Section 13.2.

Air Box Pressure

Proper air box pressure is required to maintain sufficient air for combustion and scavenging of the burned gases. Low air box pressure is caused by a high air inlet restriction, damaged blower rotors, an air leak from the air box (such as leaking end plate gaskets) or a clogged blower air inlet screen. Lack of power or black or grey exhaust smoke are indications of low air box pressure.

High air box pressure can be caused by partially plugged cylinder liner ports.

Check the air box pressure with a manometer connected to an air box drain tube.

Check the readings obtained at various speeds with the *Engine Operating Conditions* in Section 13.2.

Air Inlet Restriction

Excessive restriction of the air inlet will affect the flow of air to the cylinders and result in poor combustion and lack of power. Consequently the restriction must be kept as low as possible considering the size and capacity of the air cleaner. An obstruction in the air inlet system or dirty or damaged air cleaners will result in a high blower inlet restriction.

Check the air inlet restriction with a water manometer connected to a fitting in the air inlet ducting located two inches (2") above the air inlet housing (non–turbocharged engines) or the compressor inlet (turbocharged engines). When the insertion of a fitting at this point is not practical (non–turbocharged engines), the manometer may be connected to the engine air inlet housing. The restriction at this point should be checked at a specific 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.

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 inlet vacuum at various speeds (at no–load) and compare the results with the *Engine Operating Conditions* in Section 13.2.

PROPER USE OF MANOMETER

The U–tube manometer is a primary measuring device indicating pressure or vacuum by the difference in the height of two columns of fluid.

Connect the manometer to the source of pressure, vacuum or differential pressure. When the pressure is imposed, add the number of inches one column of fluid travels up to the amount the other column travels down to obtain the pressure (or vacuum) reading.

The height of a column of mercury is read differently than that of a column of water. Mercury does not wet the inside surface; therefore, the top of the column has a convex meniscus (shape). Water wets the surface and therefore has a concave meniscus. A mercury column is read by sighting horizontally between the top of the convex mercury surface (Fig. 2) and the scale. A water manometer is read by sighting horizontally between the bottom of the concave water surface and the scale.

Should one column of fluid travel further than the other column, due to minor variations in the inside diameter of the tube or to the pressure imposed, the accuracy of the reading obtained is not impaired.

Refer to Table 3 to convert the manometer reading into other units of measurement.

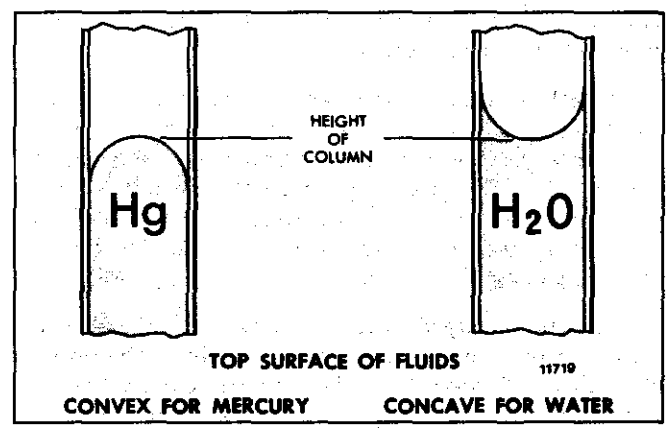
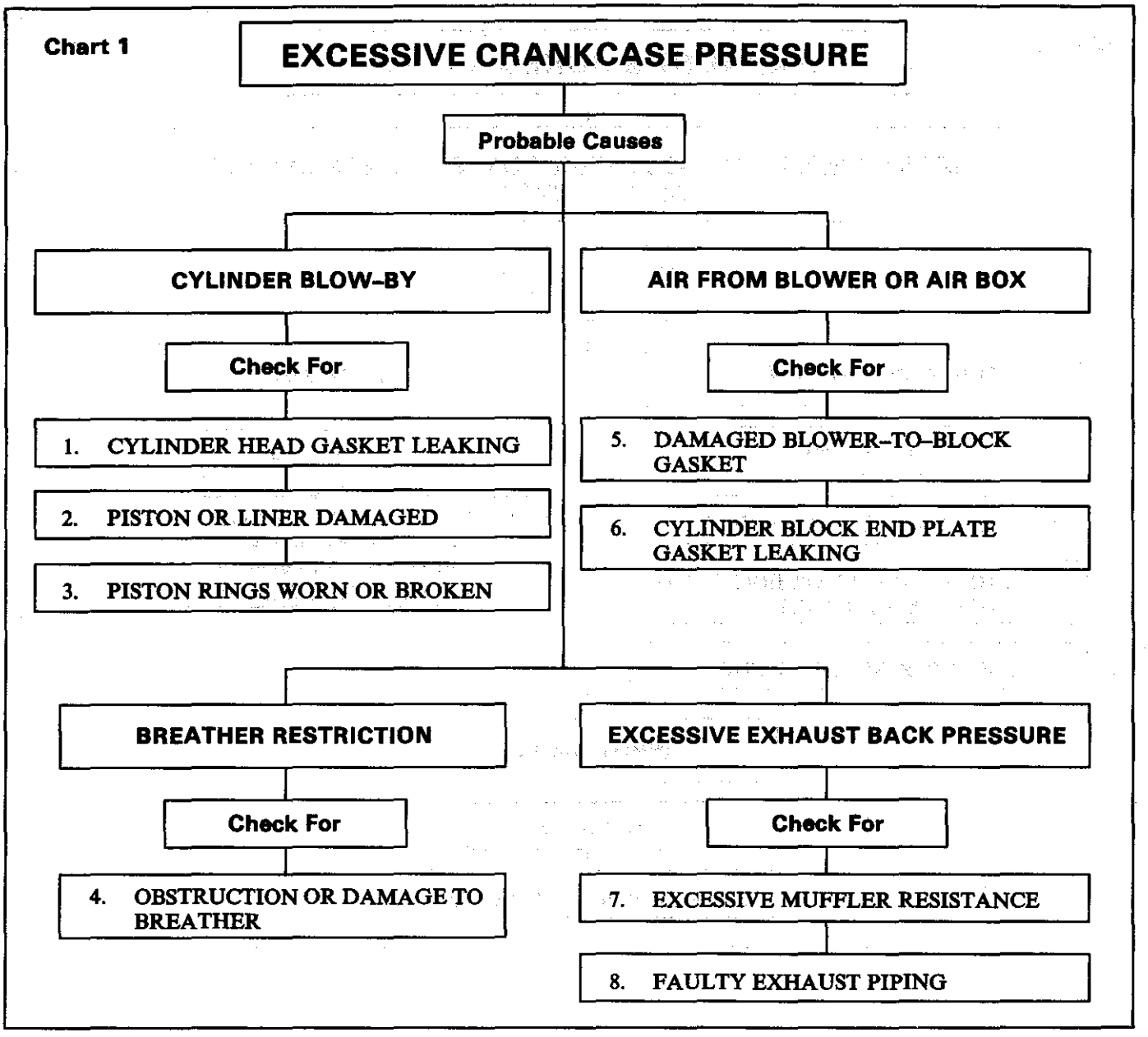


Fig. 2 – Comparison of Column Height for Mercury and Water Manometers

PRESSURE CONVERSION CHART		
1" water	=	.0735" mercury
1" water	=	.0361 psi
1" mercury	=	13.6000" water
1" mercury	=	.4910 psi
1 psi	=	27.7000" water
1 psi	=	2.0360" mercury
1 psi	=	6.895 kPa
1 kPa	=	.145 psi

TABLE 3

Chart 1



SUGGESTED REMEDY

1. Check the compression pressure and, if only one cylinder has low compression, remove the cylinder head and replace the head gaskets.
2. Inspect the piston and liner and replace damaged parts.
3. Install new piston rings.
4. Clean and repair or replace the breather assembly.
5. Replace the blower-to-block gasket.
6. Replace the end plate gasket.
7. Check the exhaust back pressure and repair or replace the muffler if an obstruction is found.
8. Check the exhaust back pressure and install larger piping if it is determined that the piping is too small, too long or has too many bends.

Chart 2

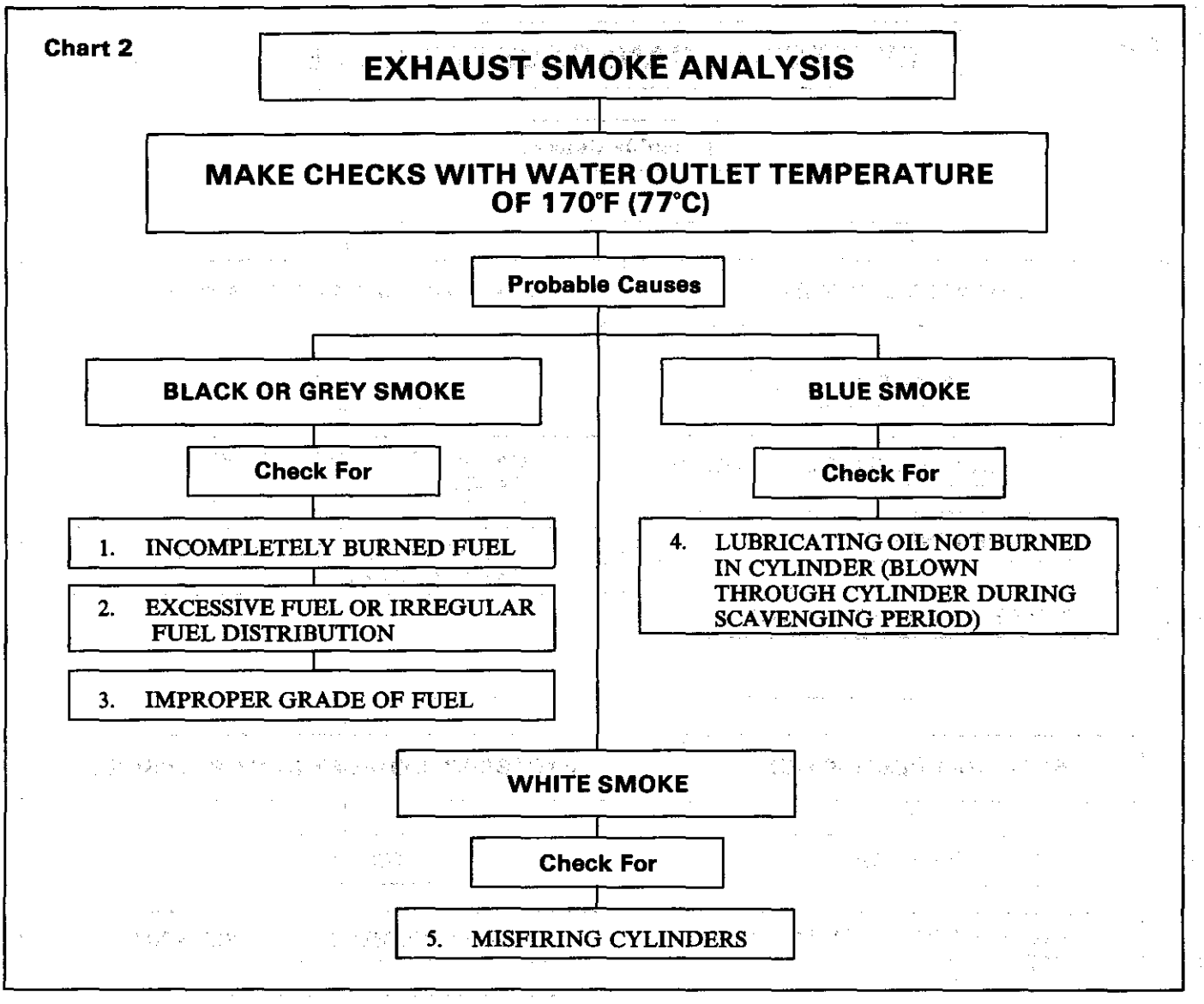


Chart 2

EXHAUST SMOKE ANALYSIS

SUGGESTED REMEDY

1. High exhaust back pressure or a restricted air inlet causes insufficient air for combustion and will result in incompletely burned fuel.

   High exhaust back pressure is caused by faulty exhaust piping or muffler obstruction and is measured at the exhaust manifold outlet with a manometer. Replace faulty parts.

   Restricted air inlet to the engine cylinders is caused by clogged cylinder liner ports, air cleaner or blower air inlet screen. Clean these items. Check the emergency stop to make sure that it is completely open and readjust it, if necessary.

2. If the engine is equipped with a throttle delay, check for the proper setting, leaky check valve and restricted filling of the piston cavity with oil from the reservoir.

   If the engine is equipped with a fuel modulator, check the cam to determine if it is stuck in the full fuel position. Verify tightness of the roller lever clamp on the control tube. Determine correctness (refer to Section 14.14) of the installed fuel modulator piston spring and check if the spring has taken a permanent "set" or if the spring rate is too low.

   The above affects only excessive acceleration smoke, but does not affect smoke at constant speed.

   Check for improperly timed injectors and improperly positioned injector rack control levers. Time the fuel injectors and perform the appropriate governor tune–up.

   Replace faulty injectors if this condition still persists after timing the injectors and performing the engine tune–up.

   Avoid lugging the engine as this will cause incomplete combustion.

3. Check for use of an improper grade of fuel. Refer to *Fuel Specifications* in Section 13.3.

4. Check for internal lubricating oil leaks and refer to the *High Lubricating Oil Consumption* Chart.

5. Check for faulty injectors (see *Locating a Misfiring Cylinder* in the front of this section) and replace, as necessary.

   - White smoke or misfire at idle may occur when any one or more injector's idle output is considerably higher or lower than the remaining injectors operated by the same control tube. Significant differences in injector idle output will affect firing impulses since some cylinders are receiving too much fuel while others are receiving little or no fuel at idle.

   - The cylinder that is not firing at idle may be detected by shorting out the injector with a screwdriver. Depress the injector follower to prevent injector operation. If there is a change noted in the engine (i.e., noise or RPM), the injector can be considered operational. If no change is noted in the engine, one cause could be that the injector is not providing sufficient fuel at idle for combustion. The rack screw should then be adjusted to increase fuel output. Turn the injector rack screw slightly (no more than 1/8 of a turn) to change the idle output. This adjustment should only be made after any heavy hitting injectors have been identified and adjusted to reduce idle output. Heavy hitting injectors generally contribute to a louder cylinder firing impulse/sound. After adjusting the suspected problem injectors, accelerate the engine several times and allow it to return to idle.

   Check for low compression and consult the *Hard Starting* Chart.

   The use of low cetane fuel will cause this condition. Refer to *Fuel Specifications* in Section 13.3.

Chart 3

HARD STARTING

Probable Causes

ENGINE WILL NOT ROTATE

Check For

1. LOW BATTERY VOLTAGE, LOOSE STARTER CONNECTIONS OR FAULTY STARTER
2. DEFECTIVE STARTING MOTOR SWITCH
3. INTERNAL SEIZURE

LOW CRANKING SPEED

Check For

4. IMPROPER LUBRICATING OIL VISCOSITY
5. LOW BATTERY OUTPUT
6. LOOSE STARTER CONNECTIONS OR FAULTY STARTER

NO FUEL

Check For

7. AIR LEAKS, FLOW OBSTRUCTION, FAULTY FUEL PUMP, FAULTY INSTALLATION
8. INJECTOR RACKS NOT IN FULL-FUEL POSITION

LOW COMPRESSION

Check For

9. EXHAUST VALVES STICKING OR BURNED
10. COMPRESSION RINGS WORN OR BROKEN
11. CYLINDER HEAD GASKET LEAKING
12. IMPROPER VALVE CLEARANCE ADJUSTMENT
13. BLOWER NOT FUNCTIONING

INOPERATIVE STARTING AID AT LOW AMBIENT TEMP

Check For

14. IMPROPER OPERATION OF FLUID STARTING AID

Chart 3

HARD STARTING

SUGGESTED REMEDY

1. Refer to Items 2, 3 and 5 and perform the operations listed.
2. Replace the starting motor switch.
3. Hand crank the engine at least one complete revolution. If the engine cannot be rotated a complete revolution, damage is indicated and the engine must be disassembled to ascertain the extent of damage and the cause.
4. Refer to *Lubrication Specifications* in Section 13.3 for the recommended grade of oil.
5. Recharge the battery if a light load test indicates low or no voltage. Replace the battery if it is damaged or will not hold a charge.

   Replace terminals that are damaged or corroded.

   At low ambient temperatures, use of a starting aid will keep the battery fully charged by reducing the cranking time.
6. Tighten the starter connections. Inspect the starter commutator and brushes for wear. Replace the brushes if badly worn and overhaul the starting motor if the commutator is damaged.
7. To check for air leaks, flow obstruction, faulty fuel pump or faulty installation, consult the *No Fuel or Insufficient Fuel* Chart.
8. Check for bind in the governor–to–injector linkage. Readjust the governor and injector controls if necessary.
9. Remove the cylinder head and recondition the exhaust valves.
10. Remove the air box covers and inspect the compression rings through the ports in the cylinder liners. Overhaul the cylinder assemblies if the rings are badly worn or broken.
11. To check for compression gasket leakage, remove the coolant filler cap and operate the engine. A steady flow of gases from the coolant filler indicates either a cylinder head gasket is damaged or the cylinder head is cracked. Remove the cylinder head and replace the gaskets or cylinder head.
12. Adjust the exhaust valve clearance.
13. Remove the flywheel housing cover at the blower drive support. Then, remove the snap ring and withdraw the blower drive shaft from the blower. Inspect the blower drive shaft and drive coupling. Replace the damaged parts. Bar the engine over. If the blower does not rotate, remove the air inlet adaptor and visually inspect the blower rotors and end plates. If visual distress is noted, remove the blower (see Section 3.4 or 3.4.1).
14. Operate the starting aid according to the instructions under *Cold Weather Starting Aids.*

Chart 4

ABNORMAL ENGINE OPERATION

Probable Causes

UNEVEN RUNNING OR FREQUENT STALLING

Check For

1. LOW COOLANT TEMPERATURE
2. INSUFFICIENT FUEL
3. FAULTY INJECTORS
4. LOW COMPRESSION PRESSURES
5. GOVERNOR INSTABILITY (HUNTING)

LACK OF POWER

Check For

6. IMPROPER ENGINE ADJUSTMENTS (TUNE-UP) AND GEAR TRAIN TIMING
7. INSUFFICIENT FUEL
8. INSUFFICIENT AIR
9. ENGINE APPLICATION
10. HIGH RETURN FUEL TEMPERATURE
11. HIGH AMBIENT AIR TEMPERATURE
12. HIGH ALTITUDE OPERATION

DETONATION

Check For

13. OIL PICKED UP BY AIR STREAM
14. LOW COOLANT TEMPERATURE
15. FAULTY INJECTORS

Chart 4

ABNORMAL ENGINE OPERATION

SUGGESTED REMEDY

1. Check the engine coolant temperature gage and if the temperature does not reach normal operating temperature while the engine is operating, consult the *Abnormal Engine Coolant Temperature* Chart.
2. Check engine fuel spill back and if the return is less than specified, consult the *No Fuel or Insufficient Fuel* Chart.
3. Check the injector timing and the position of the injector racks. If the engine was not tuned correctly, perform an engine tune–up. Erratic engine operation may also be caused by leaking injector spray tips. Replace the faulty injectors.
4. Check the compression pressures within the cylinders and consult the *Hard Starting* Chart if compression pressures are low.
5. Erratic engine operation may be caused by governor–to–injector operating linkage bind or by faulty engine tune–up. Perform the appropriate engine tune–up procedure as outlined for the particular governor used.
6. If the engine is equipped with a throttle delay, check for the proper setting, binding or burrs on the piston or bracket, and a plugged discharge orifice.

   If equipped with a fuel modulator, determine if there is any interference with the roller assembly or roller contact with the cam at *wide open throttle (WOT)* position. Check for burrs and binding on the piston and bracket bore. Determine correctness (refer to Section 14.14) of the installed fuel modulator spring and check if the spring has taken a permanent "set", or if the spring rate is too high.

   Perform an engine tune–up if performance is not satisfactory.

   Check the engine gear train timing. An improperly timed gear train will result in a loss of power due to the valves and injectors being actuated at the wrong time in the engine's operating cycle.
7. Perform a *Fuel Flow Test* and, if less than the specified fuel is returning to the fuel tank, consult the *No Fuel fuel or Insufficient Fuel Chart.*
8. Check for damaged or dirty air cleaners and clean, repair or replace damaged parts.

   Remove the air box covers and inspect the cylinder liner ports. Clean the ports if they are over 50% plugged.

   Check for blower air intake obstruction or high exhaust back pressure. Clean, repair or replace faulty parts.

   Check the compression pressures (consult the *Hard Starting* Chart).
9. Incorrect operation of the engine may result in excessive loads on the engine. Operate the engine according to the approved procedures.
10. Refer to Item 13 of this Chart.
11. Check the ambient air temperature. A power decrease of .15 to .50 horsepower per cylinder, depending upon injector size, for each 10°F (6°C) temperature rise above 90°F (32°C) will occur. Relocate the engine air intake to provide a cooler source of air.
12. Engines lose horsepower with increase in altitude. The percentage of power loss is governed by the altitude at which the engine is operating.
13. Fill oil bath air cleaners to the proper level with the same grade and viscosity of lubricating oil that is used in the engine.

    Clean the air box drain tubes and check valve (if used) to prevent accumulation that may be picked up by the air stream and enter the engine cylinders. Inspect the check valve as follows:

    A. Disconnect the drain tube between the check valve and the air box drain tube nut at the air box cover.

    B. Run the engine and note the air flow through the valve at idle engine speed.

    C. If the check valve is operating properly, there will be no air flow at engine speeds above idle.

    Inspect the blower oil seals by removing the air inlet housing and watching through the blower inlet for oil radiating away from the blower rotor shaft oil seals while the engine is running. If oil is passing through the seals, overhaul the blower.

    Check for a defective blower–to–block gasket. Replace the gasket, if necessary.
14. Refer to Item 1 of this Chart.
15. Check injector timing and the position of each injector rack. Perform an engine tune–up, if necessary. If the engine is correctly tuned, the erratic operation may be caused by an injector check valve leaking, spray tip holes enlarged or a broken spray tip. Replace faulty injectors.

Chart 5

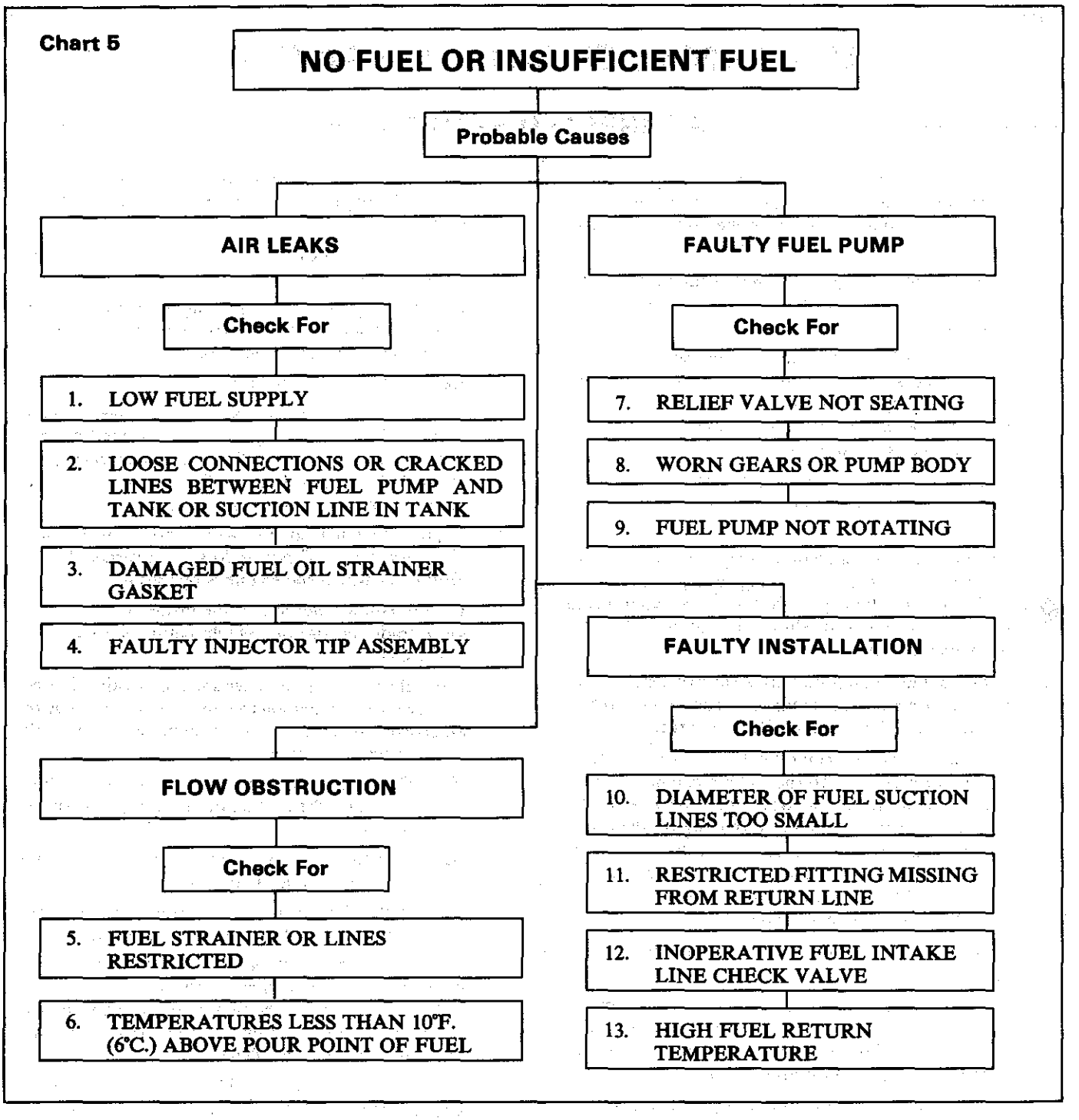


Chart 5

NO FUEL OR INSUFFICIENT FUEL

SUGGESTED REMEDY

1. The fuel tank should be filled above the level of the fuel suction tube.
2. Perform a *Fuel Flow Test* and, if air is present, tighten loose connections and replace cracked lines.
3. Perform a *Fuel Flow Test* and, if air is present, replace the fuel strainer gasket when changing the strainer element. element.
4. Perform a *Fuel Flow Test* and, if air is present with all fuel lines and connections assembled correctly, check for and replace faulty injectors.
5. Perform a *Fuel Flow Test* and replace the fuel strainer and filter elements and the fuel lines, if necessary,
6. Consult the *Fuel Specifications* for the recommended grade of fuel.
7. Perform a *Fuel Flow Test* and, if inadequate, clean and inspect the valve seat assembly.
8. Replace the gear and shaft assembly or the pump body.
9. Check the condition of the fuel pump drive and blower drive and replace defective parts.
10. Replace with larger tank–to–engine fuel lines.
11. Install a restricted fitting in the return line.
12. Make sure that the check valve is installed in the line correctly; the arrow should be on top of the valve assembly or pointing upward. Reposition the valve, if necessary. If the valve is inoperative, replace it with a new valve assembly.
13. Check the engine fuel spill–back temperature. The return fuel temperature must be less than 150°F (66°C) or a loss in horsepower will occur. This condition may be corrected by installing larger fuel lines or relocating the fuel tank to a cooler position.

Chart 6

HIGH LUBRICATING OIL CONSUMPTION

Probable Causes

EXTERNAL LEAKS

Check For

1. OIL LINES OR CONNECTIONS LEAKING
2. GASKET OR OIL SEAL LEAKS
3. AUTOMATIC OIL FILLER
4. OIL PULLOVER – AIR COMPRESSOR
5. OVERFILLED CRANKCASE
6. PLUGGED BREATHERS
7. HIGH CRANKCASE PRESSURE
8. BLUE EXHAUST SMOKE
9. EXCESSIVE OIL IN AIR BOX

INTERNAL LEAKS

Check For

10. BLOWER OIL SEALS LEAKING
11. TURBO OIL SEALS LEAKING
12. OIL COOLER CORE LEAKING
13. WORN EXHAUST VALVE GUIDES

OIL CONTROL AT CYLINDER

Check For

14. LOW COMPRESSION
15. PISTON PIN RETAINER LOOSE
16. OIL CONTROL RINGS WORN, BROKEN, IMPROPERLY INSTALLED OR SCORED
17. EXCESSIVE OIL IN AIR BOX
18. DIRT IN AIR INTAKE SYSTEM
19. SCORED LINERS OR PISTONS
20. EXCESSIVE INSTALLATION ANGLE
21. EXCESSIVE OIL IN CRANKCASE

Chart 6

HIGH LUBRICATING OIL CONSUMPTION

SUGGESTED REMEDY

NOTICE: Lube oil consumption must be verified after each repair is made.

1 & 2. Repair oil leaks by replacing necessary gaskets, seals or tightening connections. Steam cleaning the engine and operating at no–load rpm, (engine at operating temperature) will often reveal excessive oil leaks.

3. Consult the original equipment manufacturer for proper repair of the automatic oil filler system.

4. Check the air compressor for oil pullover and/or remove and replace the compressor.

5. Check dipstick and tube for proper oil pan levels to correct over filled crankcase.

6. Check crankcase pressure. Clean breathers and recheck crankcase pressure.

7. Overhaul blower, turbocharger or rekit engine (refer to Items 10, 11, 15 and 16). Also, refer to the *Excessive Crankcase Pressure* chart.

8. Remove and inspect exhaust manifolds and stacks for wetness or oil discharge. Excessive clearance between the valve stem and the valve guide can produce oil in the cylinders and stack. Repair the valve guides and/or install valve stem seals.

9. Refer to the *Abnormal Engine Operation* chart.

10. Remove the piping from the air inlet housing and remove from the blower. Operate the engine at approximately one–half throttle and at idle and inspect blower end plates for evidence of oil leakage past the seals. Use a flashlight to illuminate the end plates. If excessive oil leakage is evident on the end plates, overhaul blower.

CAUTION: The blower rotors are exposed and rotating during this test. Contact with the rotors must be avoided as personal injury could result.

11. Check for indications of oil on compressor or turbine sides of the turbocharger. Refer to Section 3.5 of the Service Manual for the proper procedure to determine turbocharger oil seal leakage.

12. Pressure test cooling system. If leak is found, remove and replace the oil cooler.

Inspect the engine coolant for lubricating oil contamination; if contaminated, replace the oil cooler core. Then, use a good grade of cooling system cleaner to remove the oil from the cooling system.

13. Replace worn exhaust valve guides.

14. Take compression test – refer to Item 16.

15. Run engine at idle speed with the air box cover removed (one at a time) to determine if oil is uncontrolled as evidenced by slobbering out the liner ports. Inspect all cylinders as more than one may be slobbering. Repair affected cylinders. Slobbering can also be caused by worn oil control rings.

CAUTION: Hot lubricating oil could be blown out the air box during this test. Contact with the hot oil could cause severe burns.

16. Check for faulty engine air induction system allowing contaminated air to enter the engine. A compression test with excessively low readings will indicate worn out cylinders. Remove and replace cylinder kits.

17. Refer to Items 10, 11, 15 and 16.

18. Refer to Item 16.

19. Check the crankshaft thrust washers for wear. Replace wore and defective parts.

20. Decrease the installation angle.

21. Fill the crankcase to the proper level only.

Chart 7

LOW OIL PRESSURE

MAKE CHECKS WITH WATER OUTLET TEMPERATURE OF 170°F (77°C)

Probable Causes

LUBRICATING OIL

Check For

1. SUCTION LOSS
2. LUBRICATING OIL VISCOSITY

PRESSURE GAGE

Check For

8. FAULTY GAGE
9. GAGE LINE OBSTRUCTED
10. GAGE ORIFICE PLUGGED
11. ELECTRICAL INSTRUMENT PANEL SENDING UNITS FAULTY

POOR CIRCULATION

Check For

3. COOLER CLOGGED
4. COOLER BY-PASS VALVE NOT FUNCTIONING PROPERLY
5. PRESSURE REGULATOR VALVE NOT FUNCTIONING PROPERLY
6. EXCESSIVE WEAR ON CRANKSHAFT BEARINGS
7. GALLERY, CRANKSHAFT OR CAMSHAFT PLUGS MISSING

OIL PUMP

Check For

12. INTAKE SCREEN PARTIALLY CLOGGED
13. RELIEF VALVE FAULTY
14. AIR LEAK IN PUMP SUCTION
15. PUMP WORN OR DAMAGED
16. LOOSE END COVER BOLTS
17. FLANGE LEAK (PRESSURE SIDE)

Chart 7

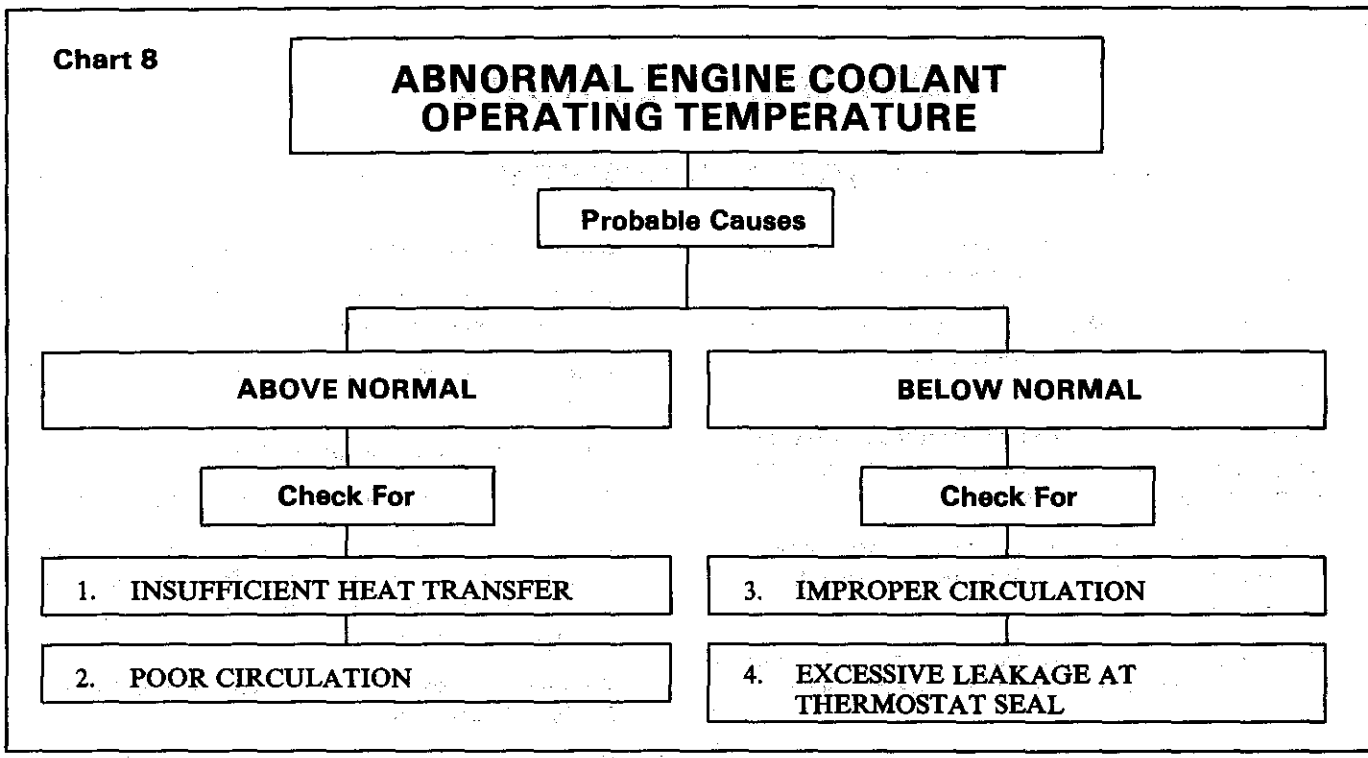
LOW OIL PRESSURE

SUGGESTED REMEDY

1. Check the oil and bring it to the proper level on the dipstick or correct the installation angle.
2. Consult the *Lubrication Specifications* in Section 13.3 for the recommended grade and viscosity of oil.

   Check for fuel leaks at the injector nut seal ring and fuel pipe connections. Leaks at these points will cause lubricating oil dilution. Refer to Section 2.0.
3. A plugged oil cooler is indicated by excessively high lubricating oil temperature. Remove and clean the oil cooler core.
4. Remove the bypass valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.
5. Remove the pressure regulator valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.
6. Change the bearings. Consult the *Lubrication Specifications* in Section 13.3 for the proper grade and viscosity of oil. Change the oil filters.
7. Replace missing plugs.
8. Check the oil pressure with a reliable gage and replace the gage if found faulty.
9. Remove and clean the gage line; replace it, if necessary.
10. Remove and clean the gage orifice.
11. Repair or replace defective electrical equipment.
12. Remove and clean the oil pan and oil intake screen. Consult the *Lubrication Specifications* in Section 13.3 for the proper grade and viscosity of oil. Change the oil filters.
13. Remove and inspect the valve, valve bore and spring. Replace faulty parts.
14. Disassemble the piping and install new gaskets.
15. Remove the pump. Clean and replace defective parts.
16. Remove the oil pan and tighten the oil pump end cover bolts.
17. Remove the flange and replace the gasket.

Chart 8



SUGGESTED REMEDY

1. Clean the cooling system with a good cooling system cleaner and thoroughly flush to remove scale deposits.

   Clean the exterior of the radiator core to open plugged passages and permit normal air flow.

   Adjust fan belts to the proper tension to prevent slippage.

   Check for an improper size radiator or inadequate shrouding.

   Repair or replace inoperative temperature–controlled fan or inoperative shutters.

2. Check the coolant level and fill to the filler neck if the coolant level is low.

   Inspect for collapsed or disintegrated hoses. Replace faulty hoses.

   Thermostat may be inoperative. Remove, inspect and test the thermostat; replace if found faulty.

   Check the water pump for a loose or damaged impeller.

   Check the flow of coolant through the radiator. A clogged radiator will cause an inadequate supply of coolant on the suction side of the pump. Clean the radiator core.

   Remove the coolant filler cap and operate the engine, checking for combustion gases in the cooling system. The cylinder head must be removed and inspected for cracks and the head gaskets replaced if combustion gases are entering the cooling system.

   Check for an air leak on the suction side of the water pump. Replace defective parts.

3. The thermostat may not be closing. Remove, inspect and test the thermostat. Install a new thermostat, if necessary.

   Check for an improperly installed heater.

4. Excessive leakage of coolant past the thermostat seal(s) is a cause of continued low coolant operating temperature. When this occurs, replace the thermostat seal(s).

.VEHICLE LOW POWER/PERFORMANCE AT LOW MILEAGE

1. **Determine the basis for the concern.** Does the concern indicate slow acceleration from a stop or slow engine recovery when changing gears? The answers to these questions often provide the proper information for the investigation.

   A. Is the truck being driven according to recommended procedures? For example, down shifting an engine with a throttle delay at high speed (rather than at low speed) will cause the engine to recover power slowly, creating an impression of low power. Driver training would help.

   B. Are the driver's expectations of vehicle performance realistic, considering truck gear ratios, loads and engine rated speed and power? The distributor or regional office should be consulted to assist in evaluation of vehicle performance (shift points and gradability, for example).

2. **Check customer engine and vehicle order specifications and vehicle road speeds, if necessary.**

   A. Determine if the engine no–load speed (rpm) and horserpower meet customer order specifications. The O.E.M. truck dealer or Detroit Diesel Corporation Regional Office can assist in this area.

   B. It is normal for the actual engine no–load speed to be slightly less (5 to 20 rpm) than the no–load speed set at Detroit Diesel Corporation due to engine accessories (air compressor, power steering pump, etc.) installed by the O.E.M. There is a ± 25 rpm manufacturing tolerance for no–load speed setting. It would be normal, therefore, for an engine order specification of 2050 rpm no–load speed to check out at 2025 to 2075 rpm in the vehicle.

   C. The rated full–load engine speed will not change because of a slight change of no–load speed (rpm) resulting from the addition of O.E.M. accessory loads.

   D. Engine speed combined with rear axle ratios and tire size provide the resultant vehicle geared road speed which may be a basis for customer concern.

   E. Vehicle highway speed is a result of the gear ratios, engine speed and gross vehicle weight. For purposes of discussion, geared speed is the speed the truck would reach with the transmission in direct drive and the engine at rated speed. Geared speed (GS) in Miles Per Hour (mph) can be computed as follows:

$$GS = \frac{\text{Full Load engine RPM} \times 60}{\text{Axle ratio} \times \text{tire revolutions/mile}}$$

   EXAMPLE:

$$GS = \frac{1900 \text{ rpm} \times 60}{4.11 \times 504} = 55 \text{ mph}$$

   The vehicle could be expected to have a maximum road speed somewhat more than 55 mph (2050 x 55/1900 – 59.3) mph on level pavement with 2050 rpm no–load engine speed. This maximum vehicle speed of 59.3 mph may not be reached because of parasitic and frictional power losses. These power losses are a result of the vehicle power train and engine–driven accessories. At speeds over 50 mph wind resistance can be responsible for the greatest engine power or road speed loss.

   These vehicle speed calculations can be used to compare designed performance with actual performance. In the example it would be expected that the vehicle should operate between approximately 55 and 59 mph with typical loads and on level pavement. If during tests the loaded vehicle operates at calculated road speeds on level pavement (without a head wind), re–evaluate the source and reason for the power concern. Average the speeds attained on a two or three mile level run both into the wind and with the wind, to determine maximum possible road speed with vehicle unloaded.

   F. Accuracy of the vehicle speedometer and tachometer is important. Low–reading instruments have caused some low power concerns. These instruments should be checked for accuracy at both high and low speed.

3. **Check for improper assembly of engine related parts and accessories installed by the vehicle manufacturer (O.E.M.).** Parts and accessories that can contribute to low power/performance are:

   A. Throttle linkage and governor shut down (adjustment).

   B. Fuel supply and return line (size and installation).

   C. Fuel filters (leaking or contaminated).

D. Fuel tanks (construction, return and supply line installation: fuel temperature should not exceed maximum allowable) – (see Section 2.5.1)

E. Air intake and exhaust components (size and installation).

F. Jacobs brake (installation and adjustment). See Items 11 thru 14.

G. Fuel heater (restriction).

H. Water separator (restriction).

4. **Check governor throttle and shutdown linkage adjustment as follows:**

A. Improper adjustment of vehicle throttle linkage and governor shut down are the most frequent causes of low power/performance concerns. When the vehicle throttle (accelerator pedal) is fully depressed, the governor throttle lever should move from idle to the full–throttle position. Low power will result if the vehicle throttle linkage cannot reach the full–throttle position.

B. The governor run–stop lever (mechanism) normally installed by the O.E.M. must be adjusted to allow an air gap or clearance (.020 min.) between the stop lever and the air or electric solenoid. Improper adjustment (lack of air gap) of the run–stop lever mechanism will not allow the injector control rack(s) to reach the full–fuel position, thus resulting in low power/performance.

5. **Check fuel system for pressure and flow as follows:**

A. First, start and run the engine. Check for proper fuel pressure at specified engine speeds (refer to Section 13.2). Checking fuel pressure will reveal conditions related to fuel flow restriction, fuel pump relief valve operation and performance conditions caused by high or low fuel pressure.

B. If fuel pressures are according to specifications, disconnect the fuel return line from the fitting at the fuel tank and check return flow rate. Hold open end in a clean container. Start and run the engine at 1000 rpm. Place the end of the fuel return line beneath the fuel level in the receptacle. After a few minutes no air or gas bubbles should be present. If any bubbles are detected, determine the cause for air entering the fuel system and repair, as required. Air in the fuel system is normally caused by a leak at fuel connections and/or filters between the suction side of the fuel pump to the supply tank and not between the pressure side of the pump and engine. Minimum fuel return rates are provided in Section 2.0.

C. If no air bubbles are present and return rate is below minimum specifications, check for fuel flow restrictions which can be caused by fuel heaters, water separators, undersize, improperly routed or damaged fuel lines,contaminated fuel filters or high fuel presure resulting from a plugged restricted fitting.

D. Always make sure there is sufficient fuel supply (at least 1/3 of normal capacity) in the fuel tanks.

6. **Check crankcase for lube oil overfill.** Overfilled engine crankcase can cause low power and higher–than–normal lubricating oil temperature. Normally, oil levels should be at or slightly below the oil pan–to–block split line with vehicle on level ground.

7. **Check engine horsepower, if necessary.** First, insure engine is at the proper operating temperature. The horsepower measurement before and after corrective action can be used to evaluate the results of the troubleshooting and repair effort. Record this power at appropriate time while troubleshooting. The actual horsepower reading should not be used to judge if engine performance is satisfactory but used only to see if a noticeable power change has taken place. Fuel quality, engine–driven accessories, drive line or tires can contribute to low power readings. It should be noted that No. 1 diesel fuel can produce up to 7% less horsepower than No. 2 fuel. Blends of No. 1 and No. 2 (common in winter) will produce less horsepower, depending on the percent of the blend.

8. **Check for evidence of brake dragging, bad driveline bearings or misaligned axles.**

9. **Check for excessive air intake restriction.** Undersize or dirty air cleaner elements, damaged or obstructed air inlet piping can also cause low power.

10. **Check turbocharger exhaust connections and exhaust system components.** A damaged, undersized or otherwise restricted muffler or exhaust back pressure and subsequent loss of engine power.

11. **Check for proper location of rocker cover(s).** If the cover(s) has been pushed towards the injector control tube assembly (inboard on V engines), the injector control lever movement may be restricted by the cover. This condition will not allow injectors to reach full fuel, thereby causing a low power/performance condition. Situations that can cause this conditon are:

A. Use of engine lifting apparatus that contacts the rocker cover(s).

B. Incorrect reinstallation of rocker cover(s) after removal for various reasons (Jacobs brake installation, for example).

12. **Check throttle delay or fuel modulator operation.** If the engine is equipped with a throttle delay, check for the proper setting and a plugged discharge orifice. If the engine is equipped with a fuel modulator, check for a pinched air supply line. Determine if there is any interference with the roller assembly or improper roller–to–cam contact when governor throttle lever is in the full–throttle position. Check for smooth operation of the piston in the bore. Check for excessive air leakage between the piston and cylinder which may be caused by excessive piston clearance due to wear.

13. **Check governor–to–injector linkage.** Removal of the governor and rocker cover(s) will be necessary to detect any binding or restriction of linkage movement.

14. **Check engine tune–up and make necessary corrections.** If all previous steps do not reveal cause for a confirmed low power/performance condition, engine tune–up settings may be considered a probable cause. It is normal for tune–up settings to vary when using correct setting procedures. Some items influencing tune–up measurements are differences in gages, individuals and mechanical variations.

At Detroit Diesel Corporation, engine tune–up settings are conducted using electronic and dial indicator gaging equipment. Finally, to determine that tune–up is within accepted tolerances, the engine is tested to assure that horsepower output is to published specifications.

Jacobs brake installation or adjustment errors can cause low power/performance conditions.

When making tune–up adjustments, refer to Section 14.0 for specifications.

Periodic inspection of tune–up gages is necessary to determine if damaged or worn. Injector timing gages are marked with the timing dimensions and have an allowable tolerance of $\pm$ .001 . Rack gages are marked with the specific dimension and have an allowable tolerance of $\pm$ .002 .

STORAGE

PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 days or less)

To protect an engine for a temporary period of time, proceed as follows:

1. Drain the engine crankcase.
2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.
3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load.

   Do not drain the fuel system or the crankcase after this run.
4. Check the air cleaner and service it, if necessary, as outlined in Section 3.1.
5. Fill the cooling system with a properly inhibited ethylene glycol base antifreeze solution (refer to Coolant Specifications in Section 13.3). Drain the raw water system and leave the drain cocks open.
6. Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with compressed air.
7. Seal all of the engine openings. The material used for this purpose must be waterproof, vapor proof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil, transmission and priming the raw water pump, if used.

EXTENDED STORAGE (more than 30 days)

To prepare an engine for extended storage, (more than 30 days), follow this procedure:

1. Drain the cooling system and flush with clean, soft water.

   Refill with a properly inhibited ethylene glycol base antifreeze solution (refer to coolant Specifications in Section 13.3).
2. Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.
3. Reinstall the injectors, time them and adjust the exhaust valve clearance.
4. Circulate the coolant by operating the engine until normal operating temperature is reached (see Section 13.2).
5. Stop the engine.
6. Drain the engine crankcase, then reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.
7. Fill the crankcase to the proper level with a 30 weight preservative lubricating oil MIL–L–21260C, Grade 2.
8. Drain the fuel tank. Refill with enough clean No. 1 diesel fuel or pure kerosene to permit the engine to operate for about ten minutes. If it isn't convenient to drain the fuel tank (i.e., marine) use a separate portable supply of the recommended fuel.

NOTICE: If engines in vehicles or marine units are stored where condensation of water in the fuel tank may be a problem, add pure, waterless isopropyl alcohol (isopropanol) to the fuel at a ratio of one pint to 125 gallons of fuel, or .010% by volume. Where biological contamination of fuel may be a problem, add a biocide such as Biobor JF, or equivalent, to the fuel. When using a biocide, follow the manufacturer's concentration recommendations, and observe all cautions and warnings.

9. Drain and disassemble the fuel filter and strainer. Discard the used elements and gaskets. Fill the cavity between the element and shell with No. 1 diesel fuel or pure kerosene, and reinstall on the engine. If spin–on fuel filters and strainers are used, discard the used cartridges, fill the new ones with No. 1 diesel fuel or pure kerosene, and reinstall on the engine.

10. Operate the engine for five minutes to circulate the clean fuel oil throughout the engine.

11. Refer to Section 3.1 and service the air cleaner.

12. MARINE GEAR

    A. Drain the oil completely and refill with clean oil of the recommended grade and viscosity. Remove and clean or replace the strainer and filter element.

    B. Start and run the engine at 600 rpm for ten minutes to coat all of the internal parts of the marine gear with clean oil. Engage the clutches alternately to circulate clean oil through all of the moving parts.

NOTICE: The performance of this step is not necessary on torque converter units.

13. TORQMATIC CONVERTER

    A. Start and operate the engine until the temperature of the converter oil reaches 150°F (66°C).

    B. Stop the engine, remove the converter drain plug and drain the converter.

    C. Remove the filter element.

    D. Start the engine and stall the converter for **twenty seconds** at 1000 rpm to scavenge the oil from the converter. *Due to lack of lubrication, do not exceed the 20 second limit.*

    E. Install the drain plug and a new filter element.

    F. Fill the converter to the proper operating level with a commercial preservative oil which meets Government specifications MIL–L–21260C, Grade 2. Oil of this type is available from the major oil companies.

    G. Start the engine and operate the converter for at least ten minutes at a minimum of 1000 rpm. Engage the clutch, then stall the converter to raise the oil temperature to 225°F (107°C).

NOTICE: Do not allow the oil temperature to exceed 225°F (107°C). If the unit does not have a temperature gage, *do not stall the converter for more than thirty seconds.*

    H. Stop the engine and allow the converter to cool to a temperature suitable to the touch.

    I. Seal the breather and all of the exposed openings with moisture–proof tape.

    J. Coat all exposed, unpainted surfaces with preservative grease. Position all of the controls for minimum exposure and coat them with grease. The external shafts, flanges and seals should also be coated with grease.

14. POWER TAKE–OFF

    A. Use an all purpose grease such as Shell Alvania No. 2, or equivalent, and lubricate the clutch throwout bearing, clutch pilot bearing, drive shaft main bearing, clutch release shaft and the outboard bearings (if so equipped).

    B. Remove the inspection hole cover on the clutch housing and lubricate the clutch release lever and link pins with a hand oiler. Avoid getting oil on the clutch facing.

    C. If the unit is equipped with a reduction gear, drain the gear box and flush with light engine oil. If the unit is equipped with a filter, clean the shell and replace the filter element. Refill the gear box to the proper level with the grade of oil indicated on the name plate.

15. TURBOCHARGER

Since turbocharger bearings are pressure lubricated through the external oil line leading from the engine cylinder block while the engine is operating, no further attention is required. However, the turbocharger air inlet and turbine outlet connections should be sealed off with moisture resistant tape.

16. HYDROSTARTER SYSTEM

Refer to Section 12.6.1 for the lubrication and preventive maintenance procedure.

17. Apply a *non–friction* rust preventive compound to all exposed parts. If convenient, apply the rust preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

    NOTICE: Do not apply oil, grease or any wax base compound to the flywheel. The cast iron will absorb these substances which can "sweat" out during operation and cause the clutch to slip.

18. Drain the engine cooling system.

19. Drain the preservative oil from the engine crankcase. Reinstall and tighten the drain plug.

20. Remove and clean the battery and battery cables with a baking soda–water solution and rinse with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte, if necessary, and fully charge the battery. Store the battery in a cool (never below 32°F or 0°C) dry place. Keep the battery fully charged and check the level and the specific gravity of the electrolyte regularly.

21. Insert heavy paper strips between the pulleys and belts to prevent sticking.

22. Seal all engine openings, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

23. Clean and dry the exterior painted surfaces of the engine and spray with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

24. Protect the engine with a good weather–resistant tarpaulin and store it under cover, preferably in a dry building which can be heated during the winter months.

Detroit Diesel Corporation does not recommend the outdoor storage of engines (or transmissions). Nevertheless, DDC recognizes that in some cases outdoor storage may be unavoidable. If units must be kept out–off–doors, follow the preparation and storage instructions already given. Protect units with quality, weather–resistant tarpaulins (or other suitable covers) arranged to provide air circulation.

NOTICE: *Do not use plastic sheeting for outdoor storage.* Plastic is fine for indoor storage. When used outdoors, however, enough moisture can condense on the inside of the plastic to rust ferrous metal surfaces and pit aluminum surfaces. If a unit is stored outside for any extended period of time, severe corrosion damage can result.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

PROCEDURE FOR RESTORING AN ENGINE TO SERVICE WHICH HAS BEEN IN EXTENDED STORAGE

1. Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. *Do not overlook the exhaust outlet.*

2. Wash the exterior of the engine with fuel oil to remove the rust preventive.

3. Remove the rust preventive from the flywheel.

4. Remove the paper strips from between the pulleys and the belts.

5. Remove the drain plug and drain the preservative oil from the crankcase. Reinstall the drain plug. Then refer to *Lubrication System* in Section 13.1 and fill the crankcase to the proper level, using a pressure prelubricator, with the recommended grade of lubricating oil.

6. Fill the fuel tank with the fuel specified under *Fuel Specifications* (Section 13.3).

7. Close all of the drain cocks and fill the engine cooling system with a properly inhibited ethylene glycol base antifreeze solution (refer to Section 13.3).

8. Install and connect the battery.

9. Service the air cleaner as outlined in Section 3.1.

10. POWER GENERATOR

    Prepare the generator for starting as outlined under *Operating Instructions* in Section 13.

11. MARINE GEAR

    Check the marine gear; refill it to the proper level, as necessary, with the correct grade of lubricating oil.

12. TORQMATIC CONVERTER

    A. Remove the tape from the breather and all of the openings.

    B. Remove all of the preservative grease with a suitable solvent.

C. Start the engine and operate the unit until the temperature reaches 150°F (66°C). Drain the preservative oil and remove the filter. Start the engine and stall the converter for twenty seconds at 1000 rpm to scavenge the oil from the converter.

NOTICE: A Torqmatic converter containing preservative oil should only be operated enough to bring the oil temperature up to 150°F (66°C).

D. Install the drain plug and a new filter element.

E. Refill the converter with the oil that is recommended under *Lubrication and Preventive Maintenance* (Section 15.1).

13. POWER TAKE–OFF

Remove the inspection hole cover and inspect the clutch release lever and link pins and the bearing ends of the clutch release shaft. Apply engine oil sparingly, if necessary, to these areas.

14. HYDROSTARTER

A. Open the relief valve on the side of the hand pump and release the pressure in the system.

B. Refer to the filling and purging procedures outlined in *Hydraulic Starting System* (Section 12.6.1). Then drain, refill and purge the hydrostarter system.

15. TURBOCHARGER

Remove the covers from the turbocharger air inlet and turbine outlet connections. Refer to the lubricating procedure outlined in *Preparation for Starting Engine First Time* in Section 13.1.

16. After all of the preparations have been completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause a smoky exhaust for a few minutes.

NOTICE: Before subjecting the engine to a load or high speed, it is advisable to check the engine tune–up.

ALPHABETICAL INDEX

*General Information and Cautions Section

*General Information and Cautions Section

