

UNITED STATES MARINE CORPS
Logistics Operations School
Marine Corps Combat Service Support Schools
Training Command
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FESCR 8205

STUDENT OUTLINE

REPAIR CUMMINS FUEL INJECTORS

LEARNING OBJECTIVES

1. Terminal Learning Objective: Given a Cummins fuel injector, the required common and special tools, test equipment, repair parts, shop supplies, TM 9-2320-272-34, Cummins service bulletins, and Hartridge operating and servicing manuals, per information contained in the references, repair the fuel injector. (8.2.3)

2. Enabling Learning Objectives: Given a Cummins fuel injector, the required common and special tools, test equipment, repair parts, shop supplies, TM 9-2320-272-34, Cummins service bulletins, and Hartridge operating and servicing manuals, per information contained in the references:
 - a. disassemble the fuel injector, (8.2.3a)

 - b. inspect the disassembled components, (8.2.3b)

 - c. repair or replace the unserviceable components, (8.2.3c)

 - d. assemble the fuel injector from serviceable components, and (8.2.3d)

 - e. test the fuel injector. (8.2.3e)

OUTLINE

1. COMPOSITION AND DESIGN CHARACTERISTICS OF CUMMINS FUEL INJECTORS
 - a. Description

(1) The PT injector is a simple mechanical unit which received fuel from the fuel pump under pressure. The injector meters and injects fuel through the small injector cup spray holes into the combustion chamber.

(2) The general description "PT injectors" is used only to indicate that the injector is used with the PT fuel system. The PT or pressure/time concept derives its name from two of the three primary variables affecting the amount of fuel that is metered per cycle in the Cummins fuel system.

(a) The "P" refers to the pressure of the fuel at the inlet of the injectors. This pressure is controlled by the fuel pump and is referred to as rail pressure.

(b) The "T" refers to the time available for fuel to flow into the injector cup. This time is controlled by engine speed through the camshaft and injection train.

(c) The third variable affecting the amount of fuel metered per cycle is the size of the passage through which fuel is allowed to flow, referred to as flow area.

(3) The PT injectors are separated into two basic groups; those which are cylindrical in shape without a flange for mounting and those which are flange mounted in the cylinder head.

b. The fuel injector combines, in a single unit, all the parts necessary to provide fuel injection at each cylinder. Those parts are:

(1) The cup, is located in the lower part of the injector. It contains the eight spray holes through which fuel is injected into the combustion chamber.

(2) The cup retainer is also located on the lower portion of the injector. It provides a place for other components to be installed.

(3) The check ball is seated on the upper part of the barrel. It is a steel ball that allows fuel to flow in only one direction.

(4) The screen mounts over the orifice plug, filtering the fuel before it enters the injector.

(5) The orifice plug is an Allen head threaded plug with a small orifice drilled through it.

(6) The fuel inlet is an orifice plug located under the screen.

(7) The spring retainer is located between the stop screw and spring.

(8) The locknut is used to secure the adjusting screw after the adjustment is made.

(9) The top stop adjusting screw is used to adjust the travel of the return spring, which in turn, controls the plunger upward movement.

(10) The injector link, as its name implies, links the injector to the rest of the injection train.

(11) The spring is mounted on top of the adapter and under the spring retainer. Once pressure is released from the plunger, it must push the plunger back up.

(12) The adapter is the largest part of the injector. It provides a place to mount all the other parts.

(13) The fuel return or outlet port is located slightly above and opposite the fuel inlet.

(14) There are three "O" rings. They form a seal between the injector and the cylinder head. The two areas are sealed off from the inlet and outlet fuel passages by the "O" rings.

(15) The plunger is two separate pieces of metal pressed together. The shiny portion of the plunger and the inside of the barrel are mated surfaces. If one or the other is to be replaced, they must be replaced as a set.

(16) The barrel is located inside the cup retainer. It contains drilled fuel passageways and an opening through which the plunger can pass.

(17) The drain port is located in the barrel and allows the fuel to flow out the return when the metering orifice is closed.

(18) The metering orifice hole is located in the cup end of the injector barrel. It allows fuel to enter the injector plunger bore and cup. This orifice hole is fixed in size and must not be altered.

(19) The plunger metering edge is the lower shoulder to the plunger and is what opens and closes the metering orifice.

(20) The top stop injector parts are the same as the standard PT-D except for the following:

(a) The adapter is longer to accommodate the stop. The plunger coupling top is smaller, allowing it to pass through the stop.

(b) The injector spring washer, adjustable stop screw, and the stop screw locknut are parts required only for the top stop injector. These items are used to limit the upward travel of the injector plunger spring.

2. PRINCIPLES OF OPERATION OF THE CUMMINS PT-D FUEL INJECTOR

a. Combustion required for satisfactory engine operation is obtained by injecting, under pressure, a small quantity of accurately timed, metered and finely atomized fuel oil into the combustion chamber. The fuel injector performs those four functions: metering, pressurizing, timing, and atomizing.

(1) It meters and injects the correct amount of fuel required to maintain engine speed and to handle the load.

(2) It creates the high pressure required for proper fuel injection.

(3) It accurately times the moment of fuel injection.

(4) It atomizes the fuel for vaporization and mixing with the air in the combustion chamber.

b. The injector plunger is actuated by rotation of the camshaft injector lobe. When the cam follower roller is on the inner base circle, the injector return spring has lifted the injector plunger, uncovering the metering orifice. Remember, the period of time the metering orifice is uncovered is referred to as metering time.

c. When the cam follower roller is on the outer base circle, the downward movement of the injector plunger has overcome the injector return spring, closed the metering orifice, and injected the metered fuel into the combustion chamber. The injector plunger is now seated in the injector cup.

d. Fuel entering the injector flows through the wire mesh filter screen and the adjustable orifice located beneath the filter screen. The size of the adjustable orifice determines the flow rate through the injector and, therefore, the pressure at the metering orifice. Any change in pressure at the metering orifice changes the amount of fuel metered and, therefore, the power output of the engine.

e. From the adjustable orifice, fuel flows down an internally-drilled passage in the injector adapter and barrel, unseating a check ball, continuing its flow toward the metering orifice. The purpose of the check

ball is to prevent the reversal of fuel flow as the plunger moves downward across the metering orifice during deceleration and shutdown.

f. The time during which the metering edge uncovers the metering orifice, is the time available for fuel to flow into the cup. This begins as the cam follower roller travels down the retraction ramp toward the inner base circle of the camshaft injector lobe. As this occurs, the injector return spring lifts the injector plunger, uncovering the metering orifice. During this time, flow through the drain port is blocked by the injector plunger.

g. Metering of fuel occurs during the entire time the cam roller is on the inner base circle. With continued camshaft rotation, the cam roller travels up the injection ramp. The upward movement of the push rod pushes the injector plunger downward, and closes off the metering orifice, completing the metering cycle. Shortly after the metering orifice is closed, the drain port is uncovered.

h. With further camshaft rotation, the injector plunger continues its downward travel as the cam roller continues up the injection ramp. The point at which the plunger makes contact with the fuel is determined by the volume of fuel in the cup. This means that the beginning of injection varies with the level of fuel in the injector cup. With an increased fuel level, the injector plunger contacts the fuel earlier, thus advancing the beginning of injection.

i. Fuel will be injected when the pressure exerted on the fuel by the downward movement of the injector plunger exceeds combustion chamber pressures. Injection ends when the plunger bottoms in the cup. Shortly before reaching the outer base circle of the injector lobe, the roller travels over the cam nose, which effects a positive ending of injection.

j. With injection completed and the injector plunger bottomed in the cup, the cam roller is now on the outer-base circle of the camshaft injector lobe. While this is happening, the drain groove on the injector plunger has aligned the drain passages in the injector barrel, permitting fuel to flow out of the drain port and return to the tank.

3. PROCEDURES REQUIRED TO REPAIR AND TEST THE PT-D FUEL INJECTOR

a. Instructions

(1) Detailed instructions for repairing the injector are contained in the manual that was issued to you at the beginning of this block of instruction. Follow those instructions carefully to effect those repair procedures on the training aid injector to which you have been assigned.

(2) Have the instructor assigned to your station check your work at each point designated in this student outline.

(3) Refer to TM 9-2320-272-34 for the procedures used to perform the repair steps listed. Use the index to locate the instructions in the manual and read the instructions carefully before performing each task.

b. Disassemble the Injector

- (1) Remove the plunger.
- (2) Remove the top stop locknut and adjusting screw.
- (3) Remove the spring retainer, and spring.
- (4) Remove the cup retainer.
- (5) Remove the injector cup.
- (6) Turn the adapter and barrel over and lift the adapter off the barrel.
- (7) Remove the check ball.
- (8) Remove all three "O" rings.
- (9) Remove the adjustable inlet orifice.

STOP! Have instructor initial.

c. Clean and Inspect Injector Components

- (1) Clean the injector components.
- (2) Inspect the plunger for pitting, wear, cracks, and looseness. Measure the flange thickness.
- (3) Inspect the barrel.

STOP! Have instructor present before proceeding.

- (4) Inspect the cup and check the spray pattern.

(a) Install the injector cup into the adapter of the Hartridge 290 injector tester, and raise the clamp lever to the clamped position.

(b) Move the "ON-OFF" ball valve to the "OFF" position.

(c) Start the injector test stand and adjust the pressure regulator on the tester to show 8 to 10 psi on the pressure gauge.

(d) Move the "ON-OFF" valve to the "ON" position.

(e) Observe the spray pattern of the injector cup to see which scribed line the spray pattern is nearest to.

(f) Compare this mark with that found with the known angle cup.

(g) Move the "ON-OFF" valve to the "OFF" position.

(h) Lower and remove the cup from the tester.

(5) Check squareness of spring. _____ Measure spring free length _____ and check spring load.

(6) Inspect spring retainer and measure for wear.

STOP! Have instructor initial.

d. Assemble the Injector

(1) Install the check ball into barrel.

(2) Place the adapter on the barrel.

(3) Install the cup.

(4) Install the cup retainer.

(5) Install the adjustable inlet orifice.

STOP! Have instructor initial.

e. Testing PT-D Injectors

(1) Perform a plunger alignment test.

(2) Perform a plunger sticking test.

(a) Connect the tester to a shop air supply of at least 30 psi.

(b) Place the injector, without spring, into the tester with the cup in the lower bearing.

(c) Loosen the set screw on the torque wrench stem and set the plunger cone one inch above the plunger surface, then retighten the set screw.

(d) Activate the air cylinder and adjust the pressure regulator to 30 psi. It can be plus or minus 2 psi.

(e) Rotate the injector adapter with the torque wrench and observe the reading on the torque wrench.

(f) If the force required to rotate the adapter is greater than 2 inch-pounds, remove the injector and put it back in the loading fixture. Loosen and retorquer the retainer to specifications.

STOP! Have instructor initial.

(3) Perform the cup-to-plunger tip test.

(a) Install and lubricate the three "O" rings and the plunger.

(b) Do not install the inlet orifice screen, clip, spring, spring retainer, stop screw, and locknut. These items must be removed for the following tests.

(c) Install the injector into the adapter pot, P/N 3375395, with the balance feed orifice facing towards the air hookup on the adapter pot.

(d) Install the injector plunger extension, P/N 3375397, in the top of the injector plunger and tighten the knurled knob to lock the plunger extension in place.

(e) Install the link, P/N 3375396, into the adapter, P/N 3375397.

(f) Insert the complete assembly into the injector guide, link end first, and secure it with the locking lever.

(g) Attach the hoses to their proper fittings on the adapter pot, P/N 3375395. The white hose is the supply line and the black hose is the drain. The white hose goes toward the injector cup.

STOP! Have instructor initial.

(h) Adjust the air pressure to 60 psi, and adjust the hand crank to read 200 pounds on the load gauge.

(i) With the air supply valve "OFF," turn the tip seat plunger leakage valve "ON."

(j) Turn the air supply valve "ON," and look for bubbles in the bubble checker.

(k) If no bubbles appear within 10 seconds or if the time between bubbles is more than five seconds, the cup to plunger seating is acceptable. If the test is unacceptable, retorque the cup retainer and perform the test again.

(4) Perform the barrel-to-plunger test.

(a) Recheck both the air pressure and load cell gauges. Make sure the air pressure is still remaining on 60 psi and the load cell remaining on 200 pounds.

(b) Zero the dial indicator.

(c) Keep light pressure on the load cell plunger toward the dial indicator while turning the crank and back out the hand crank until the dial indicator reads .048 of an inch.

(d) Turn the air supply valve "OFF."

(e) Turn the tip seat plunger leakage valve "ON."

(f) Turn the air supply valve to "ON" and gently rotate the injector plunger in small increments. Watch the flow meter for the highest reading.

(g) For a PT-D 3/8 inch plunger, if the leakage exceeds 4.5 on the flow meter, the barrel and plunger must be replaced and the test performed again.

(5) Perform a check ball leakage test.

(a) Make sure the plunger is still in the retracted position, .048 of an inch on the dial indicator, and that all valves are in the "OFF" position.

(b) Turn the check ball leakage and the air supply valve "ON." Adjust the air supply to 60 psi on the air pressure gauge. Observe the flow meter, if the reading exceeds 8.5 units, the seat must be reworked.

(c) Adjust the air supply to read 80 psi on the air pressure gauge, and observe the flow meter. If the reading exceeds twelve units of leakage, the seat must be reworked. If the reading is 10, that is one "1" unit.

(d) Turn the air supply and check ball leakage valve "OFF," and remove the injector from the tester.

STOP! Have instructor initial.

(6) First, remove the plunger, then install the spring and spring retainer. Now, reinstall the plunger and screw the stop screw and locknut assembly into the injector until the locknut contacts the adapter. This will give you a starting point for the adjustment. Remember, when you disassembled the injector you only broke the torque on the locknut and never removed it from the stop screw. If you did remove it, then install the stop screw and locknut until you have approximately two threads showing on the stop screw.

(7) The only items left to install are the inlet orifice screen and retaining clip. However, do not install them at this time. You will install the screen and clip after the flow test has been completed.

(8) Adjust the top stop plunger travel using setting fixture no. 3375160.

(a) Move the dial indicator extension out of the way so it does not get damaged.

(b) Install the injector in the setting fixture. The wrench flats on the adapter will locate the injector in the fixture. The cup must be centered over the cup seat. If you have one of the older setting fixtures, you will have to use the body wrench to hold the injector in the fixture and keep it from turning.

(c) Adjust the cup seat up against the injector cup. Torque the seat to 115 inch-pounds.

(d) The dial indicator extension must be in contact with the plunger flange. However, make sure you do not position it on an etched part of the surface.

(e) Bottom the injector plunger in the cup with the fixture handle and set the dial indicator to zero.

(f) Slowly release the plunger and observe the travel required until the plunger spring retainer contacts the injector top stop adjusting screw. When you release the plunger, make sure you do not lift up the lever. The weight on the lever simulates zero lash when the injector is in the engine.

(g) Bottom the plunger again and adjust the stop screw up or down with the stop screw wrench until the travel is equal to the specifications for the injector or within plus or minus .0005 of an inch of that specification.

(h) Once you have the travel set, torque the locknut to 55 foot-pounds. Recheck the travel after torque is obtained to make sure it was not changed by tightening the locknut.

(9) The following instructions are procedures for using setting fixture no. 3822696 to adjust the top stop plunger travel.

(a) Move the deadweights switch to the "RAISE" position and the plunger switch to the "UNLOAD" position. Use the air pressure adjust knob adjust the pressure to 80 psi. This pressure must be maintained at all times. Move the digimatic indicator and digimatic presetter power switches to the "ON" position.

(b) Install the holding bracket, part no. 3822726 into the flat machined areas of the fuel supply groove. Install the injector plunger link, part no. 205462, into the injector.

(c) Install the injector into the setting fixture. Center the injector over the fixture stop nut. Adjust the stop nut up against the injector cup. Torque the stop nut to 115 inch-pounds.

(d) Move the clamp handles to the "DOWN" position. This allows the 25 pound deadweights to be used. Move the deadweights switch to the "LOWER" position. This will lower the center plunger down against the injector link. Move the plunger switch to the "LOAD" position. This will activate the air cylinder and bottom out the plunger in the cup.

(e) Push the "I/M" selector button on the digimatic indicator so the "IN" is shown. Push the up/down direction selector button on the

indicator so the "DOWN" arrow is shown. The "IN" and "DOWN" arrow must be shown for U. S. customary values.

(f) Each setting fixture will have its own preset value. The preset value compensates for the difference in the position of the digimatic indicators from one fixture to another. You will find the preset value located on the control panel in inches. Press the "PSET" button on the digmatic presetter. Use the number keys on the presetter to enter the fixture preset value. The indicator will now show the preset value and a "P".

(g) Press the "LOAD" button on the presetter and wait 5 seconds or until the indicator shows the "DOWN" arrow and "IN". These symbols must be shown before you proceed with the setting, or the travel readings will be incorrect.

(h) When the correct symbols are displayed, move the plunger switch to the "UNLOAD" position and the indicator will read out the plunger travel. The travel will be given as a negative number.

(i) If the plunger travel is incorrect, use the adjusting tool and turn the stop screw up or down until the indicator shows the desired travel reading. Then torque the locknut to 55 foot-pounds.

(j) Check the plunger travel again to make sure that it did not change when the locknut was torqued. If the travel is not correct, adjust the stop screw again and recheck.

(k) Once the travel is set, move the deadweights switch to the "RAISE" position to move the deadweights and center plunger off the injector link. Loosen the fixture stop nut from the injector cup and remove the injector from the fixture. Remove the link and bracket from the injector.

STOP! Have instructor initial.

(10) Perform an injector flow test.

(a) Turn the main switch on the control panel to the "ON" position.

(b) Select the correct injector adapter and link from the accessory box located on the front of the injector test stand.

(c) Assemble the adapter and link to the injector.

(d) Load the injector by raising the guard and placing the injector, adapter, and link into the test stand.

(e) The two milled cutouts in the adapter must align with the two parallel bars that protrude from the clamp plate.

(f) The cup of the injector must be supported by the vee block which is attached to one of the parallel bars. The link must rest in the vee support plate, between the cam box tappet and the back of the clamp plate.

(g) Lower the injector guard.

(h) Pull the clamping valve toward the injector cup until it is against its stop. This will automatically cause the correct sealing and clamping load to be applied to the injector. The clamping control valve lever in the clamp position prevents the guard from being raised.

(i) Check the test stand parts alignment. A stamped line on the seal cylinder flange and a square notch cut out of the steel strip which covers it must be lined up. If the stamped line and notch are not lined up, the wrong adapter and link have been installed.

STOP! Have instructor initial.

(j) Check to ensure that the "O" ring in the self-sealing valve, in the fuel arm, is in position. The adapter positions the injector orifice plug correctly for the self-sealing valve in the fuel arm. When the fuel arm is lowered, the self-sealing valve will lift off its seat and allow test oil to be fed into the injector orifice plug.

(k) Make sure the fuel line valve is open and lower the fuel arm. Lock the fuel arm in position.

(l) Check to see if test oil is flowing from the injector drain port.

(m) Take several readings until the flow stabilizes. When the metering unit or the injector is cold, the readings will vary. Press the main drive "START" button.

(n) Press the "METERING" button. The dial will display the flow of the injector in cubic centimeters per stroke. When readings stabilize, stop the main drive by raising the fuel arm.

(o) After the motor has stopped, press the "METERING" button, set the dial indicator to zero with the adjusting screw, lower the fuel arm to restart the drive, and press the "METERING" button.

(p) Watch the small hand on the dial indicator to see if it turns more than one revolution. Read the output of the injector. The small hand makes one revolution for each 250 cubic centimeters of fuel per 1,000 strokes. The large hand makes one revolution for each 10 cubic centimeters of fuel per 1,000 strokes.

(q) If the fuel delivery is greater than the specification, a new orifice plug must be installed. If the fuel delivery is less than the specification, the orifice can be adjusted by burnishing.

(r) The test stand is designed to permit burnishing without removing the injector from the test stand. Insert the burnishing tool point into the orifice and push in on the tool until it clicks. Then, using the same procedures, recheck the fuel flow.

(s) When the correct fuel flow is achieved, remove the injector from the test stand.

STOP! Have instructor initial.

STUDENT REFERENCES:

TM 9-2320-272-34

Cummins Service Bulletin No. 3379071-05

H.A. 290 Cummins Injector Test Stand Operating and Servicing Manual