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FESCR 8208

STUDENT HANDOUT

REPAIR ROBERT BOSCH FUEL INJECTION PUMPS

LEARNING OBJECTIVE

1. Terminal Learning Objective: Given a Robert Bosch VE type fuel injection pump, the required common and special tools, test equipment, repair parts, shop supplies, Robert Bosch technical literature, and Hartridge 2500 operating, servicing, and spares manual, per information contained in the references, repair the fuel injection pump. (8.2.6)

2. Enabling Learning Objectives: Given a Robert Bosch VE type fuel injection pump, the required common and special tools, test equipment, repair parts, shop supplies, Robert Bosch technical literature, and Hartridge 2500 operating, servicing, and spares manual, per information contained in the references:

a. disassemble the fuel injection pump, (8.2.6a)

b. inspect the disassembled components for serviceability, (8.2.6b)

c. repair or replace the unserviceable components, (8.2.6c)

d. assemble the fuel injection pump from serviceable components, and (8.2.6d)

e. calibrate the fuel injection pump. (8.2.6e)

OUTLINE

1. DESIGN CHARACTERISTICS AND PRINCIPLES OF OPERATION OF THE ROBERT BOSCH TYPE VE FUEL INJECTION PUMP

a. Design Characteristics

(1) Because of their adaptability, the VE distributor injection pumps can be used in a wide range of applications. They are used in diesel powered passenger cars, light and heavy trucks, farm tractors and even stationary installations such as for driving pumps and electrical motors. In military equipment, VE distributor pumps are used extensively in engineer equipment such as bulldozers, forklifts, and scoop loaders. The demands placed on them, in effect, establish pump design. Because the

VE pumps are adaptable, their influence on rated engine speed, power output, and mounting is rather easy to change to suit particular needs.

(2) The type VE distributor pump has a single pump-cylinder and plunger. Fuel delivered by the plunger is apportioned by way of a distributor groove to a number of ports corresponding to the number of cylinders in the engine. The distributor pump houses, in a single unit, five functional groups.

(a) A vane-type supply pump that supplies fuel from the tank to the injection pump cavity.

(b) A high-pressure pump with distributor that produces injection pressure, moves, and distributes the fuel to the cylinders.

(c) A mechanical governor that controls engine speed by varying fuel delivery at various control ranges.

(d) An electromagnetic shutoff valve that interrupts fuel delivery to stop the engine.

(e) An injection-timing unit that adjusts the beginning of injection according to engine speed.

(f) The distributor pump can also be equipped with various supplementary functions to accommodate specific engine characteristics. The pump we have displayed is an example of supplementary functions. It has a manifold-pressure compensator (LDA) used to adjust the full-load fuel delivery in turbocharged diesel engines. It also has a hydraulic cold-start injection advance (KSB) used to increase cavity pressure for cold start up.

(3) The distributor fuel injection pump is engine driven at half crankshaft speed. It must be positively driven so that the injection pump input shaft is synchronized with the engine piston motion; this is accomplished by using a toothed belt, pinion, helical gears or a chain.

(4) Distributor pumps are produced for both clockwise and counter-clockwise rotation. This means that depending upon the direction of rotation, the injection sequence varies, although the ports are always supplied with fuel in their geometrical order. To avoid confusing the sequential order of the ports with cylinder numbers, they are labeled, A, B, C, etc. The rotational direction of the pump will be stamped on the nameplate. Look at the nameplate on your pump and you will see R 381-5. The R stands for right-hand rotation and the 381-5 is the model number. If it was stamped L 381-5, it would mean left-hand rotation. The rotation is to be viewed from the drive end.

b. Principles of Operation

(1) Fuel is drawn through the inlet port located in the bottom of the pump housing by the vane-type supply pump. However, if the fuel tank is so located that the fuel cannot be drawn by the supply pump, you could have an external supply pump used to supply fuel to the inlet port.

(2) The supply pump delivers a virtually constant flow of fuel to the injection pump cavity. To obtain a defined pressure level proportional to engine speed, a pressure control valve is required. With this valve, pressure can be set to correspond to a particular engine speed. This means that the pump cavity pressure increases along with rising engine speed. A portion of the fuel flows through the pressure control valve and returns to the suction side of the pump. For cooling and self-ventilation of the distributor injection pump, some fuel also flows through the overflow restriction on the governor cover and back to the fuel tank.

(a) The pressure control valve is mounted very close to the supply pump and connected with the upper recess by a bore. It is a spring loaded slider valve with which the pump housing pressure can be varied according to the quantity of fuel being delivered. If fuel pressure exceeds a preset value, the valve piston opens the return circuit and allows fuel to flow back to the pump suction side. If fuel pressure is too low, this return circuit remains closed. The valve opening pressure is determined by adjusting the spring preload.

(b) The overflow restriction is screwed into the governor cover of the distributor pump. It allows a variable quantity of fuel from the pump cavity to return to the fuel tank through a small bore. For the overflow fuel, this restriction offers a flow resistance that assists in maintaining fuel pressure in the cavity. Because precisely defined pressure is required in the cavity, the overflow restriction and pressure control valve are designed so they are precisely matched to each other.

(3) As the distributor plunger moves from top to bottom dead center, its rotary-reciprocating motion opens the inlet bore in the distributor head by means of a metering slit in the plunger. Fuel under pressure in the pump cavity then flows through this bore into the high pressure chamber at the end of the distributor plunger. Then motion reverses, and as the plunger progresses toward top dead center, the inlet bore is closed by the plunger. With further motion the distributor groove opens a precisely defined outlet bore in the distributor head. Fuel under pressure that has built up in the high pressure chamber and the interior bore now opens the pressure valve and is forced through the pressure line to the injection nozzle.

(4) The working stroke is thus completed as soon as the transverse cutoff bore of the plunger reaches the edge of the control spool. After this point, no more fuel is delivered to the nozzle and the pressure valve closes the line. Fuel returns through the cutoff bore to the pump cavity as the plunger completes its travel to top dead center. As the plunger returns, its transverse bore is closed at the same time the next control slit opens the fuel inlet bore. The high pressure chamber is once again filled with fuel and the cycle repeats for the next cylinder.

(5) The pressure valve is a fluid controlled, plunger type, opened by fuel pressure and closed by its return spring.

(a) The pressure valve closes the injection line off from the pump and has the job of relieving the injection line by removing a defined volume of fuel after the delivery phase. It also determines the precise point at which the injector nozzle closes at the end of injection. At the same time, stable pressure and

conditions between the injection pulses are created, regardless of the quantity of fuel being injected at that particular instant.

(b) Between plunger delivery strokes it is closed; pressure line and distributor head outlet bore are thereby separated. During delivery, the valve is lifted from its seat by the high fuel pressure. Fuel then flows via longitudinal slits into a ring groove and through the pressure valve body, the pressure line and to the injection nozzle. As delivery concludes, the plunger cutoff bore opens, pressure on the high pressure side falls to that of the pump cavity and the pressure valve is closed by its spring.

(6) The variable-speed governor controls idle speed regulation, maximum no-load speed, and maintains intermediate speeds as determined by the driver.

(a) The input shaft drives the governor assembly, which consists of a centrifugal-weight housing and the weights themselves, as well as the governor spring and lever assembly. Radial motion of the centrifugal weights is translated into axial movement of the sliding sleeve. The force acting on this sleeve and its position influence the position of the governor mechanism.

(b) In turn, the governor mechanism consists of a control lever, tensioning lever and starting lever. The control lever is pivoted in the pump housing and can be adjusted by the full-load adjusting screw. The starting and tensioning lever also rotate relative to the control lever.

(c) The starting lever has a ball pin on its underside that engages with the control spool. The starting spring is attached to its upper end. At the upper end of the tensioning lever is a retaining pin over which is fitted the idle spring. The governor spring is also hooked into the end of the retaining pin. A lever and the control lever shaft connect to the engine speed control lever.

(d) Interaction of spring and sleeve force defines the governor position; control movement is transferred to the control spool, thus determining the quantity of fuel delivered by the distributor plunger.

(e) In the starting position, with the engine stationary, the centrifugal weights and sliding sleeve are in their initial position. The starting lever is moved to the starting position by its spring and pivots around the pivot pin. At the same time, the control spool on the distributor plunger is held in its starting position by the ball pin of the starting lever. This set of conditions means that the plunger has a large stroke (maximum delivery = starting delivery) before delivery ends. Once starting begins, it takes only a modest rotational speed to affect the centrifugal weights and move the sliding sleeve against the weak starting spring. The starting lever again pivots around the pivot pin, reducing delivery automatically to the idle level.

(f) At an idle, with the engine running and the accelerator pedal released, the engine speed control lever is in its idle position against its stop, the idle adjusting screw. Idle speed is chosen so that the unloaded engine runs reliably. Control is by the idle spring on the retaining pin, which counteracts the force from

the centrifugal weights. This balance of forces determines the control spool's position with reference to the plunger cutoff bore, and therefore the length of the delivery stroke. At engine speeds above idle, the spring is collapsed and therefore no longer effective.

(g) At engine speeds above idle, the starting and idle springs are collapsed and have no more effect on governor action; the governor spring now assumes this function.

1 By pressing the accelerator pedal, the driver moves the engine speed control lever into a position corresponding to a desired high speed. This movement stretches the governor spring by a certain amount, with the result that spring force now exceeds that of the centrifugal weight.

2 Governor spring tension pulls the starting and tensioning levers, which pivot around the pivot pin and move the control spool into a position that increases fuel delivery. Increased engine speed is the result. The centrifugal weights then swing outward due to the increased speed and move the sliding sleeve in opposition to the governor spring tension. The control spool, however, remains in its "full" position until balance is attained.

3 If engine speed continues to increase, the weights swing farther outward and sleeve forces becomes dominant. Now the starting and tensioning levers pivot around the pivot pin moving the control spool in its stop direction so that the cutoff bore is opened earlier. Delivery can be reduced all the way to minimum in this process, which puts a cap on engine speed.

4 Therefore, for each position of the engine speed control lever, there is a precise engine speed range between full-load and no-load; as long as the engine is not overloaded. The result is that the governor, working within the parameter of its speed droop, maintains the engine speed dictated by the accelerator pedal.

(h) For engine braking in a downhill operation, the conditions are reversed. The engine is driven by the vehicle; engine speed tends to increase. The weights swing outward and the sleeve pushes against the starting and tensioning levers, which in turn move the control spool toward less fuel delivery. This continues until the smaller delivery corresponds to the new load condition, at the extreme fall to zero. If the engine is completely unloaded, maximum idle speed is reached.

(7) The hydraulic timing-advance device is built into the underside of the distribution pump, at right angles to the pump longitudinal axis. The timing piston is guided by the pump housing. On one side of the piston is a fuel inlet bore, on the other side a spring. A sliding block and an actuating pin connect the piston with the roller ring.

(a) The timing piston is held in its initial position by a preload spring. During operation, fuel pressure in the pump cavity is regulated proportional to engine speed by the pressure control valve and the overflow restriction; as a

result, the piston side opposite the spring is under the same pressure, which increases with increasing engine speed.

(b) When engine speed reaches approximately 300 rpm, fuel pressure reaches a value sufficient to overcome the spring preload and move the timing piston. This axial piston motion is transmitted via the sliding block and pin to the roller ring, which rotates in bearings. This alters the arrangement of the cam plate and roller ring so that the rotating cam plate is lifted at an earlier point in time by the rollers. The rollers with their ring are thus turned by a specific angle relative to cam plate and distributor plunger. This angle can be as much as 12 degrees of camshaft rotation or 24 crankshaft degrees.

(8) In the VE distributor pump, fuel shutoff can be accomplished mechanically or electrically.

(a) The mechanical fuel shutoff is a lever assembly, mounted in the governor cover and consisting of outer and inner stop levers on a common shaft. The outer stop lever is actuated by the driver. Both stop levers then rotate, the inner one coming into contact with the governor starting lever. In turn, the starting lever rotates on the pivot pin forcing the control spoon into its "stop" position. Now the cutoff bore of the distributor plunger is open; the plunger no longer delivers fuel, and the engine stops.

(b) Because it is more convenient for the driver, electric shutoff via the vehicle ignition switch is fast replacing the mechanical arrangement. The solenoid valve that interrupts fuel flow is installed on the distributor head, top side, in the injection pump. When the ignition switch is on, the solenoid holds the valve off its seat and thus the inlet bore to the high pressure chamber, open. When the ignition switch is turned off, the magnetic field collapses and the spring closes the valve. Now the inlet bore is closed; no more fuel reaches the plunger.

2. DEMONSTRATION AND PRACTICAL APPLICATION ON REPAIR OF THE ROBERT BOSCH TYPE VE FUEL INJECTION PUMP

a. Disassembly of the Fuel Pump

(1) The numbers in parentheses reflect the item number of each item as illustrated in figure No. 1, page No. IV-H-26 of this handout. You will have to refer to figure No. 1 throughout the repair procedures in order to correctly identify each item to be removed or installed.

(2) Unlock the drive shaft (12).

(a) Unscrew the shaft locking pin (393) 1/8 inch.

(b) Install the spacer (394) on the shaft locking pin (393).

(c) Retighten the shaft locking pin (393) against the spacer (394).

(3) Remove the nut (206), lockwasher (207), and key (205) from the drive shaft.

(4) Check the drive shaft bushing for excessive wear.

(a) Fasten dial indicator holder KDEP 1128 with a dial indicator to the pump flange locating collar. The dial indicator should be positioned at nine o'clock on the drive shaft.

(b) Preload the dial indicator approximately 2.0mm and zero the gauge.

(c) Move the shaft back and forth by hand, noting the reading on the dial indicator.

(d) Once you have the reading, reposition the dial indicator ninety degrees from the first measurement, preload and zero the gauge.

(e) Take a reading while moving the shaft up and down.

(f) If either reading exceeds a maximum of 0.25mm, replace the housing.

(5) Break the torque on the hex nut (90) and remove the full-load adjusting screw (88) with hex nut (90), washer (87), and O-ring (91).

(6) Release the spring tension from the large spring (220) on the control lever (72). Unscrew the Allen head screw (75) and remove the top lever (304) with the spring (306), large flat washer (305), and lockwasher (73).

(7) Note the location of the locating mark on the control shaft (68) in relation to the marks on the lever assembly (72). It must be installed in the same position.

(8) Remove the lower lever assembly (72) and large spring (220) with its two retainers (325) and (329).

(9) Remove the four Allen head screws (123) from the cover (67/1).

(10) Lift the cover (67/1) slightly and push the control lever shaft (68) through the cover. Set the cover aside and unhook the governor spring (122) from the control lever shaft. Remove the O-ring (66) and washer (69) from the control lever shaft.

(11) Unhook the governor spring (122) from the retaining pin (806). Remove the retaining pin, spring seat, and idle spring (806).

(12) Remove the gasket (92) from the cover. Release the tension from the mechanical shutoff lever spring (67/9). Remove the nut (67/13), lockwasher (67/6),

lever (67/12), spring (67/9), and spacer (67/11). Push the shutoff lever shaft (67/8) through the cover, remove the washer (67/4), and O-ring (67/10).

(13) Break the torque on the governor shaft nut (107). Position the pump drive shaft end down and remove the governor shaft (108). Take care not to lose the thrust washer and shim from under the flyweight assembly. Lift out the flyweight assembly (112) and remove the thrust washers (111) and shim (110).

(14) Remove the central screw plug (130) on the distributor head with socket KDEP 1080. Remove the O-ring (129).

(15) Remove the delivery valve holders (58), delivery valve springs (56), spacers (57), and delivery valves (55).. Keep all components of each outlet together. They must be reinstalled in their original outlets. Remove the copper gaskets (54), using extractor hook KDEP 2938.

(16) Remove the screws (60). Remove the distributor head (50), being careful not to drop the correction lever springs (106), guide pins (49), shims (822), and spring seat (47). The plunger may stick in the distributor head, causing the springs, guide pins, and shims to fall out. Remove the O-ring (51) from the distributor head.

(17) Place the distributor head in a vise and remove the electrical shutoff solenoid (240) and O-ring (807).

(18) Lift out the pump plunger together with the metering sleeve, shim (50/5), thrust washer (50/6), spring seat (50/7), and plunger return springs (804). Remove the prestroke shim (52) under the plunger foot.

(19) While supporting the governor lever assembly (95), remove the ping screws (104) and copper gaskets (105), using socket KDEP 1087. Remove the governor lever assembly (95), consisting of the starting lever, tensioning lever, and correction lever.

(20) Remove the cam plate (29). Remove the drive disc (27).

(21) Dismantle the timing device by removing the timing piston cap (37) with shims (821). Remove the O-ring (30) and spring (34). Remove the cover plate (39) and O-ring (36). Remove the retaining clip (803). Turn the drive shaft so the drive tangs are at right angles to the connecting pin. Push the connecting pin into the center of the roller ring. Remove the timing piston (31) with the slider (32).

(22) Push the drive shaft (12) up through the pump housing. Remove the woodruff key (13), governor drive gear (16), and rubber buffers (15). Remove the drive shaft thrust washer (17).

(23) Remove the supply pump as follows:

(a) Unscrew the countersunk screws (10) from the supply pump retainer plate (9).

(b) Insert supply pump holder KDEP 1097 against the supply pump retaining plate (9). While holding the tool against the plate, tilt the pump downward.

(c) Tap gently on the housing with a mallet and let the retainer (9), supply pump impeller with vanes, and eccentric ring (7) slip down and out of the housing. Place impeller retainer KDEP 1101 over the supply pump impeller to keep the vanes in place.

(24) Position the pump horizontally. Unscrew the pressure regulator (135) with socket KDEP 1086, and remove the O-rings (133 and 134). If you should have to disassemble the pressure regulator, use sleeve puller KDEP 1027 to remove the sleeve. Then remove the plunger and spring.

(25) Remove the drive shaft oil seal (3) from the housing, using puller KDEP 1114.

b. Inspect Fuel Pump Components

(1) Thoroughly clean all parts in solvent.

(2) Make sure all fuel passageways are open and free of any material that could cause a restriction to fuel flow.

(3) Inspect each item under the light and magnifier. There are no measurements to be made during your inspection of the components to determine the amount of wear. However, the inspection of components should include looking for excessive wear patterns. Also the control edges of the pump plunger must give a sharp appearance.

(4) If the distributor head, pump plunger, or metering sleeve are to be replaced, all three components must be replaced as a set.

(5) Explain and demonstrate to the instructor the procedures for inspecting the components.

STOP! Have instructor initial. _____

c. Assembly of the Fuel Pump

(1) During reassembly, all parts should be coated with test oil and all O-rings should be coated with petroleum jelly.

(2) Press the oil seal (3) into the pump housing. After the seal is installed, mount the pump housing in the injection vise and position the pump with the drive end up.

(3) Place the supply pump retaining plate (9), impeller with vanes, and eccentric ring (7) on supply pump holder KDEP 1097. Note that the two holes opposite

one another on the eccentric ring are not equally spaced to the inner wall of the ring.

(a) Place the eccentric ring on the supply pump holder with the fuel passage hole towards you.

(b) The direction of rotation for this pump is to the right, R on the name plate, so the narrow space must be on the right.

(c) The curved edge of the impeller vanes must be towards the eccentric ring.

STOP! Have instructor initial._____

(d) Insert the supply pump from below. Make sure that the fuel passage hole is toward the governor side of the pump. Be careful not to tilt the eccentric ring. Do not remove the tool yet. Repositon the pump, drive end down, and withdraw the tool.

(e) Check that all three holes in the retainer plate line up with the holes in the eccentric ring and the pump housing. The fuel passage hole must be toward the governor side. Secure with the countersunk screws (10). Torque to 2 Newton meters.

(4) Installation of the drive shaft assembly.

(a) Assemble the governor drive gear (16) onto the drive shaft (12) so the recess in the gear faces toward the tangs of the drive shaft.

(b) Lubricate the new rubber buffers (15) with petroleum jelly and press in by hand.

(c) Use petroleum jelly to stick the thrust washer (17) and woodruff key (13) on the drive shaft.

(d) Position the pump horizontally.

(e) Install assembly sleeve KDEP 2939 on the end of the drive shaft. Insert the drive shaft into the pump housing so the woodruff key engages with the keyway in the supply pump impeller.

(f) reposition the pump, drive end down.

(5) Installation of the cam roller and timing advance assemblies.

(a) The rollers must not fall out or be interchanged. If this should happen, the heights of the rollers must be measured. The difference in the roller heights must not be more than 0.02mm from maximum roller height to minimum roller height. Correct by interchanging the roller assemblies until the tolerance can be met.

(b) When installing the rollers, the convex washer must be on the outside of the rollers, with the curved edge facing the outer ring.

(c) Insert the connecting pin (803), hole end first, into the roller ring, with the hole vertical.

(d) Rotate the drive shaft so the drive tangs are parallel to the timing piston bore.

(e) Carefully lower the roller ring (802) into the pump housing so the connecting pin points toward the timing piston bore.

(f) Use petroleum jelly to stick the slider (32) into the timing piston (31).

(g) Insert the timing piston into the housing so the recess for the return spring is on the same side as the fuel return bore. The hole in the slider should point toward the roller ring.

(h) Push the connecting pin into the slider to the timing piston and secure it with the retaining clip (803). Place the retaining clip (803) over the retaining pin.

(i) Check the timing piston for free movement.

STOP! Have instructor initial. _____

(j) Position the cover (39) and gasket (36) to the housing with two screws (38) torqued to 6 Newton meters.

(k) Refer to the appropriate test specifications sheet on page IV-H-25 to determine if there is a shim pack dimension listed for this particular pump. It will be listed as the SVS dimension. As you can see, there is no dimension listed for this pump. However, there will always be at least one shim at each end of the timing piston spring. If you were working on a VE pump that had a dimension listed, you would measure the original shim pack (821) removed from the pump and adjust the thickness as required to obtain the dimension listed. We will use the two shims removed from our pump.

(l) Insert one thick shim in the timing piston and install the timing piston spring (34).

(m) Install the O-ring (30) and cover (37) with the remaining timing piston shim (821). Secure them with screws (40) torqued to 6 Newton meters.

(6) If the pressure regulator (135) was disassembled, reinstall the spring and plunger into the regulator. Gently tap the retaining sleeve into the pressure regulator until it is flush with the end of the regulator body. Install new O-rings (133 and 134) on the pressure regulator. Using socket KDEP 1086, screw in and torque the pressure regulator to 8 Newton meters.

(7) Install the drive disc (27) in the roller cage, with the recess facing up.

STOP! Have instructor initial. _____

(8) Insert the cam plate (29) so the plunger drive pin is aligned with the woodruff key in the drive shaft.

(9) Check the plunger spring pretension.

(a) The plunger spring pretension is measured as the distance between the machined surface of the distributor head and the top of the plunger.

(b) Fit the dial indicator in holder KDEP 1088. Preload the dial indicator and zero it on a flat surface plate.

(c) Place the guide pins (49) into the distributor head (50). Install the original shims (822), spring seats (47), and plunger return springs (804) on the guidepins.

(d) Place the spacer (50/5), thrust washer (50/6), and spring seat (50/7) on the pump plunger. Slide the plunger into the distributor head.

(e) Hold the distributor head horizontally, keeping all components in contact with one another without compressing the spring. Seat the dial indicator holder squarely on the machined surface of the distributor head and subtract the reading on the dial indicator from the preload setting to determine the distance to the top of the plunger.

(f) Compare this distance with the valve given in the test specification sheet, page IV-H-25. It will be listed as the KF dimension.

(g) Adjust the distance by changing shims (822) between the guidepins and the spring seat. Use only one shim on each side. Both shims must be the same thickness. If there is a choice between tow different thicknesses of shims, use the thicker shim.

STOP! Have instructor initial. _____

(h) Remove the plunger with the spring seat, thrust washer, and shim from the distributor head.

(10) Check the governor linkage assembly (95) ball stud for freedom of movement in the metering sleeve socket.

(11) Slide the metering sleeve onto the plunger so the relief bore is toward the plunger foot.

(12) Place the original prestroke shim (52), removed during disassembly, on the cam plate. Do not use anything to hold the prestroke shim in place.

(13) Place the plunger with spacer, thrust washer, spring seat, and metering sleeve on the cam plate so the drive pin engages in the plunger foot and the prestroke shim fits in the recess or the plunger foot.

STOP! Have instructor initial. _____

(14) Install the governor lever assembly (95). Screw the pin screws (104) with copper caskets (105) into the housing, using socket KDEP 1087. Make sure the pin screws engage the lever assembly and torque them to 10 Newton meters. Engage the lever assembly ball in the metering sleeve socket.

(15) Place the plunger return springs (804) on the lower spring seat. Install the guide pins (49) with spring seats (47) and shims (822) in the plunger return springs.

(16) Clamp the distributor head in a vise with soft jaws. Screw in and torque the electrical shutoff solenoid (240), with a new O-ring (807), to 40 Newton meters.

(17) Installation of distributor head (50).

(a) Install a new O-ring (51) on the distributor head.

(b) Rotate the lower spring seat so the plunger springs are at the correct angle to aline the guidepins with their respective holes in the distributor head.

(c) Stick the correction lever springs (106) in the distributor head with petroleum jelly.

(d) Without cocking, lower the distributor head onto the plunger and into the pump housing. Make sure the control lever ball stays engaged in the metering sleeve.

(e) To prevent excessive strain on the plunger, tighten the distributor head mounting screws (60) evenly to 11 Newton meters.

STOP! Have instructor initial. _____

(18) Screw the central screw plug (130) with O-ring (129) into the distributor head with socket KDEP 1080 and torque to 60 Newton meters.

(19) Install the delivery valves (55) with copper gaskets (54), springs (56), spacers (57), and delivery valve holders (58) in their original location. Torque the delivery valve holder to 35 Newton meters.

(20) Position the governor shaft shim (110) and thrust washer (111) in the pump housing.

(21) Assemble the flyweight carrier (112) with flyweights (805), washer (114), and guide bushings (115) with end plug (117). Position the flyweight assembly in the pump housing.

(22) Screw the governor shaft (108) with O-ring (109) into the pump housing until a distance of 1.5 to 2.0mm from the housing surface to the end of the governor shaft is established.

(23) Measure the axial play of the flyweight assembly with a feeler gauge between the stop pin and the flyweight carrier. It should be 0.25 to 0.45mm. To adjust the amount of play, exchange the governor shaft shim (110) with a different size.

STOP! Have instructor initial. _____

(24) Position the pump horizontally and lock the governor shaft in position with nut (107) torqued to 25 Newton meters.

(25) Check the starting fuel dimension.

(a) Mount gauge block KDEP 1084 on the pump housing, using the cover screws (123). The recess on the gauge block should be on the bottom, facing the correction lever. The correction lever will be pressing against the gauge block.

(b) Push the tensioning lever toward the drive end against its stop pin in the pump housing. Hold the starting lever against the tensioning lever, making sure the tensioning lever stays against its stop pin. With a feeler gauge, measure the gap between the guide bushing end plug and the starting lever.

(c) Compare this value with the value listed on the test specification sheet on page IV-H-24. It will be listed as the MS dimension.

(d) If the starting fuel dimension is not correct, it is adjusted by exchanging the guide bushing end plug (117). To exchange the end plug, position the pump with the drive end down, unscrew the governor shaft, and remove the guide bushing. Push out the end plug from the guide bushing using a suitable tool and install a new one. Reinstall the guide bushing and recheck the starting fuel dimension.

STOP! Have instructor initial. _____

(e) Remove the gauge block from the housing.

(26) Installation of the mechanical shutoff device.

(a) Place the shim (67/4) on the shutoff lever (67/8) and push the shaft through the cover from the inside. Position the O-ring (67/10), shim (67/11), and tension spring (67/9) on the outside of the cover, over the shaft.

(b) Insert the 27.7mm spacer block KDEP 1130 between the inside edge of the cover and the internal shutoff lever. Hold the lever against the spacer block. Install the shutoff control lever (67/12) on the shaft so the smallest possible gap exists between the lever and the cover. Secure the control lever with lockwasher (67/6) and nut (67/13) torqued to 5 Newton meters.

(c) Measure the gap with a feeler gauge and make a note of the distance for later use when making the final adjustment.

(d) Position the end of the tension spring (67/9) in the hole of the control lever (67/12).

STOP! Have instructor initial. _____

(27) Place idle spring and retainer (806) on the retaining pin and push the pin through the tensioning lever. Connect one end of the governor spring (122) to the retaining pin and the other end to the control lever shaft (68). The end of the spring connected to the control lever shaft should have the spring hook opening pointing downward.

(28) Place the shim (69) and O-ring (66) on the control lever shaft (68). Use assembly sleeve KDEP 2937 to install the O-ring. Install the gasket (92) in the groove of the cover. Push the control lever shaft up through the pump cover bushing, being careful not to damage the O-ring or bushing. Secure the cover with the screws (123) torqued to 6 Newton meters.

(29) Rotate the control lever shaft counterclockwise until spring tension is felt. Position the control lever return spring (220) with retainers (325 and 329) over the control lever shaft. Position the bottom lever (72) on the shaft so that alignment marks noted during disassembly are lined up. Position the spacer (305), lockwasher (73), and upper lever (304) with spring (306) on the shaft. Install the flange nut (75) and torque it to 5 Newton meters.

(30) Position the upper end of the return spring (220) on the tang of the lower control lever (72).

(31) Install a new O-ring (91) on the full-load stop screw (88). Screw the full-load stop screw into the housing until it bottoms, then back it out one full turn. Torque the nut (90) to 25 Newton meters.

(32) Install the inlet fitting (246) with gasket (245) and torque to 20 Newton meters. Install the return fitting (136) with gaskets (251), hand tight.

(33) Adjust the mechanical shutoff lever (67/12) movement.

(a) Insert a feeler gauge of the same thickness established during assembly between the cover and shutoff lever. Using a caliper, measure the distance from the support bracket to the shutoff lever. Hold the shutoff lever against the stop adjusting screw (67/17) and measure the distance again.

(b) Subtract the two readings; this is the total movement of the shutoff lever. Adjust the stop adjusting screw until the total movement is 2.5 to 22.0mm.

STOP! Have instructor initial. _____

d. Precalibration Procedures **********

(1) Mount the fuel pump to the test stand.

(a) Install the mounting flange to the universal-mounting bracket.

(b) Mount the pump to the mounting flange and install the drive coupling on the pump drive shaft. Secure the coupling with a lock washer and nut.

(c) Slide the pump toward the test bench drive until the drive tangs of the pump drive coupling are engaged with the jaws to the test bench drives coupling. Secure the mounting bracket with the through bolts and nuts. To lock the jaws of the test bench drive coupling on the pump drive coupling tangs, tighten the 4mm Allen head screw.

(d) Remove the timing piston cover plate and install the timing probe adapter part no. AE3/4/2, in its place, on the pump.

(e) After removing the overflow fitting, position a banjo, part no. ALP 269/1, with a copper washer on each side over the overflow port. Install a banjo adapter, part no. ALP 145, through the banjo and copper washers into the pump housing. Position another banjo part no. ALP 237 with a copper washer on each side on the banjo adapter. Install the overflow fitting through the banjo and copper washers into the adapter.

(f) Connect a line from the bottom banjo connector to the 11 bar auxiliary gauge on the test bench.

(g) Connect the Thermister Pipe Assembly part no. 167-11-34 to the top banjo connector and the return line from the Thermister Pipe Assembly to the back leakage connector on the test bench. Connect the temperature lead from the Thermister Pipe Assembly to the Celsius socket on the test bench.

(h) Using another banjo connector part no. ALP 237 with two copper washers and a banjo bolt, part no. ALP 144, connect the supply line from the inlet fitting of the pump to the test oil supply 1-4 bar connector on the test bench.

(i) Set the volts on the computer screen.

(j) Test the electrical shutoff device to make sure the solenoid is working at the voltage given in the test specification sheet. You should be able to hear the solenoid click on and off as you connect and disconnect the electrical connection. It will be checked again later during the test specification checks.

(2) Perform the plunger pre-stroke check. On pumps with a specified lift to port closure, the pre-stroke dimension is checked hydraulically on the test bench. This check is not necessary on zero pre-stroke pumps, because the plunger position is adjusted during assembly.

(a) After removing the central screw plug bleeder screw, mount the pre-stroke measuring device with extension, and dial indicator.

(b) With the pump plunger at bottom dead center, preload the dial indicator and clamp it in place.

(c) Start the test oil system on the test bench. Place a drip pan under the overflow tube and head assembly.

NOTE: Test oil will flow out of the overflow tube of the measuring device and the outlet ports of the head as soon as you adjust the test oil feed pressure. You should try to perform the next step as quickly as possible.

(d) Adjust the test oil feed pressure to 0.35 bar. Manually rotate the pump in the proper direction until the flow of fuel from the tube slows to drops. Note the reading on the dial indicator and turn off the test oil system.

(e) Subtract the reading noted during the test and the preload setting. Compare the value with the pre-stroke value listed under "Start of delivery," on the appropriate test specification sheet.

(f) Correct any deviation by inserting the correct plunger pre-stroke shim under the plunger foot. The pump must be partially disassembled in order to change the pre-stroke shim.

1 If the reading was too high, late port closure, insert a thicker shim.

2 If the reading was too low, early port closure, insert a thinner shim.

(g) When the pre-stroke is correct, remove the pre-stroke measuring device and install the bleeder screw with a new copper washer seal in the central screw plug.

(3) Complete precalibration connections and checks.

(a) Connect the test lines from the nozzles to the pump. Back off the low speed and high speed stop screws.

(b) Adjust the test oil temperature to 40C.

(c) Hold the control lever against the high speed stop screw with a tensioning spring and adjust the test oil feed pressure to the required pressure listed on the test specification sheet.

(d) Select the injectors on the screen for the injectors used.

(e) Select the metering mode (Calibration).

(f) Run the pump at about 100 rpm. And bleed the air from the test lines.

(g) Warm up the pump for about 10 minutes at 1000 rpm. The pump must deliver fuel at this time. If the pump does not delivery fuel, screw in the full-load stop screw. If this does not work, the pump must be checked for a mechanical defect.

NOTE: Make sure computer learns the firing order. The nozzles on the screen will turn blue.

e. Calibrate Fuel Pump. Refer to the test specification sheet, page VII-29, for the setting values. The test specifications in parentheses are the values used when testing a used pump.

(1) With the control lever held against the high- speed stop screw, run the pump at the full-load speed. Adjust the full-load fuel delivery with the full-load screw to approximately the give value.

(2) Zero timing advance on the test bench.

(3) Set the supply pump pressure and timing piston travel.

(a) Run the pump at the speed listed under "Timing-device travel" and "Supply-pump pressure." Note the supply pump pressure on the 14 bar pressure gauge and the timing piston travel on the timing piston travel gauge.

(b) A change in supply pump pressure will affect the timing piston travel. Adjust the pressure regulator to attain the supply pump pressure and timing piston advance given in the test specification sheet.

(c) To increase the supply pump pressure, us tool KDEP 1092 and press the plug in the pressure regulator.

(d) To reduce the supply pump pressure, the plug in the pressure regulator must be drawn back.

1 Remove the regulator and disassemble it per the instructions covered during the repair of the pump.

2 After you have the regulator disassembled, use a suitable tool and press the plug back flush with the regulator body.

3 Reassemble the pressure regulator and install it back in the pump.

4 Adjust the supply pump pressure to the value listed on the specification sheet.

(e) If the specified timing piston travel cannot be attained within the supply pump pressure tolerances, the travel may be adjusted within the tolerances of the timing piston shim pack. If the timing piston travel cannot be attained by adjusting the shims, replace the timing piston spring.

(4) Set the full-load delivery.

(a) With the control lever against the high-speed stop screw, run the pump at the lower full-load speed.

(b) Adjust the full-load delivery with the full-load stop screw to the value listed under "Full-load delivery" on the test specification sheet.

(5) Set the low idle-speed regulation.

(a) Return the control lever to the low-speed stop screw.

(b) Run the pump at the listed speed and check fuel delivery.

(c) Adjust the fuel delivery, with the low-speed stop screw, until the value listed is obtained.

(6) Set the full-load speed regulation.

(a) With the control lever against the high-speed stop screw, run the pump at the listed speed.

(b) Check the fuel delivery and adjust the high-speed stop screw to obtain the correct fuel delivery.

(7) Measure the overflow quantity.

(a) Measure the overflow quantity over a ten second period at the appropriate speed and compare it with the test specification sheet.

(8) Check the starting fuel delivery.

(a) Connect the test line from outlet "A" to a test nozzle set to 196 bar opening pressure.

(b) Run the pump at the speed given under "Start." Check the fuel delivery, it must be within the quantity specification listed.

(c) If the starting fuel delivery is not attained, the starting fuel dimension (MS) may not be correct. Recheck the starting fuel dimension and correct as necessary.

(d) Insufficient fuel delivery may also be caused by an excessively worn plunger.

(9) Perform the injection pump specifications checks.

(a) Now that the setting values are correct, run the pump through the specification checks listed on the test specifications sheet. Perform the checks in the order listed and at each speed listed.

(b) The timing device and supply pump pressure can be checked at the same time at each speed.

(10) Perform lock timing. This pump is equipped with lock timing to ensure that the pump will be in time with the engine, so the fuel delivery is in the firing order of the engine.

(a) If the pump housing does not have a timing mark, reinstall the prestroke measuring device while the pump is still mounted to the test bench.

(b) With the delivery port of the plunger lined up with outlet port D, rotate the drive shaft in the direction of rotation 1.5mm from bottom dead center. Hold the shaft in this position, remove the lockscrew spacer, and torque the lockscrew to 30 Newton meters. This is listed under the "Start of delivery" block on the test specification sheet.

(c) If the pump housing has a timing maker, after the pump is removed from the test bench, rotate the drive shaft until the keyway of the drive shaft is aligned with the timing mark.

(11) Remove the pump from the test bench.

(a) Remove the prestroke measuring device and the timing piston travel gauge.

(b) Reinstall the bleeder screw and copper plate with O-ring.

(c) Disconnect and remove all lines and fittings and store them in their proper place.

(d) Remove the pump. Ensure the lock timing is correct and the lock screw is torqued to 30 Newton meters. Install new tamper-proof seals where required.

STOP! Have instructor initial._____

POS	DESCRIPTION	PART No.	QTY	REMARKS
1.	Universal Mounting Bracket	APB 28/1	1	
2.	Mounting Flange	APB 148	1	
3.	Drive Coupling	ADC 30.2	1	
4.	Overflow Orifice Screw	1 463 456 303	1	Marked "OUT"
5.	Test Nozzle Holder Assy.	ISO 4010	6	
6.	Test Line	1 880 750 017	6	6x2x840 mm
7.	Timing Piston Gauge	EFEP 459VE	1	
8.	Prestroke Device		1	
9.	Extension		1	
10.	Dial Indicator		1	
11.	Temperature Gauge		1	
12.	Return Line to Back Leakage			
13.	Housing Pressure Line to Aux Gauge 14 Bar			
14.	Supply Line to Test Oil Supply			

BOSCH-INJ.-PUMP TEST SPECIFICATIONS (Note inst. in remarks column)

Test sheet : CUM 5,9 W36
Edition : 20.04.90
Replaces : -
Calibrating oil : ISO 4113

Injection pump : VE 6/12F1050 R381-5
Type number : 0 460 426 157

Customer-specific information
Customer : CDC

Engine : 6 BT

Power k: 93
Speed 1/mi: 2100

TEST BENCH REQUIREMENTS

Calibrating -oil
return temp. C
with thermometer : 40...48
electronically : 42...50

Inlet pressure, bar: : 0.35

Calibrating nozzle-holder
assembly : 1 688 901 027

Opening
pressure bar: 250...253

Perforated-plate diameter	mm: 0.5	
Test injector tubing	: 1 680 901 027	
Outside diameter	: 6	
x Wall thickness	: 2	
x Length	mm: 840	
Start of delivery		
Prestroke	mm: 0,3	
	(from BDC): + -0,02(0,04)	Record reading._____
Start of delivery block		
Piston stroke	mm: 1,5	
	mm: + -0, 02(0,6)	
Outlet	: D	

Injection-pump setting values
Test specifications in parentheses

Timing-device travel:

Speed	1/min: 750	
Setting value	mm: 3,4...3,8	Record movement._____

Supply-pump pressure:

Speed	1/min: 750	
Setting value	bar: 3,5...4,1	Record pressure._____

Full-load del. w/out charge press:

Speed	1/min: 750	
Del. quantity	cm3/:	
	1000H: 64,5...65,5	Record delivery._____
Disperson	cm3/: 4,0	
	1000H: 4,5	Record dispersion.____

Low-idle speed regulation:

Speed	1/min: 375	
Del. quantity	cm3/:	
	1000H: 10,2...12,0	Record delivery._____
Dispersion	cm3/: 5,5	
	1000H: (7,0)	Record dispersion.____

Full-load speed regulation:

Speed	1/min: 1100	
Del. quantity	cm3/:	

	1000H: 46,0...52,0	Record delivery._____

Start:

Run test stand at 500 to relearn firing order

Speed	1/min: 100	
Del. quantity	: -	
mind	1000H: 46,0...52,0	Record delivery._____

cm3/1000H: 70,0

Inspection-pump test specifications
Test specifications in parentheses

Timing-device characteristic:

1st speed	1/min: 500	
TD travel	mm: 1,5...2,3	
	mm:(1,2...2,6)	Record movement._____
2nd speed	1/min: 750	
TD travel	mm: 3,4...3,8	
	mm:(2,9...4,3)	Record movement._____
3rd speed	1/min: 1050	
TD travel	mm: 5,0...5,8	
	mm:(4,7...6,1)	Record movement._____

Supply-pump pressure characteristic:

1st speed	1/min: 500	
Supply-pump pressure	bar: 2,4...3,0	Record pressure._____
2nd speed	1/min: 750	
Supply-pump pressure	bar: 3,5...4,1	Record pressure._____
3rd speed	1/min: 1050	
Supply-pump pressure	bar: 4,6...5,2	Record pressure._____

Overflow quantity at overflow valve:

1st speed	1/min: 500	
Overflow	: 41...83	
quantity	cm3/10s: (26...98)	Record overflow._____
2nd speed	1/min: 1050	
Overflow	: 55...138	
quantity	cm3/10s: (40...153)	Record overflow._____

Delivery-quant. and breakaway char:

1st speed	1/min: 1250	
Del. quantity	cm3/: 0,0...3,0	Record delivery._____
	1000H: -	

2nd speed	1/min: 1130	
Del. quantity	cm3/: 15,0...55,0	Record delivery._____
	1000H: -	
3rd speed	1/min: 1100	
Del. quantity	cm3/: 46,0...52,0	Record delivery.
	1000H: (43,0...55,0)	
4th speed	1/min: 1050	
Del. quantity	cm3/: 60,5...63,5	Record delivery.
	1000H: (59,0...65,0)	
5th speed	1/min: 900	
Del. quantity	cm3/: 62,0...65,0	Record delivery._____
	1000H: (60,0...67,0)	
6th speed	1/min: 750	
Del. quantity	cm3/: 64,5...65,5	Record delivery._____
	1000H: (62,0...68,0)	

Zero delivery (stop):

Mech. shutoff:

Speed	1/min: 1050	
Del. quantity	cm3/: 0..3	Record delivery._____
	1000H: -	

Elect. shutoff:

Speed	1/min: 375	
ELAB	volt: -	
Del. quantity	cm3/: 0,0...3,0	Record delivery._____
max.	1000H: -	

Idle delivery:

1st speed	1/min: 375	
Del. quantity	cm3/: 10,0...12,0	Record delivery._____
	1000H: (6,0...16,0)	
2nd speed	1/min: 500	
Del. quantity	cm3/: 0,0...4,0	Record delivery._____
	1000H: -	

Automatic starting fuel delivery:

1st speed	1/min: 130	
Del. quantity	cm3/: -	
	1000H: 70,0	Record delivery._____
2nd speed	1/min: 350	
Del. quantity	cm3/: -	
	1000H: 70,0	Record delivery._____

Shutoff electromagnet:

Cut-in		
min. voltage	: 20,0	
Rated voltage	: 24,0	Record cut-in volts.

Mounting and assembly dimensions:

Designation	
K	mm: -
KF	mm: 5,0...5,4
MS	mm: 1,3...1,7
SVS max.	mm: -

Remarks:

: C.D.C. #391 6933

Heavy-duty fuel-injection pump for DI-engines: only test using timing-device-travel measuring device with metal jacket.

STUDENT REFERENCES:

Robert Bosch Technical Instruction for VE Pump
Robert Bosch Repair Instruction for VE Pump
Robert Bosch Test Instruction for VE Pump
Hartridge 2500 Operating, Servicing, and Spares Manual