

Issue 1; December 16, 2019

Engine platform: M43  
Engine section: Cylinder head

Engine type: all variants of M43 and M46DF  
Validity: until further notice

**Information for all owners and operators**

**Action: for your information**

## Nozzle sleeve redesign

As part of our continuous product improvement (CPI), the design of the nozzle sleeve on MaK M43 engines was reviewed. Since July 2018, nozzle sleeves of a new design have been delivered as spare part and the injector assembly was changed in the same way for new engines. A new cleaning tool for the sealing surface of the nozzle sleeve to the injector was developed and introduced as spare part as well as the standard tool for new on-board special tool sets.

The trigger for this design change was the occasional occurrence of failures of nozzle sleeves in the past and the increasing frequency of such failures since the introduction of ECAs, resulting in more frequent fuel change over from HFO to MDO fuel and vice versa.

Deep analysis of this matter showed a certain sensitivity of the injector assembly to temperature changes. Especially the condition of the sealing surface nozzle sleeve was found to be most significant in this context.

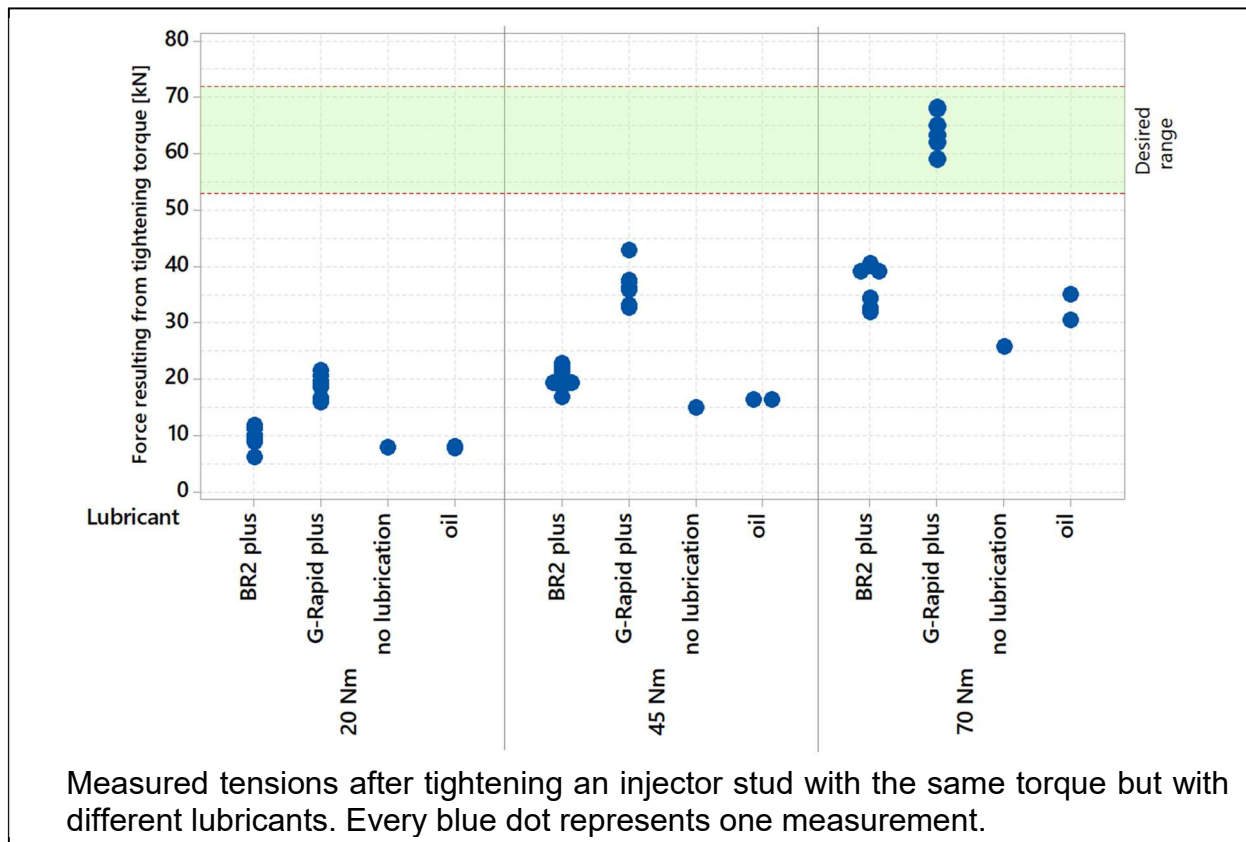
The following issues or a combination of them were involved in this failure mode:

### 1. Loss of pretension of fuel injector stud bolts

A loss of pretension of the fuel injector stud bolts is typically caused by a combination of improper tightening torque during assembly and the thermal growth and shrinking of fuel system components during switchover between MDO and HFO.

The torque applied to the injector assembly hexagon nuts creates a force which presses the fuel injector onto the nozzle sleeve sealing surface. The tension bolts of the injector assembly will maintain this force even if the injector body will grow / shrink due to thermal effects caused by different fuel temperature (HFO / MDO). The force created by the injector assembly will create a pressure fit between injector and nozzle sleeve sealing surface. If the force decreases, the pressure fit on the sealing surface will weaken and exhaust gas blow-by might occur.

The procedure with which the injector assembly is installed by the hexagon nut has a significant influence on the sealing between injector and nozzle sleeve. For example, in case other lubricant than "Molykote G Rapid plus" is used as lubricant on threads and nut contact surfaces, the tension created on the nozzle sleeve sealing surfaces will change and most likely be lower, confirmed by tests. Please note the following graph.



## 2. Insufficient cleaning of nozzle sleeve sealing surface during injector replacement.

When pulling an injector, carbon residues might fall on the sealing surface of the nozzle sleeve. If these residues are not completely removed before inserting a new injector, the dirt particles will be forced into the nozzle sleeve sealing surface and create a potential origin for exhaust gas blow-by. Therefore, checking the nozzle sleeve sealing surface for any deformation before reusing it as well as thorough cleaning of the surface before inserting the injector is imperative.

## 3. Lack of nozzle sleeve seat rework capability

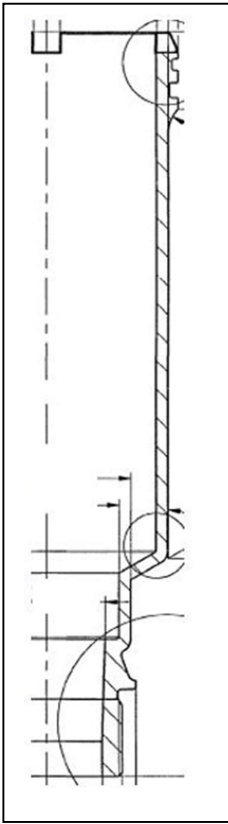
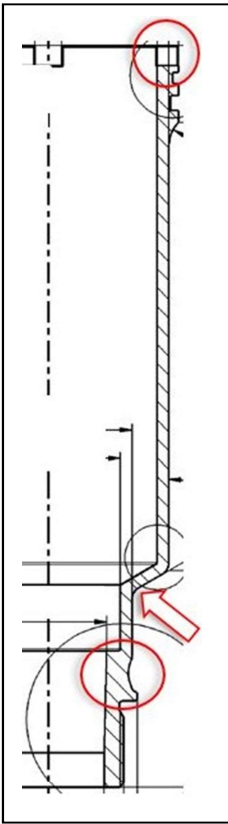
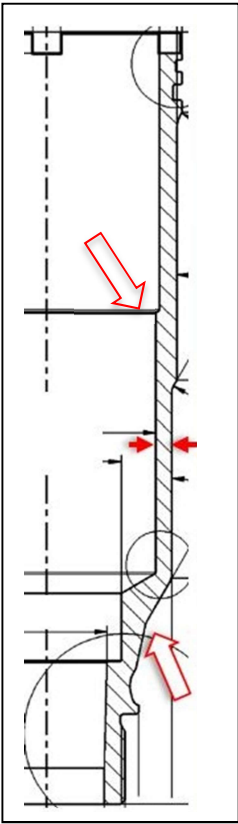
The former nozzle sleeve cleaning tool can be used to scratch residues off the sealing surface only. It was not intended to properly rework the sealing surface. The recent investigations have shown that under certain circumstances it might even damage the sealing surface of the nozzle sleeve and possibly cause exhaust gas blow by.

To improve the situation different measures were taken and tested in the field. Some were already introduced as replacement and series standard.

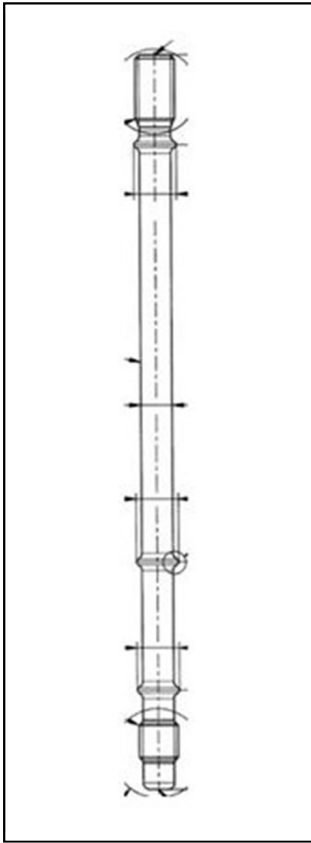
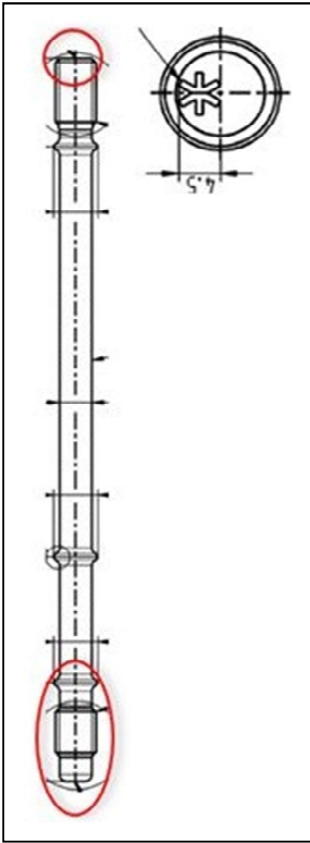
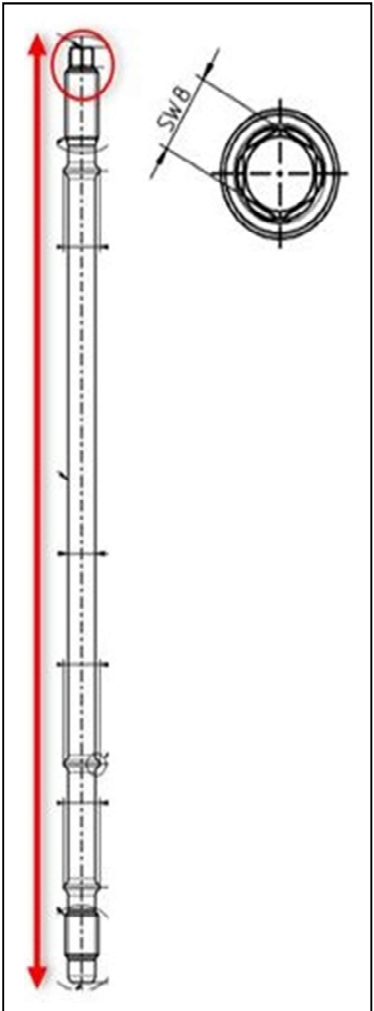
The current related job card shows the different assembly steps and is attached to this Service Information. Please follow the steps described in the job card for cleaning and judging of the injector sealing surface in the nozzle sleeve. An accurate sealing surface is required for successful injector assembly and avoiding exhaust blow-by.

In the following please find parts details of the different design steps for your information.

## Nozzle sleeve:

Original design until July 2017	Reinforced design from July 2017 until July 2018	New series design since Jul - 2018
Designed for 60Nm fuel injector tightening torque	Designed for 70Nm fuel injector tightening torque	Designed for 70Nm fuel injector tightening torque
		
	<ul style="list-style-type: none"> <li>- Stiffer in the area around the injector sealing surface</li> <li>- Enlarged radius (arrow)</li> <li>- Chamfer on top for easy identification</li> </ul>	<ul style="list-style-type: none"> <li>- Wall thickness increased by 30%</li> <li>- Stronger, more rigid design</li> <li>- Chamfer on top and diameter step inside for easy identification</li> </ul>

**Tension bolt:**

Original design until July 2017	Reinforced design since July 2017	Future serial design
Designed for 60Nm fuel injector tightening torque	Designed for 70Nm fuel injector tightening torque	Designed for 70Nm fuel injector tightening torque
		
	<ul style="list-style-type: none"> <li>- Longer thread</li> <li>- Marked with a star for easy identification.</li> </ul>	<ul style="list-style-type: none"> <li>- Length increased by about 32%</li> </ul>

**Future tension sleeve:**

The length of the injector assembly tension sleeve will be increased by about 32% to fit the new tension bolt.

## Nozzle sleeve cleaning tool:

The step in the inside diameter of the new nozzle sleeve, introduced into serial production in July 2018, does not allow using the old tool for cleaning of the new nozzle sleeves sealing surface. We highly recommend scrapping of the old cleaning tool.

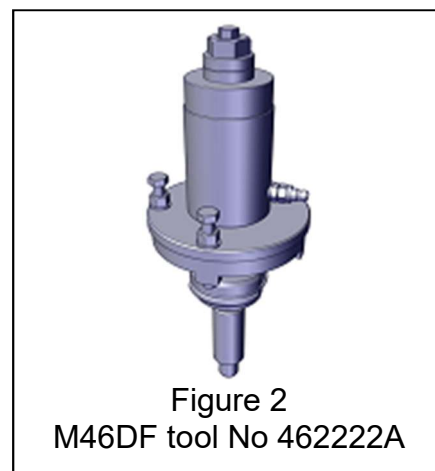
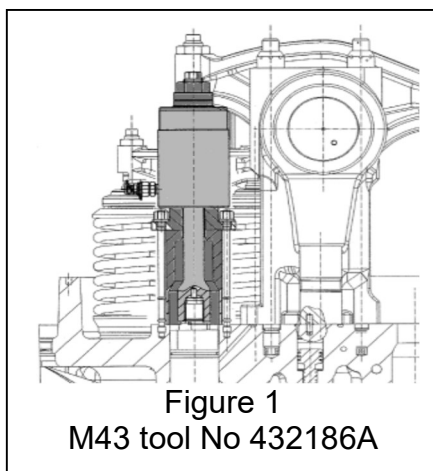
With the new cleaning tool, it is possible to smoothen the nozzle sleeve sealing surface to give it a nice fit again. Small damages and dents can be removed. The tool is delivered with emery cloth of three different grain sizes. The usage of the new tool is explained in the new job card in detail.

## Injector removal tool:

To fit the current as well as the future longer tension bolts, a new manual injector removal tool will be designed and introduced in near future. A new issue of this Service Information will be published when the new tool is available.

Note:

- The current injector removal tool will not fit the future injector assembly.
- A hydraulic injector removal tool is available as an option (no series standard; figure 1+2)



## Parts availability schedule:

Nozzle sleeve	series standard	available
Tension bolt long	future standard	spring 2020
Tension sleeve	future standard	spring 2020
Cleaning tool	future standard	available for M43C, M46DF; M43 spring 2020
Injector removal tool	future standard	spring 2020

The parts scheduled for spring 2020 are in purchasing process. When all new parts are available, we will publish a new issue of this Service Information.

**Further information:**

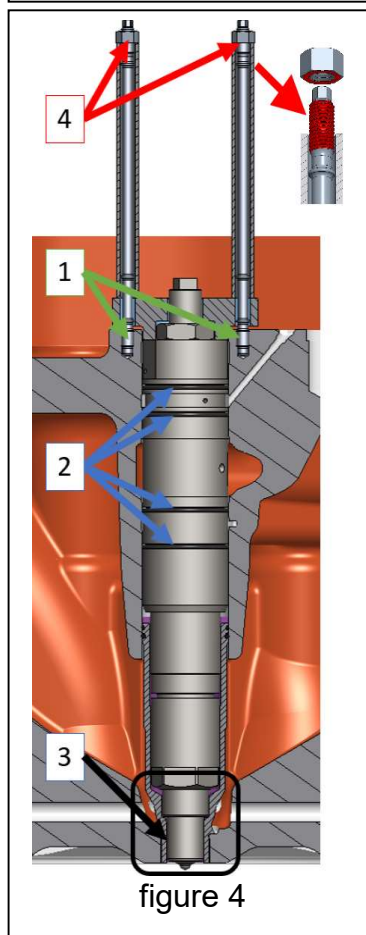
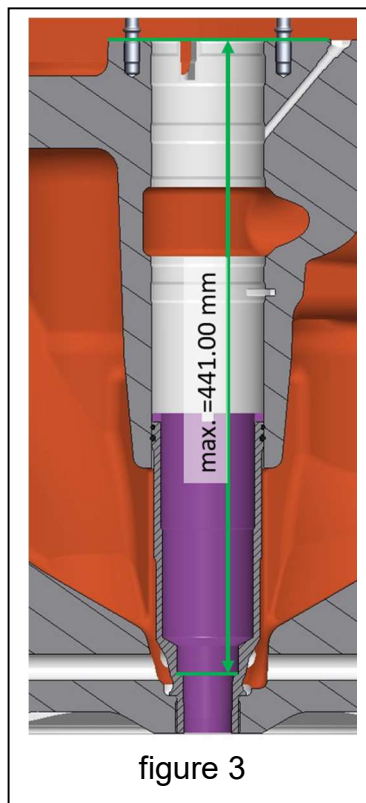
- Wear and tear limit

Because of the somewhat abrasive cleaning procedure a wear limit of the new nozzle sleeve sealing surface is introduced. The distance between nozzle sleeve sealing surface and the top plate of the cylinder head has to be measured after rework. All dimensions greater than 441.00 mm (figure 3) will require an exchange of the nozzle sleeve.

- Correct lubrication during assembly (figure 4)
  - The tension bolts are installed with **lubricating oil** at the thread and applying a torque of **40 Nm** (figure 4 position 1, green arrows).
  - All injector O-rings are to be greased with Petrol Gel Amber (figure 4 position 2, blue arrows).
  - Do NOT apply high temperature paste or other assembly paste to the injector, especially not to the sealing surface of the injector / nozzle sleeve (figure 4 position 3, black arrows)! The sealing surface has to be dry.
  - The application of **Molykote G Rapid plus** to all threads of the injector tension bolts, tension sleeve contact surfaces and nuts is required (figure 4 position 4, red arrows). Applying a torque of **70 Nm in three steps (20Nm – 45Nm – 70Nm)** is required.

**Recommendation:**

For the time being we recommend installing new series design nozzle sleeves at the next cylinder head overhaul, using the tightening torque (depending on the parts variant at site) and following the lubrication procedures as stated.



See also: A5.05.07.05.01.nn, A5.05.07.08.01.nn

Spare parts sheets:

**Personnel requirement:** 1 pers.

**Personnel qualification:** Skilled engine hand

**Operating medium:** Every fuel

### Activities:

1. Fuel injector - removal
2. Fuel injector - installation

Engine type	Tools and auxiliary materials	Pos.	Tool No.	
M 43 C	Fuel injector removal device	W1	439111 A	
VM 43 C	Seat cleaner for nozzle sleeve	W2	432120 B	
M 46 DF	Torque wrench 20-200 Nm	W3	1.9454-202	*
	Molykote paste "G-Rapid Plus"		1.9493-001	*/**
VM 46 DF	Petro Gel Amber		461114-041	*/**
* no picture				
** or equivalent product				

### NOTE

When the engine is operated on heavy fuel, it is necessary, prior to carrying out any work on the injection system, to run the engine on distillate fuel until there is only distillate fuel in the injection system, but at least for 0.5 hours.

## 1. Fuel injector - removal

- 1.1 Secure the engine to prevent unintentional starting.  
Secure the components that have been shut down against being switched on inadvertently.

### Conventional diesel engine:

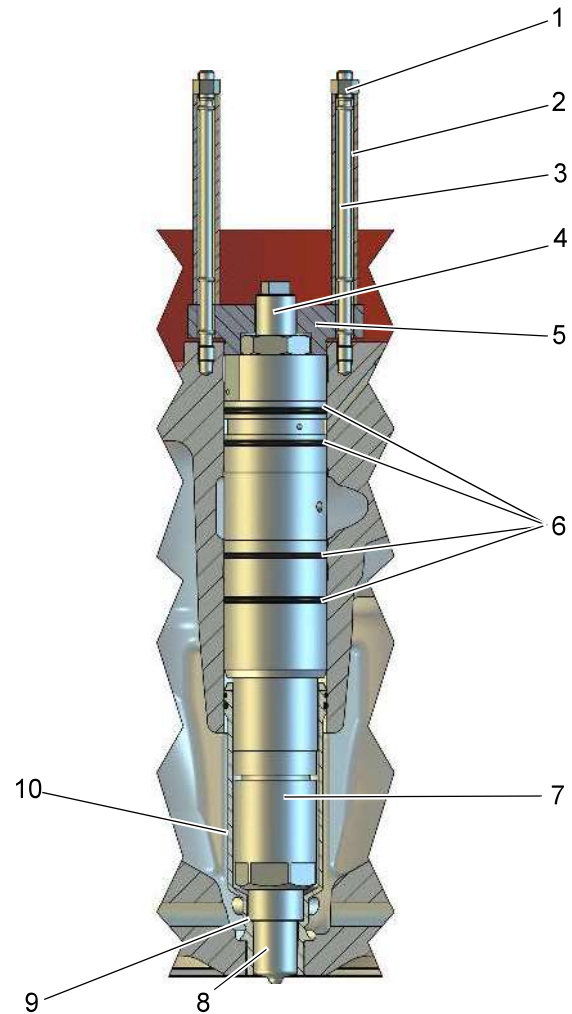
- Interrupt the starting air supply.
- Switch off and block the fuel supply to the engine.
- Switch off the cooling water preheating.
- Switch off the lubricating oil stand-by pump / prelubrication pump.
- Throw and secure the emergency stop lever (if provided).
- Set the selector switch at the control stand to "Repair".



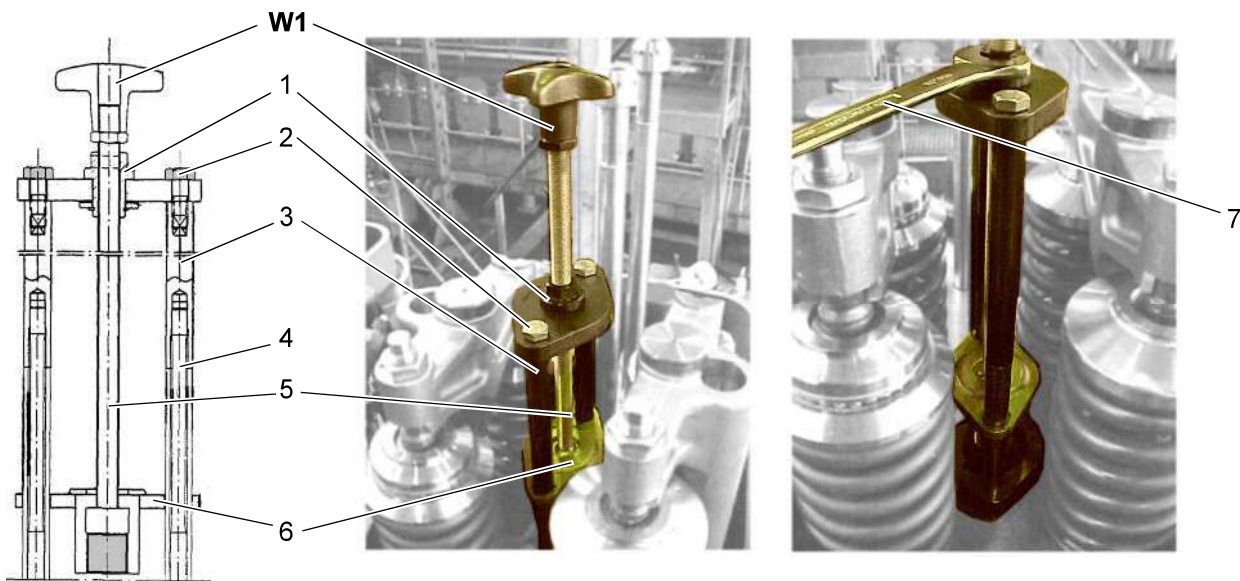
**Dual fuel engine:**

- Interrupt the starting air supply.
- Switch off and block the fuel supply to the engine.
- Interrupt the cooling water preheating.
- Switch off the lubricating oil stand-by pump / prelubrication pump.
- Set the selector switch at the control stand to "Repair".

- 1.2 Remove the valve cover and the pump chamber covering of the cylinder head concerned.
- 1.3 Remove the fuel injector delivery pipe (A5.05.07.05.01.nn).
- 1.4 Dismount the hexagon nuts (1/1), remove the extension sleeves (1/2) and the flange (1/5).
- 1.5 Install the extension sleeves again.
- 1.6 Firmly install the fuel injector removal device (2/W1) on the adjusting screw (1/4) of the fuel injector (1/7):
  - 1.6.1 Put in place the removal device as a complete unit.
  - 1.6.2 Slightly loosen the hexagon head bolts (2/2) and firmly install the threaded pieces (2/3) on the studs (2/4) until reaching the end stop.



1 Schematic diagram



2 Schematic diagram

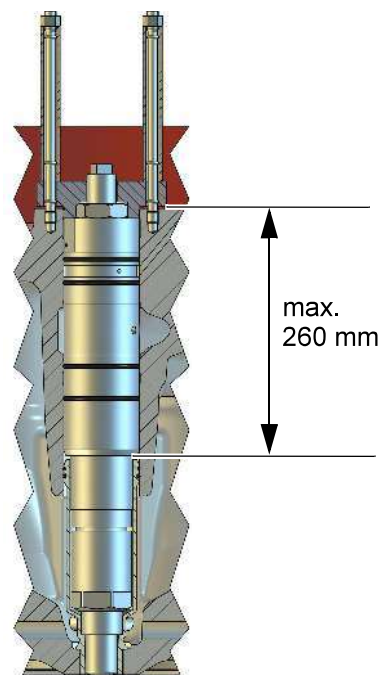


- 1.7 Firmly tighten the hexagon head bolts (2/2).
- 1.8 Firmly mount the threaded rod (2/5) at the star knob onto the adjusting screw (2/4).
- 1.8.1 Place the anti-twist device (2/6) over the hexagon of the threaded rod.

	<b>CAUTION</b>
	<b>Risk of damage due to sticking fuel injectors!</b> <ul style="list-style-type: none"><li>• Do not use any undue force!</li><li>• If the fuel injector cannot be extracted, please contact your <b>authorized Caterpillar dealer</b> and / or install the spare cylinder head.</li></ul>

- 1.9 Loosen the fuel injector by turning the threaded sleeve (2/1) with a wrench (2/7) and unscrew it until the bottom O-ring (1/6) is exposed.
- 1.10 Remove the hexagon head bolts (2/2).
- 1.11 Extract the fuel injector by means of the removal device.
- 1.12 Unscrew the threaded sleeve (2/1) from the fuel injector, remove the threaded pieces (2/3) and reassemble the removal device (V1).
- 1.13 Remove the extension sleeves (1/2).
- 1.14 Clean the fuel injector on the outside, mark it with the cylinder number and check correct functioning of the injection nozzle (A5.05.07.08.01.nn).

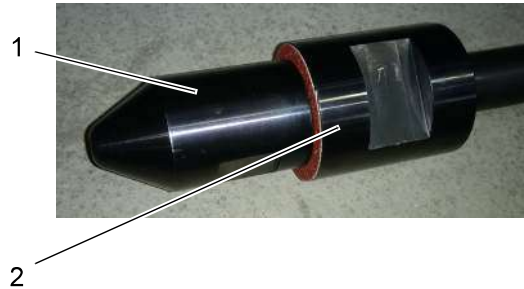
	<b>NOTE</b>
	Exhaust gas deposits in the area of the nozzle nut indicate a failure of the nozzle sleeve/ nozzle element sealing structure (1/8). In case of a damaged sealing structure, ignition pressure may reach the clearance between nozzle sleeve and fuel injector and cause deformation to the nozzle sleeve. Such deformation can be determined indirectly by measuring the distance between top edge of the cylinder head and top edge of the nozzle sleeve.



**3** Schematic diagram

- 1.15 Check the nozzle sleeve (1/10) for exhaust gas deposits. Determine the dimension between top edge of cylinder head and top edge of nozzle sleeve (**Fig. 3**). Dimensions in excess of 260.0 mm are impermissible and require a replacement of the nozzle sleeve.

- 1.16 Remove any contamination of the nozzle seat at the fuel injector (1/9) with a rag. It is not allowable to use a wire brush.  
Clean the nozzle seat in the nozzle sleeve (1/10) with the seat cleaner (W2).  
Visually inspect the nozzle seat with warm (yellowish) and cold (bluish) light.
- 1.17 If no damage is visible at the nozzle seat after cleaning, proceed with step 1.19.



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Schematic diagram

- 1.18 If any contamination or mechanical damage is visible at the nozzle seat after cleaning, refinish the nozzle seat:
- 1.18.1 Place 80 grade abrasive paper onto the abrasive paper support of the seat cleaner (W2) and fasten the abrasive paper support (4/2) to the guide mandrel (4/1) (mind the left-hand thread).

	<b>CAUTION</b>
	<p><b>Risk of damage to the engine!</b></p> <p>If the components are not fastened to each other properly, they may loosen while cleaning the seat and fall into the combustion chamber.</p>

- 1.18.2 Push the guide bush of the seat cleaner (W2) up to the top edge of the abrasive paper support and after that insert it into the fuel injector receiving hole. Slowly lower the seat cleaner down to the nozzle seat.
- 1.18.3 Actuate the crank handle for approximately 60 seconds and refinish the nozzle seat.

	<b>CAUTION</b>
	<p><b>Risk of damage to the nozzle seat due to improper handling!</b></p> <ul style="list-style-type: none"> <li>• During refinishing make sure to maintain an even contact pressure.</li> </ul>

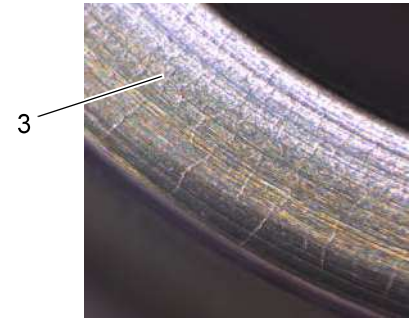
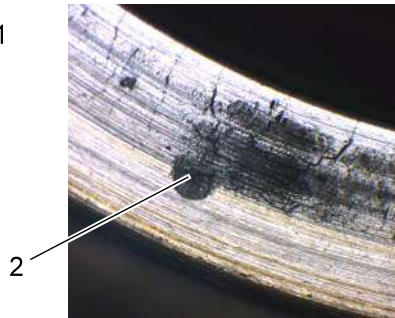
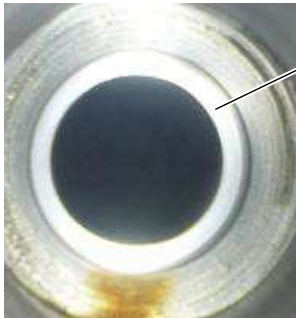
- 1.18.4 Remove the seat cleaner (W2) from the cylinder head. Use a lint-free rag to free the nozzle seat of any chips created during this procedure and visually inspect with warm (yellowish) and cold (bluish) light.  
After a successful refinishing procedure the complete seat surface should present a metallic shine (5/1).

If there is still any mechanical damage (dents) visible on the sealing surface, repeat steps 1.18.2 to 1.18.3.



## NOTE

Dark spots (5/2) are indicative of deeper, thermal damage to the nozzle sleeve. In case of thermal damage (5/3), destruction of the entire seat area cannot be excluded. If dark spots or bigger damage can still be seen on the nozzle seat after several refinishing operations, the nozzle sleeve must be replaced.



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Schematic diagram

1.18.5 Change the seat cleaner (W2) over to 120 grade abrasive paper and refinish the sealing surface for approximately 60 seconds. Use a lint-free rag to remove any chips.

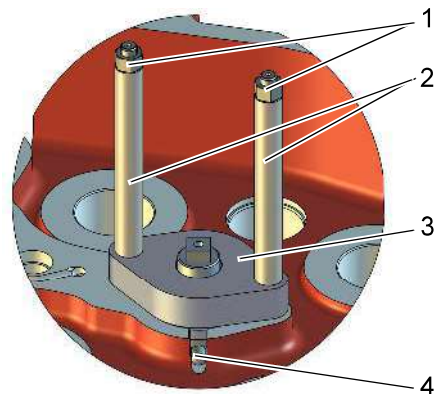
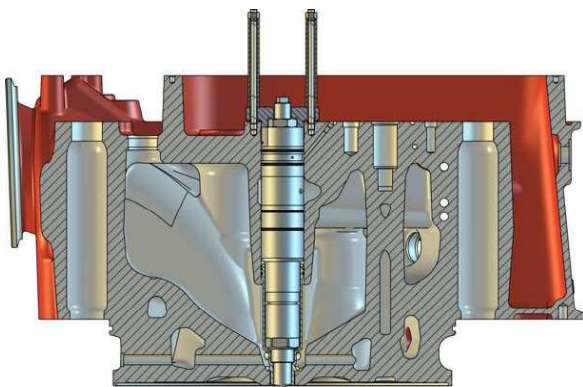
1.19 Change the seat cleaner (W2) over to 240 grade abrasive paper and refinish the sealing surface for approximately 60 seconds. Continually reduce the contact pressure during this time. Use a lint-free rag to remove any chips.

## 2. Fuel injector - installation

2.1 Apply a thin coat of Molykote paste to the thread of the studs (1/3) and the contact surface of the nuts (6/1). Apply a thin coat of Petro Gel Amber to the O-rings.

2.2 **Insert new** O-rings (1/6) untwisted into the O-ring grooves.

2.3 Insert the fuel injector into the nozzle sleeve paying attention to the position of the locating pin (6/4).



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Schematic diagram

- 2.4 Put on the flange (6/3) with the recess pointing downwards.
- 2.5 Install the extension sleeves (6/2).
- 2.6 Tighten the hexagon nuts (6/1) evenly by hand and loosen them again. This is to ensure that the injection nozzle is really at its end position but can still slightly move and align when the delivery pipe is installed.
- 2.7 Install the fuel injector delivery pipe (A5.05.07.05.01.nn).
- 2.8 **Tighten the hexagon nuts (6/1) of the studs as follows:**

	<b>NOTE</b>
<p>Different studs are being used! Check which type of stud is used in your engine. The tightening torque depends on the type of stud.</p>	

- 2.8.1 **Studs without marking:**  
Tighten the hexagon nuts alternately and evenly with a torque of **60 Nm** in three steps:
 

Step 1	20 Nm
Step 2	40 Nm
Step 3	60 Nm.

- 2.8.2 **Studs with star-shaped marking on the head (Fig. 7):**  
Tighten the hexagon nuts alternately and evenly with a torque of **70 Nm** in three steps:
 

Step 1	20 Nm
Step 2	45 Nm
Step 3	70 Nm.



Schematic diagram

- 2.9 Install the valve cover and the pump covering.
- 2.10 Lift the measures for securing the engine to prevent unintentional starting.

### Conventional diesel engine:

- Reestablish starting air supply.
- Set the emergency stop lever to operating position (if provided).
- Reestablish fuel supply to the engine.
- Switch on the cooling water preheating.
- Switch on the lubricating oil stand-by pump / prelubrication pump.
- Set the selector switch at the control stand to "Engine" or "Remote".

### Dual fuel engine:

- Reestablish starting air supply.
- Reestablish fuel supply to the engine.
- Switch on the cooling water preheating.
- Switch on the lubricating oil stand-by pump / prelubrication pump.
- Set the selector switch at the control stand to "Engine" or "Remote".