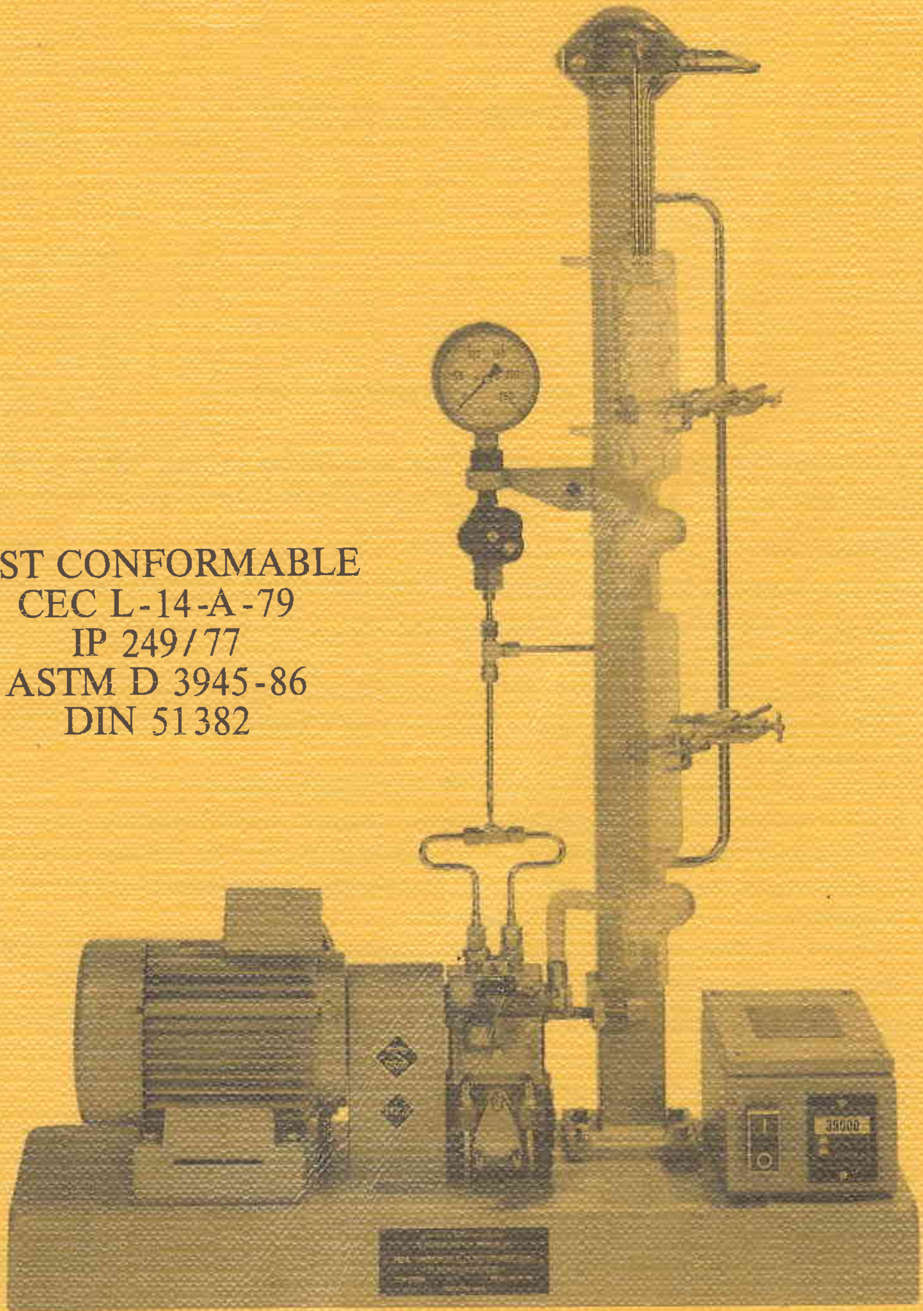
# APPARATUS FOR THE DEVELOPMENT OF PERFORMANCE TEST FOR LUBRICANTS AND ENGINE FUELS

TEST CONFORMABLE
CEC L-14-A-79
IP 249/77
ASTM D 3945-86
DIN 51382



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# Evaluation of the Mechanical Shear Stability of Lubricating Oils Containing Polymers

**APPROVED TEST METHOD**

**CEC CODIFICATION SYSTEM**

CEC STANDARD TEST METHODS are codified according to a system consisting of nine letters and digits arranged in five groups, the latter four being separated by a hyphen; thus:

(i) the CEC initials

(ii) a letter indicating the field of application or the nature of the standard test procedure, where:

- L indicates test procedures for LUBRICANTS (engine or transmission) using standard engines or test apparatus.
- F indicates test procedures for FUELS, using standard engines or test apparatus.
- A indicates the specification of any laboratory APPARATUS that the CEC has developed in relation to test procedures.
- M indicates METHODS, or CODES of PRACTICE, used for:
  —the evaluation of the performance of engines, transmissions or other mechanical components using reference fuels or lubricants under specified running conditions, *or*:
  —the evaluation of the condition of engines, transmissions, or other mechanical components after completion of a test, *or*:
  —the evaluation of fuels or lubricants using specified engines, transmissions, or other mechanical components when operated under specified running conditions.

(iii) two or three digits indicating the chronological order of the procedure in one of the above classes.

(iv) a capital letter indicating the status of the procedure, thus:

- X for EXPERIMENTAL procedures; these are undergoing correlation programmes.
- T for TENTATIVE procedures; correlation programmes on these have been completed.
- A for APPROVED procedures; the Tentative stage on these has been completed and final modifications have been made.

EXPERIMENTAL procedures are available only to CEC member organisations; all others are generally available.

(v) two figures indicating the year in which the procedure was agreed and accorded status by Council.

REFERENCE FUELS and REFERENCE LUBRICANTS for use in correlation programmes or test development are codified RF and RL respectively, followed by a number. Details of Reference and Standardisation Lubricants are to be found in the CEC Handbook of Reference/Standardisation Oils for Engine/Rig Tests.

## CONTENTS

## SAFETY

### General

It has been assumed by the compilers of this test method that anyone using the method will either be fully trained and familiar with all normal engineering and laboratory practice, or will be under the direct supervision of such a person.

It is the responsibility of the operator to ensure that all local legislative and statutory requirements are met.

The Co-ordinating European Council disclaims responsibility for any loss or damage arising from the use or abuse of this method of test.

### Specific Hazards

There are no particular hazards associated with this test apart from those normally associated with the operation of moving machinery and for which normal good engineering practice should be observed.

## INTRODUCTION

A variety of lubricating oils, in particular multi-grade engine oils, contain polymeric additives, which reduce the tendency of the oils to change viscosity as temperature changes.

The continuous shearing of a lubricating oil, e.g. in an engine, results in a reduced effectiveness of these polymeric additives. It therefore became necessary to investigate this performance aspect with a standard laboratory rig test. The test method presented herewith was primarily developed for the testing of polymer-containing engine oils. The temperature of 100°C, at which the percentage viscosity drop is observed in this test, was chosen for this type of lubricating oil on the basis of the viscosity classification for engine oils. For hydraulic oils a test temperature of 40°C was chosen.

The results according to this test method characterize the "shear stability" of the test oil, the "percent viscosity loss" being used as the criterion of stability.

As mentioned in paragraph 3 of this test method, the percent viscosity loss is inversely proportional to the shear stability, i.e. small numerical values for the percent viscosity loss mean a high shear stability. This definition may seem illogical in the first instance but it was deliberately adopted in this test method because it is used in methods and specifications already in use (e.g. ASTM-D-2603-70, IP294/73T and DIN-51382) and it seemed desirable to avoid the possibility of confusion.

The present test method is intended for the evaluation of the shear stability of finished oils only and not for the shear stability of polymers alone. The latter is defined as a "shear stability constant".

The method described has been given full approval by the Co-ordinating European Council, with the reference number CEC L-14-A-78.

Results obtained from tests according to the ASTM-D-2603-70 standard method of test for sonic shear stability of polymer-containing oils of the American Society for Testing and Materials (ASTM), Philadelphia Pa., USA, do not lend themselves for comparison with this standard method.

The test method will also be used for hydraulic fluids. In this case shear stability is of special concern for hydraulic fluids that show a high VI and are intended for use in hydraulic equipment in the open.

# Evaluation of the Mechanical Shear Stability of Lubricating Oils Containing Polymers

**CEC L-14-A-78**

## 1. SCOPE

This method is intended for the testing of lubricating oils containing polymers. Lubricating oils which may contain solid contaminants should not be introduced into the apparatus (e.g. used engine oils). Special precaution is needed, if hydraulic oils contain light volatile material.

## 2. PURPOSE OF TEST

This method provides a means for evaluating the shear stability of polymer containing oils. The shear stability estimated by this procedure permits conclusions to be drawn with respect to the permanent drop in viscosity to be expected in service.

## 3. DEFINITION

The shear stability according to this standard method is defined as the percent drop in viscosity computed from the following formula:

$$\text{Percent drop in viscosity} = \frac{\nu_0 - \nu_1}{\nu_0} \times 100 \times F \qquad (1)$$

where: $\nu_0$ = kinematic viscosity of the unsheared oil
$\nu_1$ = kinematic viscosity of the sheared oil
F = correction factor (for calculation see section 10)

Note: A small numerical value indicates a high shear stability.

## 4. UNITS

% for percent viscosity drop.
cSt for kinematic viscosity.
The SI-unit for the kinematic viscosity is $m^2/s$.
1 $mm^2/s$ = $1 \times 10^{-6} m^2/s$ = 1 centistoke = 1 cSt.

## 5. OUTLINE OF METHOD

A sample volume of 170 $cm^3$ is subjected to a specified number of cycles in the apparatus, the principal components of which are a two-cylinder fuel injection pump and an injection nozzle set to 175 bar.*

The kinematic viscosity of the untreated sample and also of the sheared sample is measured according to DIN 51562 or ASTM D-445.

For engine oils containing polymers, the number of cycles is 30; the kinematic viscosity is measured at 100°C.

For hydraulic oils containing polymers, the number of cycles is 250; the kinematic viscosity is measured at 40°C.

* 1 bar = 1.0197at.

## 6. PREPARATION

### 6.1 *Determination of the system dead volume*

Before the apparatus is brought into service, the "dead volume" must be determined. This is the internal volume of the external system (including the injector pump) between the three way cock (item 8 in Fig. 1 of the appendix) below the fluid reservoir and the injector nozzle (item 1). This volume should be between 15 and 25 cm3 and may be obtained by several approaches; e.g.

- pumping around the system one oil with an entrained column of another oil; the oils differing widely from each other in colour and viscosity.
- actual measurement of the internal volumes of the dismantled components comprising the "dead volume".
- requesting a precise determination of the "dead volume" by the equipment manufacturer before accepting the apparatus.

### 6.2 *Preparation of apparatus*

Before putting the apparatus into operation, the glass container with cooling jacket (5) is connected to the water cooling supply.

The level of the pump oil is to be checked.

For satisfactory reproducibility, it is essential that every test is begun with a warm injection pump and that the oil under test is at room temperature. This can be achieved if, before the actual measurement, the apparatus is operated for at least 30 minutes under the test conditions. Part of the sample used for checking the flow rate (see paragraph 6.3) can be used for this.

The cooling should be adjusted so that during the warming-up period a steady temperature of 30-35°C at the control point (Fig. 1) is obtained.

Ensure that ambient (room) temperature is 20-25 deg. C.

### 6.3 *Cleaning of the apparatus*

The apparatus is first drained of the previous test oil by operating it for a brief period.

Then three cleaning runs with the oil to be tested follow. The first two cleaning runs are carried out with at least 50 $cm^3$ of oil and the third cleaning run with a minimum of 170$cm^3$.

Care must be taken that during the cleaning runs 1 and 2 the lower outflow from the atomisation chamber is open.

In the third cleaning run, and for all test runs, the draining cock should be closed so that the spray-off takes place into the chamber filled with oil. In this way foaming of the oil is prevented.

### 6.4 *Setting the flow rate*

For the third cleaning run the flow rate should be set to 170 $\pm$ 5 $cm^3$/min, using the pump adjustment screw (12). This setting is carried out after the oil has circulated for 3 min in the apparatus. In this way it is ensured that after the flow has been adjusted up to the test conditions, and the apparatus is free from air. It may be necessary to loosen the ventilating screw (14) to release air from the pump. As soon as liquid runs off continuously, the screw (14) is shut off.

After the flow rate has been set to 170 $\pm$ 5 $cm^3$/min, the number of impulses, $n$, that has been recorded on the stroke counter for 1 minute's pumping is noted. The oil is drained from the container (7) via the three-way cock (8), so that the dead space of the apparatus remains filled with oil.

### 6.5 *Checking the apparatus*

The apparatus should be checked with the calibration oil after 750 cycles or after 3 months, whichever occurs first.

With the use of the calibration oil, the kinematic viscosity loss at 100°C after 30 cycles should be between 2.50 and 3.10 $mm^2$/s. If greater deviations occur, a fresh setting of the apparatus, perhaps by the exchange of components, such as nozzle, filter cartridge, pump or parts of the pump, will be necessary.

Results obtained with an apparatus not set according to specification should be rejected.

With a new nozzle the apparatus must be checked after the four-hour running-in period (see Appendix).

With a new nozzle a greater change in severity might be encountered. In this case a more frequent check with the reference oil might for a time be necessary.

Results that have been obtained with a non-standard apparatus must be rejected.

## 7. PROCEDURE

Two measurements must be made on each sample.

### 7.1 *Shearing of the specimen*

The shear test is carried out with 170cm$^3$ in total (this includes filling volume and dead volume) of the oil to be investigated. For this, 200cm$^3$ of the oil to be tested are put into the glass container (7) of the apparatus prepared according to paragraph 8. Approximately 50cm$^3$ of oil are supplied through the pump (11) in order to displace the oil present in the apparatus which is removed by suitably setting the upper three-way cock (6) on the glass container (5), and discarded.

Upon the attainment of the graduation required for the desired oil volume (glass container, 7), the pump is stopped.

The automatic stroke counter is set at the number of passes chosen for the product tested (i.e. cycles $\times$ $n$ impulses).

Both glass cocks (6, 8) are then opened and the oil continuously circulated until the automatic cut-off functions, or to the calculated time.

A steady temperature of 30-35°C at the control point (Fig. 1) should be reached not later than 10 cycles.

For engine oils containing polymers the number of cycles is 30.

For hydraulic oils containing polymers the number of cycles is 250.

7.2 *Viscosity measurement*

The kinematic viscosities of the unused oil sample, and of the oil after test, are determined according to DIN 51562 or ASTM D-445. These are determined at 100°C for engine oils and at 40°C for hydraulic oils. To achieve a satisfactory precision it is recommended that the same capillary be used for the viscosity measurement of the oil before and after the shear test.

The viscosity of hydraulic oils, if required, may also be measured at 100°C.

## 8. EVALUATION

The viscosity loss is expressed as a percentage according to the equation in paragraph 3. To improve the precision of the method for engine oil testing, the individual severity of the test apparatus has to be taken into account. This is done by adopting formula 2:

$$F = \frac{\nu_2}{\nu_3} \qquad (2)$$

where: F = correction factor

$\nu_2$ = nominal viscosity loss with RL 34 ($2.80 mm^2/s$ at 100°C after 30 cycles).

$\nu_3$ = viscosity loss with RL 34 as actually determined with the apparatus (30 cycles).

This factor (F) must be between the limits of 0.90 and 1.12 (see section 8.4), otherwise the test rig must be adjusted.

The applicability of this factor to hydraulic oil testing has not been examined.

## 9. REPORTING

Results should be reported as:

a) No. of cycles
b) kinematic viscosity of the unsheared oil
c) temperature at which the viscosities were measured
d) factor F
e) corrected average value of the percent viscosity loss in two tests (rounded to the nearest 0.5%).

Example for reporting the result for a polymer-containing lubricating oil with a viscosity loss of 10.5% and a kinematic viscosity of $15.3 mm^2/s$ prior to shearing, including viscosity loss of $2.70 mm^2/s$ as measured for the calibration oil. (RL34):

| | | | |
|---|---|---|---|
| Test Oil | | : | — |
| Test | | : | CEC L-14-A-78 |
| No. of Cycles | | : | 30 |
| Kin. visc. of unsheared oil | $mm^2/s$ | : | 15.3 |
| Temperature at which viscosities measured | °C | : | 100 |
| F | | | |
| Average viscosity loss (corrected) | % | : | 11 |

## 10. PRECISION (acc. to DIN 51 848, p. 3 or ASTM Book 1968 — part 18, app. II)

Reference should be made to the following criteria for estimating the reliability of the results.

*Repeatability*

(same operator, same apparatus)

Duplicate results by the same operator should be regarded as satisfactory if they do not deviate from one another by more than the corresponding values quoted in the following table.

*Reproducibility*

(different operators, different apparatus)

Results obtained by each of two different laboratories should be regarded as satisfactory if they do not deviate from one another by more than the corresponding values quoted in the following table:

| Percent Viscosity Loss | Repeatability (%) | Reproducibility (%) |
|---|---|---|
| Engine Oils | 1.5 | 4.5 |
| Hydraulic Oils | 2.0 | 3.5 |

# APPENDIX

1. Spray nozzle.
2. Atomisation chamber.
3. Outlet of the atomisation chamber.
4. Distributor plate.
5. Glass container with cooling jacket.
6. Three-way cock downstream of cooler.
7. Glass container.
8. Three-way cock downstream of glass container
9. Support column.
10. Connection with pump-suction opening.
11. Double-plunger injection pump.
12. Pump setting screw.
13. Electric motor.
14. Venting screw/pump.
15. Stroke counter.
16. Pressure tubing from pump to injector.
17. Return line for overflowing liquid.
18. Manometer
19. Filter cartridge
20. Nozzle holder

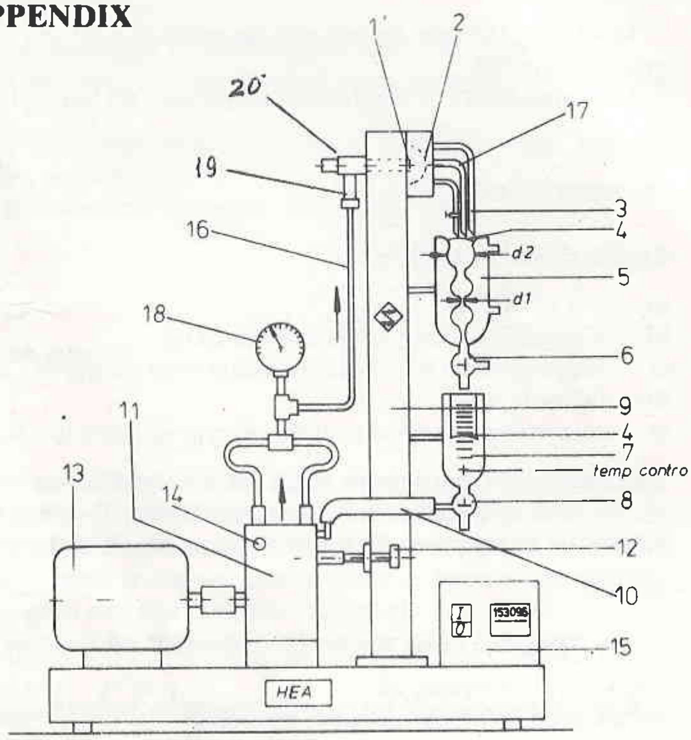
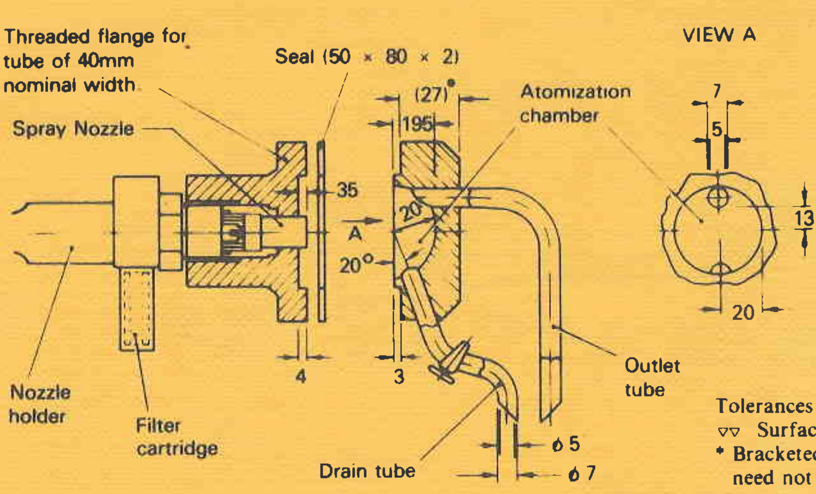



**FIGURE 1 APPARATUS FOR SHEAR STABILITY TESTING.**

## List of special spare parts to this Shear Testing Apparatus

Diesel injection fuel pump
Nozzle holder KD 43
Spray nozzle DN 8 S2, calibrated
Filter cartridge
Glass container with cooling jacket
Glass container with graduation 250 ml
Digital stroke counting compl.
Digital counter only
Readswich for counter
Atomization chamber
Distributor plate with books
Distributor plate only
Thermometer 100°C with hull
Manometer 0-250 bar
Cog belt
Digital Thermometer with feeler compl.
Pressure tubing from pump to atom. chamber
Contactor
Nozzles test apparatus
Calibration Oil RL 34, 1 liter
Cabinet for sound absorbing,
sound softer than 78%



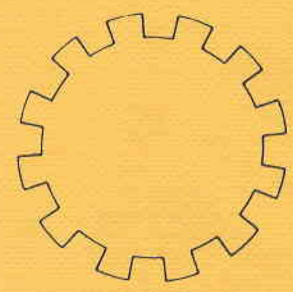



**FIGURE 3** - DISTRIBUTOR PLATE

Tolerances see DIN 7168, page 1

▽▽ Surface sequence 1 DIN 3141

* Bracketed measure (27) referring to model shown need not be observed.

**FIGURE 2** - ATOMISATION CHAMBER WITH SPRAY NOZZLE AND NOZZLE HOLDER

The dimensions shown in Fig. 2 for the atomisation chamber (2) should be observed.

A Bosch DN 8 S2-type pintle nozzle injector should be used as spray nozzle (1) and a Bosch KD 43 SA 53/13 with filter cartridge as nozzle holder. The injector opening pressure is to be set at 175 bar under static conditions with diesel fuel, using a nozzle tester. After pressure testing the nozzle should be cleared of all diesel fuel.

With a brand-new nozzle the pressure setting should be followed by a 4-hr. running-in period with the calibration oil.

The two glass containers (5 and 7), approx. 250 cm$^3$, are open at the top and can be closed below with a three-way cock (6 and 8). These three-way cocks (6, 8) should be of the cone type with a non-exchangeable solid plug (cf. DIN 12 544), bore 8 mm nominal size. The rubber tubing (10) connects the three-way cock (8) with the pump (11).

The glass container (5) is designed as a condenser, i.e. it has a jacket for circulating the cooling liquid. The inner glass wall is designed similarly to a spherical condenser. The diameter $d_1$ is approx. 50 mm, the diameter $d_2$ approx. 25 mm, the length, L, approx. 180 mm.

For distributing the test fluid, a distributor plate (4) should be fitted on the glass container (5) so that uniform run-down on the glass wall is ensured. A watch glass of approx. 40 mm diameter with serrated edge, allowing the oil to pass through (Fig. 3) may be used as a distributor plate. A protruding edge should be provided in the upper part of the glass container (5) to hold the distributor plate.

The glass container (7) has an inner diameter of approx. 45 mm and contains a similar distributor plate in order to prevent channelling in the liquid during the test. The glass container (7) is graduated in 25 cm$^3$ intervals. The temperature control point is placed immediately above the outlet of glass container (7) (cf. Fig. 1).

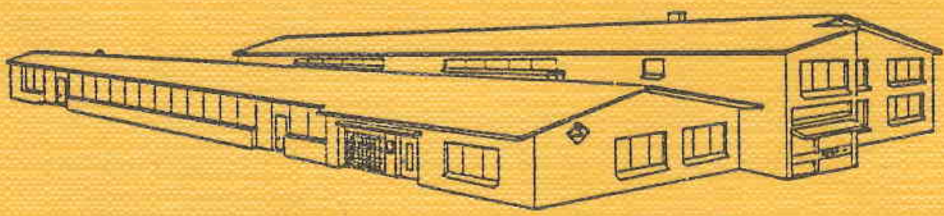
A double-plunger injection pump, type Bosch PE 2 A 90 D 300/3 S 2266 is used for pressure build-up.

The electric motor (13) is a three-phase AC motor with 1.1 kW output and 925 $\pm$ 25 rpm.

The stroke counter (15) for counting the pump strokes is fitted with an automatic cut-off

The dead space for oil between the three-way cock (8) and the outlet of the nozzle (1) must be 20 $\pm$ 5 cm$^3$.

An oil pressure gauge may be connected to the pressure line (16).



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