Designation: D7043 – 17

# Standard Test Method for Indicating Wear Characteristics of Non-Petroleum and Petroleum Hydraulic Fluids in a Constant Volume Vane Pump[1]

This standard is issued under the fixed designation D7043; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope*

1.1 This test method covers a constant volume vane pump test procedure operated at 1200 r/min and 13.8 MPa.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.2.1 *Exception*—There are no SI equivalents for the inch fasteners and inch O-rings that are used in the apparatus in this test method.

1.2.2 *Exception*—In some cases English pressure values are given in parentheses as a safety measure.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2882 Test Method for Indicating Wear Characteristics of Petroleum and Non-Petroleum Hydraulic Fluids in Constant Volume Vane Pump (Withdrawn 2003)[3]

D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products and Lubricants

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *flushing, v*—process of cleaning the test system before testing to prevent cross-contamination.

3.1.2 *torquing, v*—process of tightening the pump head bolts to achieve a uniform clamping force.

## 4. Summary of Test Method

4.1 An amount of 18.9 L ± 0.5 L of a hydraulic fluid are circulated through a rotary vane pump system for 100 h at a pump speed of 1200 r/min ± 60 r/min and a pump outlet pressure of 13.8 MPa ± 0.3 MPa (2000 psi ± 40 psi). Fluid temperature at the pump inlet is 66 °C ± 3 °C for all water glycols, emulsions, and other water containing fluids and for petroleum and synthetic fluids of ISO Grade 46 or lighter. A temperature of 80 °C ± 3 °C is used for all other synthetic and petroleum fluids.

4.2 The result obtained is the total mass loss from the cam ring and the twelve vanes during the test. Other reported values are initial flow rate and final flow rate.

4.3 The total quantity of test oil required for a run is 26.5 L.

## 5. Significance and Use

5.1 This test method is an indicator of the wear characteristics of non-petroleum and petroleum hydraulic fluids operating in a constant volume vane pump. Excessive wear in vane pumps could lead to malfunction of hydraulic systems in critical applications.

## 6. Apparatus

6.1 The basic system consists of the following (see Fig. 1):

6.1.1 *AC Motor,* 1200 r/min, or other suitable drive, with 11 kW (15 hp) as suggested minimum power requirement

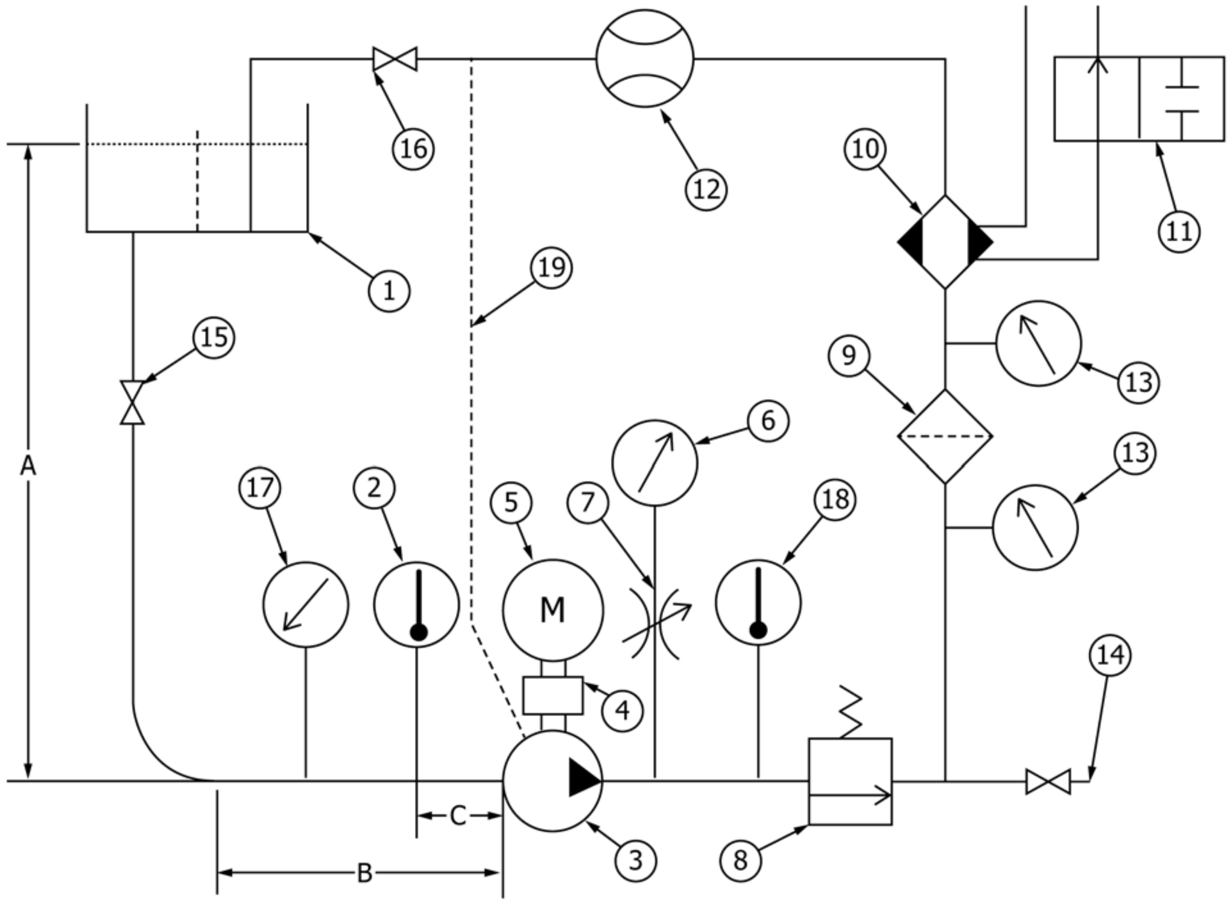
[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.N0 on Hydraulic Fluids.

Current edition approved July 1, 2017. Published July 2017. Originally approved in 2004. Last previous edition approved in 2012 as D7043 – 12. DOI: 10.1520/D7043-17.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

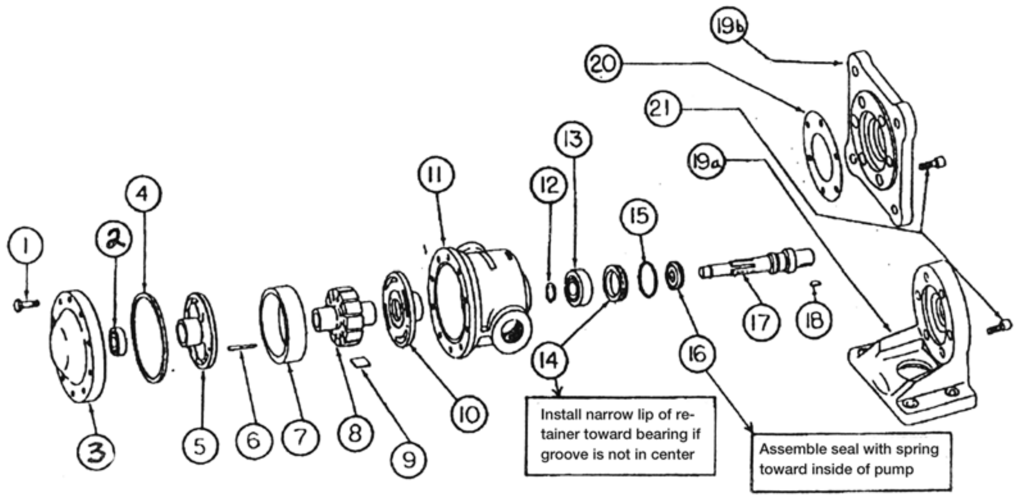
[3] The last approved version of this historical standard is referenced on www.astm.org.

*A Summary of Changes section appears at the end of this standard




| Item | Description | Required? |
|---|---|---|
| 1. | Reservoir | |
| 2. | Inlet temperature sensor | |
| 3. | Pump | |
| 4. | Flexible coupling | |
| 5. | Motor | |
| 6. | High pressure gauge | |
| 7. | Snubber valve | |
| 8. | Relief valve | |
| 9. | Filter | |
| 10. | Heat exchanger | |
| 11. | Temperature control valve | |
| 12. | Flow meter | |
| 13. | Low pressure gauge | |
| 14. | Fluid sampling port | |
| 15. | Pump inlet valve | Not required |
| 16. | Return line valve | Not required |
| 17. | Inlet vacuum gauge | Not required |
| 18. | Outlet temperature sensor | Not required |
| 19. | Case drain for B1 pump | |
| A. | 61 to 66 cm, vertical | Required |
| B. | 15.2 cm, minimum horizontal | Required |
| C. | 10.2 cm, maximum | Required |

**FIG. 1 System Schematic**




| Description of Items | | | |
|---|---|---|---|
| Item Number | Name | Amount | Description |
| 1 | Head Bolt | 8 | ⅜-16 × 1-¼-in. hex head cap screw, Grade 8 |
| 2 | Head Bearing | 1 | No. 6200, open type |
| 3 | Pump Head | 1 | Vickers 24064 |
| 4 | Head Packing[A] | 1 | –235 square cut O-ring |
| 5 | Outer Bushing | 1 | Conestoga 2882-4E |
| 6 | Alignment Pin | 1 | Conestoga 2882-10 |
| 7 | Cam Ring[B] | 1 | Conestoga 2882-5 |
| 8 | Rotor[B] | 1 | Conestoga 2882-1C |
| 9 | Vane[B] | 12 | Conestoga 2882-V12 (12 piece kit) |
| 10 | Inner Bushing | 1 | Conestoga 2882-4C |
| 11 | Pump Body | 1 | Vickers 188235 |
| 12 | Retaining Ring | 1 | 20-mm steel retaining ring 3AM1–20 |
| 13 | Shaft Bearing | 1 | #6204, open type |
| 14 | Seal Retainer | 1 | Vickers 185078 |
| 15 | O-Ring[A] | 1 | –223 O-ring |
| 16 | Shaft Seal[A] | 1 | double lip with garter spring .875 × 1.500 × .312 rubber clad |
| 17 | Shaft | 1 | Conestoga 2882-2A |
| 18 | Key | 1 | Conestoga 2882-20A or Vickers 1612 |
| 19a | Foot Mount | 1 | Vickers 188234 |
| 19b | Flange Mount | 1 | Vickers 188233 |
| 20 | Gasket | 1 | Conestoga 2882-27 or Vickers 2546 not used with Foot Mount (item 19a) |
| 21 | Screw | 6 | ⅜-16 × ⅞ socket head cap screw |

[A] Specify compound.
[B] Specify size.

**FIG. 2 Pump Components**

(Item 5, Fig. 1). The motor must have right hand rotation (counterclockwise rotation as viewed from the shaft end).

6.1.2 *Test Stand Base,* with appropriate, rigid mounting for the motor, pump, reservoir, and other components.

6.1.3 *Rotary Vane Pump,* replaceable cartridge type. A Vickers[4] V104C or V105C or Conestoga USA B1 housing is used along with internal components from Conestoga USA, Inc.[5] The assembly should produce 28.4 L ⁄min flow at 1200 r ⁄min with ISO Grade 32 fluid at 49 °C, at 6.9 MPa (Item 3, Fig. 1; Fig. 2; Fig. 3). (**Warning—**Eaton-Vickers test pump is rated at 6.9 MPa (1000 psi) but is being operated at 13.8 MPa (2000 psi). A protective shield around the pump is recommended.)

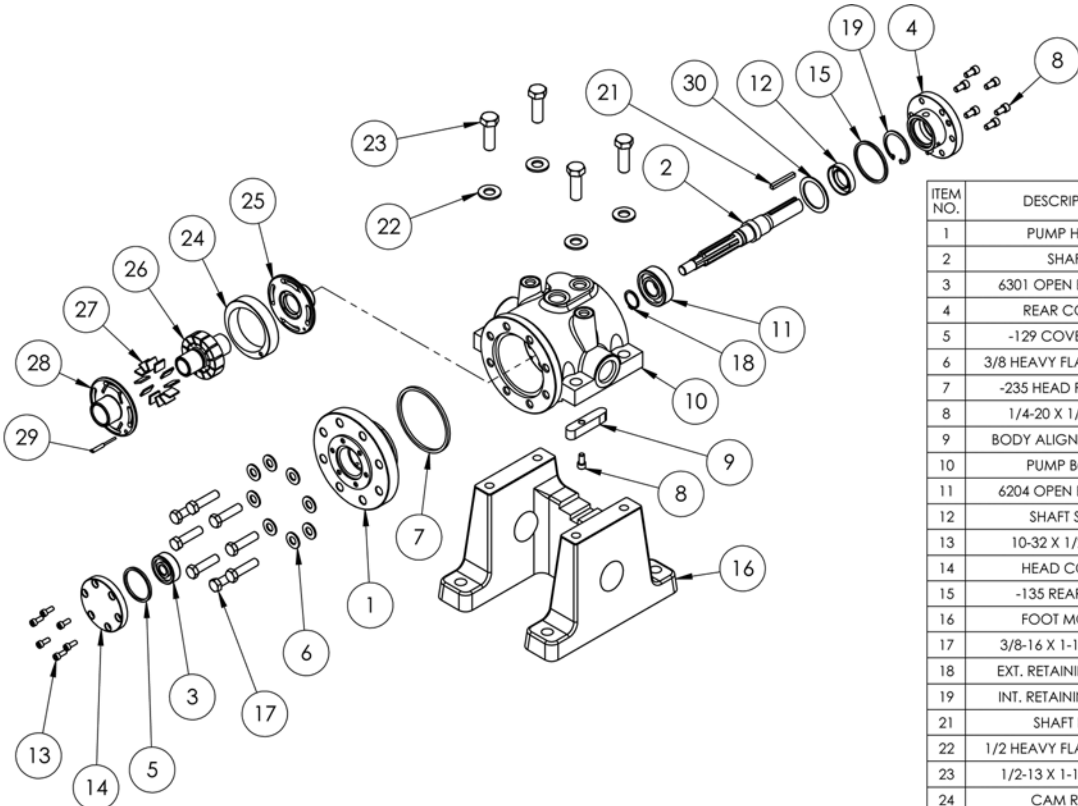
NOTE 1—This test method has been written for the use of Conestoga USA Inc. internals along with an Eaton-Vickers or Conestoga USA housing and head. If components from other manufacturers are used, refer to Test Method D2882 – 00 for preparation and selection guidelines.

6.1.3.1 The replaceable cartridge consists of the cam ring, the rotor, two bushings, a set of twelve vanes, and an alignment pin.

6.1.3.2 The individual cartridge parts are purchased separately. Conestoga USA, Inc. part numbers for these items are: cam ring No. 2882-5, alignment pin No. 2882-10, rotor No. 2882-1C, bronze bushings No. 2882-4C and 2882-4E, and vane kit (12 vanes) No. 2882-V12.

[4] Previously available, this apparatus was made obsolete in 2000 by Vickers, which is part of Eaton Hydraulics Group USA 14615 Lone Oak Road Eden Prairie, MN 55344. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[5] The sole source of supply of the apparatus known to the committee at this time is Conestoga USA Inc., P.O. Box 3052, Pottstown, PA 19464. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.




| ITEM NO. | DESCRIPTION | PART NO. | QTY. |
|---|---|---|---|
| 1 | PUMP HEAD | B1-7 | 1 |
| 2 | SHAFT | B1-2 | 1 |
| 3 | 6301 OPEN BEARING | B1-15 | 1 |
| 4 | REAR COVER | B1-9 | 1 |
| 5 | -129 COVER SEAL | B1-35 | 1 |
| 6 | 3/8 HEAVY FLAT WASHER | B1-42 | 8 |
| 7 | -235 HEAD PACKING | 2882-18 | 1 |
| 8 | 1/4-20 X 1/2 SHCS | B1-23 | 7 |
| 9 | BODY ALIGNMENT KEY | B1-6C | 1 |
| 10 | PUMP BODY | B1-6 | 1 |
| 11 | 6204 OPEN BEARING | B1-4 | 1 |
| 12 | SHAFT SEAL | 2882-16 | 1 |
| 13 | 10-32 X 1/2 SHCS | B1-22 | 6 |
| 14 | HEAD COVER | B1-8 | 1 |
| 15 | -135 REAR SEAL | B1-36 | 1 |
| 16 | FOOT MOUNT | B1-30 | 1 |
| 17 | 3/8-16 X 1-1/2 HHCS | B1-21 | 8 |
| 18 | EXT. RETAINING RING | 2882-24 | 1 |
| 19 | INT. RETAINING RING | B1-37 | 1 |
| 21 | SHAFT KEY | 2882-20A | 1 |
| 22 | 1/2 HEAVY FLAT WASHER | B1-30H | 4 |
| 23 | 1/2-13 X 1-1/2 HHCS | B1-30G | 4 |
| 24 | CAM RING | 2882-5 | 1 |
| 25 | INNER BUSHING | 2882-4C | 1 |
| 26 | ROTOR | 2882-1C | 1 |
| 27 | VANE | 2882-3 | 12 |
| 28 | OUTER BUSHING | 2882-4E | 1 |
| 29 | ALIGNMENT PIN | 2882-10 | 1 |
| 30 | W1819-020 WAVE SPRING | B1-25 | 1 |

**FIG. 3 Conestoga USA, Inc., B1 Pump Assembly**

6.1.3.3 There are to be no modifications to the pump housing such as plugging the drain hole in the pump body or drilling and tapping a hole in the head for an external drain.

6.1.4 *Reservoir,* (Item 1, Fig. 1).

6.1.4.1 The reservoir shall be equipped with a removable baffle and a close fitting lid, all of stainless steel construction. The reservoir can be square or rectangular (with a flat bottom) or cylindrical (with a spherical or cone shaped bottom) and must be designed so as to avoid air entrainment in the fluid.

NOTE 2—A suitable reservoir design is presented in Test Method D2882 – 00.

6.1.4.2 To promote deaeration and thermal mixing of the fluid, the baffle shall be designed so that returning fluid will follow an indirect path from the return port to the outlet port.

6.1.4.3 To avoid air entrainment, the reservoir shall be designed so that the return line enters well below the fluid level, fluid flow does not cascade over the baffle, and there will be a minimum of 15 cm of fluid depth above the pump inlet line.

6.1.4.4 Fluid ports may be added as required by the user for the installation of a low level switch, reservoir temperature sensor, bottom drain, and so forth.

6.1.4.5 If the reservoir is positioned so that the contents cannot be visually checked for aeration by removing the lid, a fluid-tight glass viewing port may be located in the side of the reservoir.

6.1.5 *Outlet Pressure Control Valve,* Eaton-Vickers pressure relief valve (CT-06-C/3.4 to 13.8 MPa) with either manual or remote control (Item 8, Fig. 1).[6]

6.1.6 *Temperature Control Device,* suitable for controlling coolant flow to the heat exchanger to maintain test fluid at the specified temperature (Item 11, Fig. 1).

6.1.7 *Temperature Indicator,* (Item 2, Fig. 1) shall have an accuracy of ±1 °C and shall have an appropriate sensor to monitor pump inlet temperature.

6.1.7.1 To prevent a flow restriction near the pump inlet port, the temperature probe shall have a diameter of not more than 6 mm.

6.1.7.2 The test fluid temperature shall be measured within 10.2 cm of the pump inlet (Dimension C, Fig. 1). The sensing probe shall be inserted into the midpoint of flow.

[6] Request Vickers publication I-3369-S for the relief valve service data. See http://hydraulics.eaton.com/products/vickers.html.

NOTE 3—Some users have found the addition of a pump outlet temperature sensor to be a useful diagnostic tool. If used, it shall be suitable for 13.8 MPa duty and should be placed in the high pressure line between the pump and the relief valve (Item 18, Fig. 1).

6.1.8 *Heat Exchanger,* (Item 10, Fig. 1). The heat exchanger should be of adequate size and design to remove the excess heat from the test system when using the available coolant supply.

NOTE 4—It is suggested that a shell-and-tube-type heat exchanger, if used, should be connected in reverse (the hydraulic fluid is passed through the tubes and not around them) so that the interior of the heat exchanger can be effectively cleaned between tests.

6.1.9 *Pressure Indicator,* (Item 6, Fig. 1) to measure pump discharge pressure shall have an accuracy of at least ±0.3 MPa at 13.8 MPa. The gauge shall be suitable for 13.8 MPa duty.

6.1.9.1 The pressure indicator should be snubbed (Item 7, Fig. 1) to prevent damage from pulsations or sudden fluctuations of system pressure.

6.1.10 *Filter Unit (Item 9, Fig. 1),* 3 µm (minimum Beta 3 ratio of 100) replaceable fiberglass element with housing. Two new filter elements are required for each test.

6.1.10.1 The filter housing shall be non-bypassing and shall be provided with dual pressure gauges (Item 13, Fig. 1) or another suitable indicator to monitor pressure across the filter to warn of impending collapse of the element.

6.1.10.2 If dual pressure gauges are used to monitor filter pressure, the rated collapse pressure of the filter element should be known. The collapse pressure should be within the range of the gage.

6.1.11 *Flow Measuring Device,* (Item 12, Fig. 1) with an accuracy of at least ±0.4 L/min.

6.1.12 While not required, it is suggested that low-level, high-pressure, high-temperature, and low-flow safety switches be incorporated into the system.

6.1.13 A check should be made to ensure that the flush and test fluid are not incompatible with hoses, seals, or any other materials in the system.

NOTE 5—The use of galvanized iron, aluminum, zinc, and cadmium should be avoided because of their high potential for corrosion in the presence of many non-petroleum hydraulic fluids.

6.1.14 *Flexible Motor Coupling,* (Item 4, Fig. 1).

6.2 The various components of the test system shall be placed in the system as indicated in Fig. 1.

6.2.1 The test system shall be arranged and provided with necessary drain valves so that complete draining is possible with no fluid trap areas.

6.2.2 Good hydraulics piping practices should be used when constructing the test system to avoid air ingestment points and flow restrictions.

6.2.3 The pump should be mounted so that its internal surfaces can easily be inspected and cleaned, alignment can be checked, and the operator has comfortable access when torquing the head.

6.2.4 The reservoir shall be located above the pump so that the fluid level in the reservoir will be between 61 cm and 66 cm above the center line of the pump when the test system is fully charged with 19 L of test fluid (Dimension A, Fig. 1).

6.2.4.1 The reservoir should be mounted so that it can be cleaned and filled with ease and the contents may be readily inspected by removal of the reservoir lid.

6.2.5 The inlet line (from the reservoir to the pump intake) shall have an internal diameter of at least 25 mm and shall have a straight horizontal run of at least 15 cm to where it connects to the pump inlet port (Dimension B, Fig. 1). If a hose is used, it shall be rated for vacuum service. The B1 pump uses dual inlet hoses with an internal diameter of 22 mm.

NOTE 6—Some users have found the addition of a compound pressure gage near the pump inlet port to be a useful diagnostic tool (Item 17, Fig. 1). However, exercise care to ensure that any ports added to the inlet line do not become air ingestment points.

NOTE 7—The use of a solenoid valve, finger screen or other device which restricts pump inlet flow is discouraged. Inlet restrictions adversely affect pump performance.

NOTE 8—When tubing is used for the pump inlet line, some users prefer to use a radius bend instead of an elbow near the pump inlet. If used, the straight run described in 6.2.5 shall be measured between the end of the bend and the pump inlet port. For optimal flow properties with 25 mm tubing, a 100 mm (4 in.) bend radius is recommended.

6.2.6 The high pressure discharge line (from the pump to the pressure control valve) shall be rated for 14 MPa (2000 psi) duty and have a minimum internal diameter of 15 mm. The B1 pump uses dual discharge hoses with an internal diameter of 10.4 mm.

6.2.7 The fluid return line and fittings (from the pressure control valve to the filter, flow counter, heat exchanger, and reservoir) shall be rated for 3 MPa duty and have a minimum internal diameter of 15 mm.

NOTE 9—Some users find the addition of a shut off valve on the return line (Item 16, Fig. 1) to be a useful addition to the piping since it allows filter changes and other system maintenance to be performed without draining the reservoir.

6.2.7.1 (**Warning—**If a shut-off valve is installed in the fluid return line, the user shall take procedural steps to ensure that this valve has been opened before the pump is started. If the valve is not opened, low-pressure system components will rupture, possibly endangering personnel.)

NOTE 10—Some users find the addition of a valve on the pump inlet line (Item 15, Fig. 1) to be a useful addition to the piping since it allows filter changes and other system maintenance to be performed without draining the reservoir. A full flow type of valve with an orifice of at least 25 mm (1 in.) is recommended.

6.2.7.2 (**Warning—**If a shut-off valve is installed in the pump inlet line, the user shall take procedural steps to ensure that this valve has been opened before the pump is started. If the valve is not opened, the pump will cavitate.)

6.2.8 The case drain hose for the B1 pump (Item 19, Fig. 1) shall be rated for 3 MPa duty and have a minimum internal diameter of 8 mm. The B1 case drain must connect to the return line so that the drain flow is unrestricted when the pump is in operation.

## 7. Reagents and Materials

7.1 **Warning—**Use adequate safety provisions with all solvents.

7.2 *Aliphatic Naphtha, Stoddard Solvent,* or equivalent is satisfactory. (**Warning—**Combustible. Vapor harmful.)

7.3 *Precipitation Naphtha* (**Warning—**Extremely flammable. Harmful if inhaled. Vapors can cause flash fire.)

7.4 *Isopropanol* (**Warning—**flammable.).

7.5 **Warning—**In instances when the solvents listed in Section 7 are not effective, alternative solvents may be used. It is the responsibility of the user to determine the suitability of alternative solvents and any hazards associated with their use.

## 8. Test Stand Maintenance

8.1 Sensors and shut-off switches should be checked periodically for proper calibration and operation in accordance with good engineering practice as determined by the user.

8.2 It is recommended that the pump shaft (Item 17, Fig. 2; Item 2, Fig. 3), seals (Items 4, 15, 16, Fig. 2; Items 5, 7, 12, 15, Fig. 3), and bearings (Items 2, 13, Fig. 2; Items 3, 11, Fig. 3) be replaced after every five runs (or sooner if high weight loss, vibration, cavitation, or visual deterioration is encountered).

8.2.1 A variety of seal compounds is available for the pump. It is the responsibility of the user to determine the best seal composition to use with any given fluid. If possible, check the cure date of the seal.

8.3 Inspect the pump body and head.

8.3.1 Visually examine the pump head and the interior of the pump body (Items 3 and 11, Fig. 2; Items 1, 10, Fig. 3). Replace if evidence of deterioration is observed.

8.3.2 When the pump has been disassembled for seal and bearing replacement, carefully inspect the faces of the pump body and head which seal against the bushing faces (Surfaces A and B, Fig. 4) for high spots, warped condition, or other damage which may interfere with a good fluid seal. Discard any unsuitable components.

8.3.3 Check that the Eaton-Vickers head bearing (Item 2, Fig. 2) is a press fit into the head. If it is loose, discard the head. The B1 head bearing (Item 3, Fig. 3) should be a close slip fit to the head.

8.3.4 Check that the shaft bearing (Item 13, Fig. 2; Item 11, Fig. 3) makes a close slip fit into the body. If it is loose, discard the body.

8.3.5 Check that the bore for the cartridge (Diameter E, Fig. 4) is not greater than 76.23 mm.

8.3.5.1 If the bore is oversized, the ring may crack when the pump is pressurized.

8.3.5.2 If the bore is oversized, a piece of 0.025 mm shim stock trimmed to 20 mm by 235 mm can be wrapped around the ring to pack out the excess clearance. Installation of the shim requires that the cartridge assembly be made in the pump housing and that the housing bore and ring outside diameter are clean and dry.

8.3.6 Check that the pump body ports align properly with the bushing ports, with no overlapping, which might restrict fluid flow.

NOTE 11—In some cases in which operational problems continue without apparent cause, a change of pump body or head, or both, has been known to alleviate the problem.

8.4 Inspect the shaft (Item 17, Fig. 2; Item 2, Fig. 3; Fig. 5).

8.4.1 Check that the splines of a new shaft are smoothly cut, have consistent width from the outer diameter to the root, and are parallel with the axis of the shaft. Avoid reusing shafts if the rotor has worn deep marks in the splines (Items 1, 2, 3, and 4, Fig. 5).

8.4.2 Check new shafts and used shafts that have been subjected to pump failure or overheating for bending, twisting, or damage to the key seat or splines (Items 5 and 7, Fig. 5).

8.4.3 Check the surface where the shaft seal rides for conditions that may cause the seal to leak (Item 6, Fig. 5).

8.5 Check alignment of the pump and motor shafts. Maximum values of 0.08-mm parallel misalignment and 0.3° angular misalignment are suggested limits.

8.5.1 Alignment checks should be made with a torqued cartridge in place.

8.5.2 Using a test indicator, inspect the shaft for a bent condition by rotating it by hand with the motor coupling removed (Item 7, Fig. 5).

8.5.3 Precision ground coupling halves that have identical outside diameters and run true to the shaft with which they are used (pump or motor) will permit the use of a straight edge and feeler gages to achieve close alignment of the pump and motor shafts.

8.6 Periodically clean the eight tapped holes that receive the pump head bolts and the threads of the head bolts themselves (Item 1, Fig. 2; Item 17, Fig. 3). The threads may be coated with a light oil to prevent corrosion. To ensure even torquing of the cartridge, housings or head bolts with damaged threads should be discarded.

8.7 Periodic disassembly of the relief valve (Item 8, Fig. 1) for cleaning and inspection is recommended.

## 9. Sampling

9.1 The sample of fluid shall be thoroughly representative of the material in question, and the portion used for the test shall be thoroughly representative of the sample itself.

## 10. Flushing

10.1 Proper cleaning and flushing of the entire system is extremely important to prevent cross-contamination of test fluids.

10.2 Flushing procedure for petroleum and synthetic fluids:

NOTE 12—This flushing sequence is not adequate when changing fluid types such as from glycol to phosphate ester, oil to glycol, and so forth (see 7.5).

10.2.1 Drain all old fluid from the system, remove used test cartridge (if present), remove, and discard old filter. Wipe out pump and filter housings and the reservoir and baffle.

10.2.2 Install a flush cartridge (any good, previously used cartridge) and a new filter.

10.2.3 Close all drain valves and torque the pump head. Open the pump inlet and return line valves if used (see Notes 9 and 10).

10.2.4 Charge the system with 7.6 L of flushing fluid. For petroleum and synthetic fluids use either Stoddard solvent (**Warning—**see 7.2) or base stock depending on the similarity of the old and new test fluids.

NOTE 13—One flush of this petroleum solvent is usually sufficient to

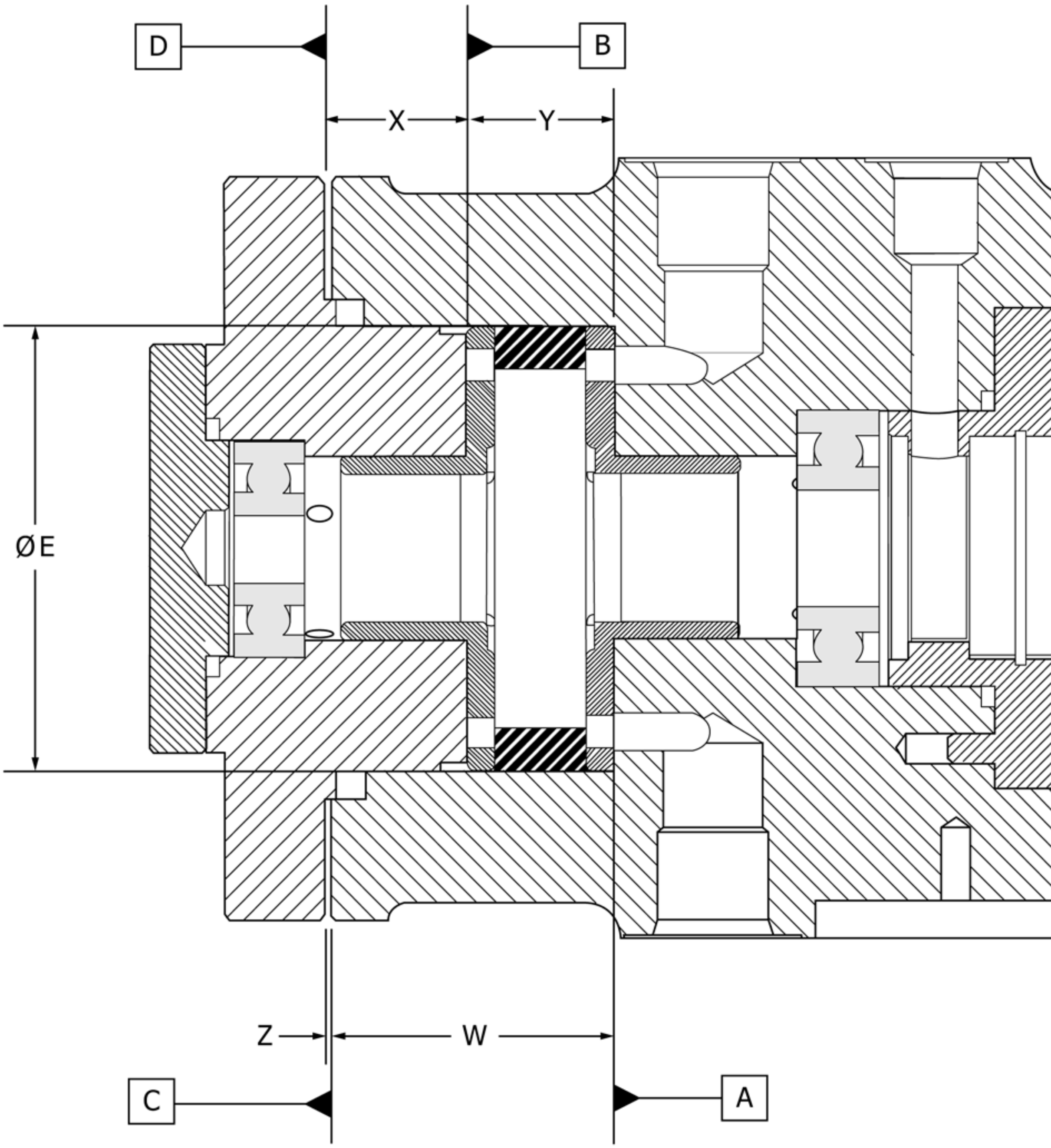



FIG. 4 Pump Housing

clean a system in which an oil was run. Other solvents can be used when oxidized oil has coated the reservoir and lines (**Warning—**see 7.5). Repeat the flush if the first flush is cloudy or opaque.

10.2.5 Reduce the setting of the pressure control valve so that pressure will not be generated when flow starts.

10.2.6 Jog the pump drive motor ON and OFF switches to remove the air from the test system. Continue until the fluid returning to the reservoir is visually free of air.

10.2.7 Flush for 30 min at 0.7 MPa and 38 °C to 49 °C.

10.2.8 Drain system, remove filter element, and flush cartridge. Wipe out pump and filter housings and the reservoir and baffle.

10.2.9 Reinstall used filter element and flush cartridge, torque pump head, reduce setting of pressure control valve, close all drain valves, and open pump inlet and return line valves.

10.2.10 Recharge system with 7.6 L of test fluid.

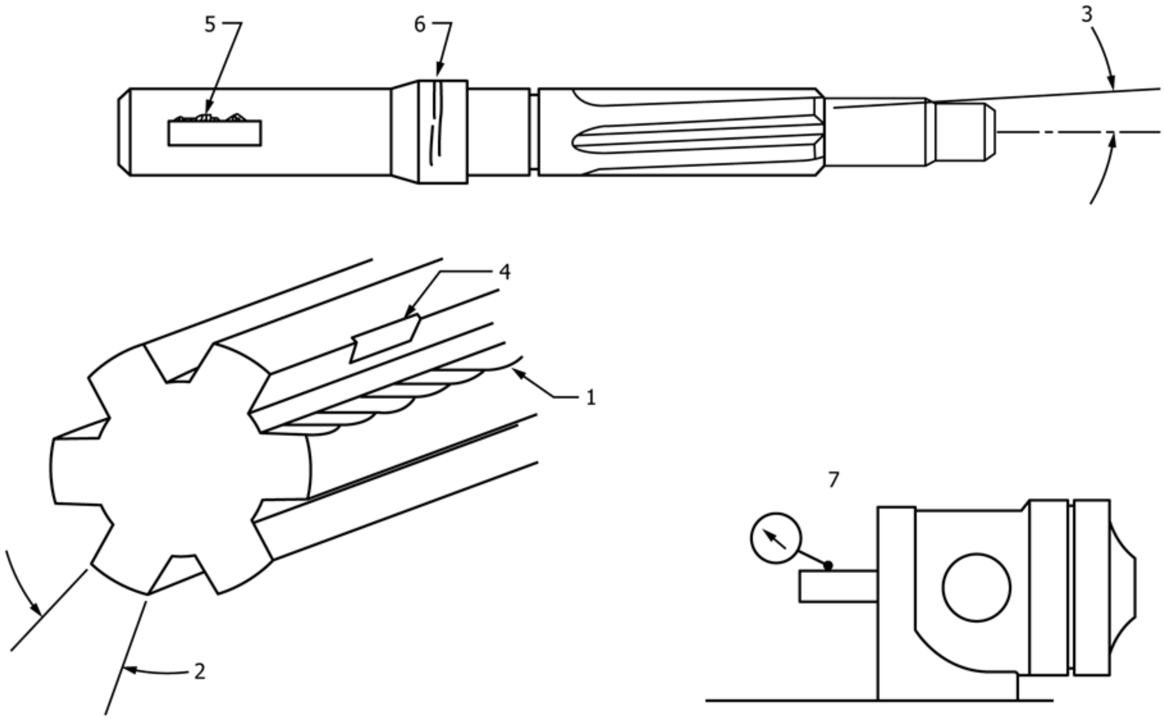



FIG. 5 Shaft Inspection

10.2.11 Jog the pump drive motor ON and OFF switches to remove the air from the test system. Continue until the fluid returning to the reservoir is visually free of air.

10.2.12 Flush for 30 min at 0.7 MPa and 38 °C to 49 °C.

10.2.13 Completely drain the system of all fluid.

10.2.14 Remove the flush cartridge and wipe out the pump housing.

10.2.15 Remove and discard the used filter element, clean the filter housing, and install a new filter element.

10.3 Flushing procedures for water glycol and other water based fluids:

10.3.1 To clean the system for water glycol testing, disassemble the system, including the pump body, heat exchanger, (see Note 4), and relief valve.

10.3.2 Water rinse and clean rubber hoses by passing a bristle brush through the length of the hose several times. Then rinse hoses with water and dry with compressed air. Check hoses for cracking, hardening, and tackiness. Replace as needed.

10.3.3 Water rinse and dry other rubber parts and gaskets with compressed air. Check for wear, cracks, and tackiness. Replace as needed.

10.3.4 Clean metal parts by first rinsing with water, then scrubbing with a soft bristle brush, and rinsing with water again, and then blowing dry with air. If a shell-and-tube heat exchanger is used as described in Note 4. Clean the heat exchanger tubes with a brass rifle cleaning brush, or other brush suitable for the size of the tubes. Clean the metal tubing and holes in the castings with a test tube brush.

10.3.5 After water cleaning, place all metal parts in a solvent bath composed of a mixture of 50 % naphtha and 50 % isopropanol (**Warning—**see 7.2 and 7.4) and agitate for at least 30 min. Then drain the parts and dry with compressed air.

NOTE 14—It is critically important not to wash pumps run with other fluids, for example, polyol esters and mineral oils, in the same bath used to clean pumps run with water glycol.

NOTE 15—Hoses that have been previously used with mineral oils, phosphate esters, polyol esters, or PAO fluids should not be used with water glycols.

## 11. Preparation of Test Cartridge

11.1 Figs. 2 and 3 show the various components of the test cartridge.

11.2 Inspect all cartridge components for manufacturing or material irregularities. Use a new ring and set of vanes for each test. Reuse of the rotor and bushings is permissible if they are in satisfactory condition.

11.3 It is essential that the user is familiar with precision inspection practices, has quality instruments, and is adept in their use.

11.4 *Rotor Selection and Preparation:*

11.4.1 Between tests it is important to ensure that the rotor faces, journals, and slots are free of any varnish or other buildup that may inhibit free movement of the vanes.

11.4.2 If necessary, polish both faces of the rotor by holding it flat against a piece of P1200 grit paper which is supported by a glass plate or other suitable flat surface (Fig. 6). Protect the rotor journal by placing a piece of masking tape on the vertical edge of the glass or by wrapping the journal with masking tape. Push the rotor along the paper while giving the rotor one-quarter turn. Repeat until all portions of both rotor faces have been polished.

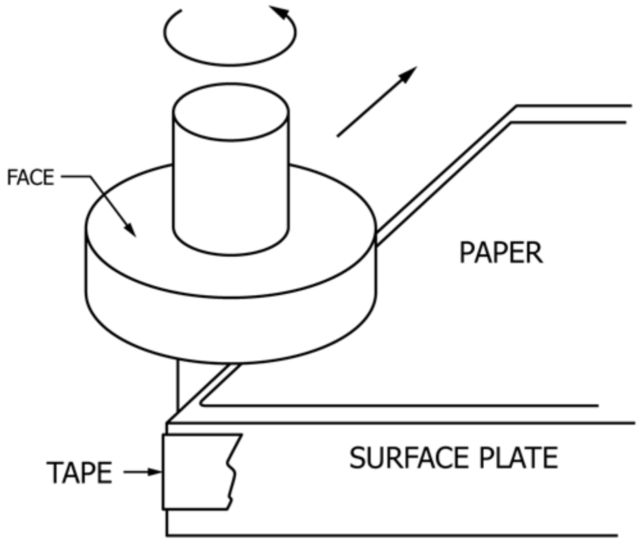



FIG. 6 Rotor Preparation

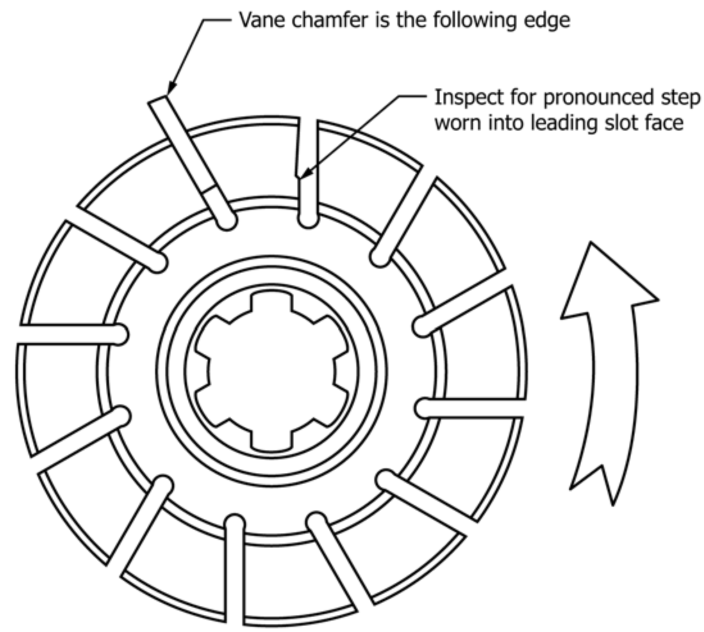



FIG. 7 Rotor Inspection

11.4.3 In some cases, it may be necessary to polish the inside surfaces of the vane slots to remove buildup, corrosion, or burrs. A piece of P1200 grit paper wrapped around a strip of steel or brass has proven satisfactory.

11.4.4 If necessary, the journals may be polished by hand with P1200 grit paper.

11.4.5 Wash the rotor with Stoddard solvent (**Warning—**see 7.2) and brush out the vane slots to remove any grit and oil. Air dry.

11.4.6 Ensure that clean vanes will fall freely through the vane slots.

11.4.7 Inspect used rotors for a pronounced step worn in the leading face of the rotor slot by the vanes when they are at full extension (Fig. 7). Also, check for excessive vane play in the slots. Discard rotors with these deficiencies.

11.4.8 Measure the thickness of the twelve rotor segments and record the measurements. Discard rotors when the thickness of the segments varies more than 0.005 mm.

11.5 Roll the alignment pin on a flat surface to determine if it is straight. Discard bent pins.

NOTE 16—The amount of ring to rotor clearance, rotor to vane clearance, bushing concavity, bushing thickness, and applied head bolt torque is determined by the operator. The values given in this section are starting guidelines. In general, lower viscosity fluids require tighter clearances and flatter bushings. Experience will be the final guide for the operator.

11.6 Choose a set of components so that the average rotor thickness will be 0.017 mm to 0.035 mm less than the average ring thickness. Choose a set of vanes so that they will be 0.002 mm to 0.015 mm less than the average rotor thickness. The ring and vane dimensions have been recorded on their packaging at the factory.

11.7 Choose a pair of bushings with similar thickness and concavity. The CUP measurement listed on the bushing packaging is the amount of concavity between the outer diameter and the shank. A higher number indicates greater concavity.

11.8 Clean the cartridge parts in Stoddard solvent (**Warning—**see 7.2), rinse with precipitation naphtha (**Warning—**see 7.3) and air dry.

11.9 Use a degausser to demagnetize the ring and vanes. Determine the mass (separately) of the cam ring and the complete set of twelve vanes. Determine these two masses to the nearest milligram and record these values.

NOTE 17—Magnetized parts can affect the performance of electronic balances.

## 12. Procedure

12.1 *Pump Cartridge Assembly*—(See Fig. 8 and Fig. 7.)

NOTE 18—Assembly is best done by assembling directly into the housing rather than on the bench. Components often become misaligned when a preassembled cartridge is inserted into the housing.

12.1.1 Wet all cartridge components with a thin film of test fluid and lay them out on a scrupulously clean surface.

12.1.2 Ensure that the pump body and head are clean.

NOTE 19—Debris on the sealing surfaces between the bushings and the pump body and head faces (Surfaces A and B, Fig. 4) will contribute to internal leakage, causing poor flow from the pump.

12.1.3 Insert the inner bushing (2882-4C) into the pump body. Bottom it against the pump body and rotate it slightly in both directions to ensure it is properly seated. Align the hole in the bushing with the alignment pinhole in the pump body.

12.1.4 Insert the cam ring (2882-5) so that the larger diameter of the stepped hole will be toward the operator. Ensure that the ring has seated against the 2882-4C bushing and align the stepped hole in the ring with the alignment holes in the bushing and the pump body.

12.1.4.1 If used, the shim described in 8.3.5.2 is added while the ring is being inserted. After installation, the ring should have some free movement in the bore. If it has jammed, remove the ring and shim and reinstall.

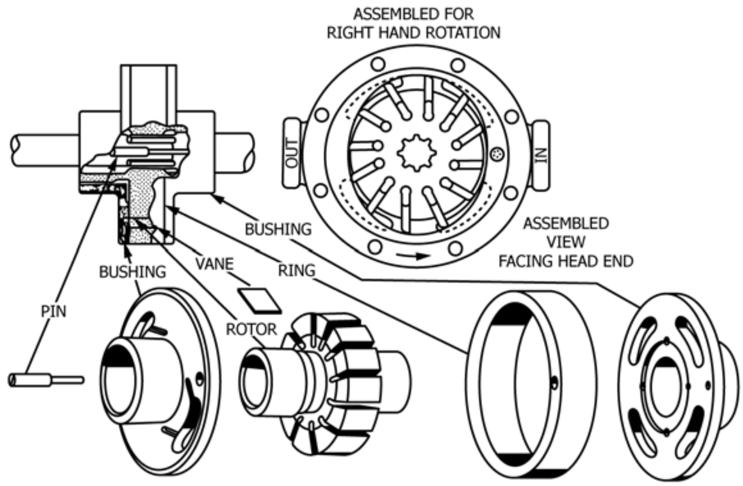



FIG. 8 Cartridge Kit

12.1.5 Insert and bottom the alignment pin (2882-10). The large diameter end should be toward the operator and should be bottomed in the cam ring so that approximately 8 mm of the large diameter end is visible above the ring surface.

12.1.6 Insert the rotor (2882-1C) making certain that the rotor directional arrow points counterclockwise (Fig. 8, Fig. 7).

12.1.7 Insert the 2882-3 vanes into the rotor slots making certain that the chamfered edge will be in contact with the cam ring and will be the trailing edge when the rotor turns counterclockwise (Fig. 8, Fig. 7).

12.1.7.1 Ensure that the vanes move freely in the rotor slots when assembling. If the vanes do not move freely, remove the rotor and check for dirt or burrs in the rotor slots or on the vanes.

12.1.8 Insert the outer bushing (2882-4E) and engage the alignment pin. After installing the 2882-4E bushing, approximately 3 mm of the large diameter end of the alignment pin should be visible above the bushing surface.

12.2 *Torquing the Pump:*

12.2.1 Install the packing seal, pump head, and head bolts. Bring the head bolts to finger tight.

12.2.2 Close all drain valves. Open pump inlet and return line valves, if used (see Notes 9 and 10).

12.2.3 Pour enough test fluid into the reservoir to ensure that the pump case is full.

12.2.4 Use a torque wrench to tighten the eight head bolts (Fig. 9), a maximum of 1130 N-mm at a time, using the following sequence: top right (1), bottom left (2), right low (3), left high (4), then bolts (5), (6), (7), and (8). Slowly rotate the pump shaft by hand while tightening the bolts or at the end of each sequence. Record the final level of torque (usually about 4520 to 7910 N-mm. The pump should rotate with a slight drag on the shaft but there should be no binding.

12.2.4.1 Bind is characterized by a catch or tight spot in an otherwise smooth shaft rotation or complete seizure or stoppage, requiring abnormal hand effort to turn the shaft, or both.

12.2.4.2 If binding occurs at less than 3390 N-mm, there probably is a misalignment within the pump and it should be disassembled and all components checked.

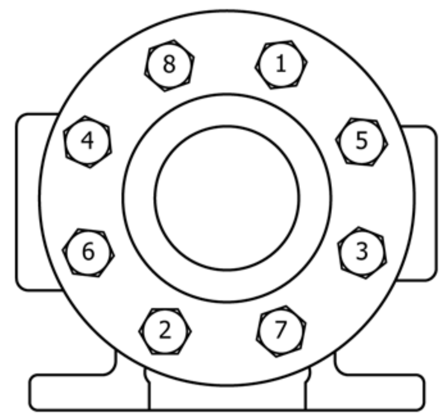



FIG. 9 Head Bolt Torquing Sequence

NOTE 20—To eliminate the drag of the motor while rotating the pump shaft, some users disconnect the pump to motor shaft coupling during torquing.

NOTE 21—Some users have found that reversing the torquing sequence (that is, 2-1-4-3-6-5-8-7) every other sequence helps avoid binding and cocking of the pump head.

NOTE 22—To get more even torquing, some users use brass washers under the head bolts to reduce tightening friction.

NOTE 23—To ensure that the cartridge seats properly against the pump housing and head sealing faces (Planes A and B, Fig. 4), some users use feeler strips between the head and housing while torquing the head. This technique requires that the head and housing have parallel faces and shoulders (Planes A and C, B and D, Fig. 4) and accurate measurements have been made (Measurements W and X, Fig. 4). The gap (Z) that should be present when the cartridge has been properly seated will be equal to Y (cartridge thickness) + X − Y. Ensuring that the gap is consistent around the pump head during the torquing procedure will also guard against cocking the head, which may cause it to jam in the housing bore.

12.3 *Test Startup and Operation:*

12.3.1 If not already done, close all drain valves and open the reservoir outlet valve and return line valve.

12.3.2 Pour approximately 12 L of the test fluid into the reservoir.

12.3.3 Reduce the setting of the pressure control valve so that pressure will not be generated when flow starts, and turn off cooling water if not already done.

12.3.4 Jog the pump drive motor ON and OFF switches until fluid is returned to the reservoir.

12.3.5 Pour the remainder of the test fluid into the reservoir.

12.3.6 Start the pump and adjust the speed to 1200 r/min.

12.3.7 Observe the fluid in the reservoir to ensure that it is clear and does not contain noticeable amounts of entrained air before increasing pressure.

12.3.8 Adjust pump outlet pressure to 2.1 MPa (300 psi).

12.3.9 Warm up for 1 h in six 10 min steps, at increased pressure levels. The pressure levels are 2.1 MPa, 4.1 MPa, 6.2 MPa, 8.3 MPa, 10.3 MPa, and 12.4 MPa (300 psi, 600 psi, 900 psi, 1200 psi, 1500 psi, and 1800 psi). During this warm-up period, pump inlet temperature will be rising. When this temperature is within 3 °C (5 °F) of the control level, start to apply cooling through the heat exchanger system to minimize temperature override on the test fluid.

NOTE 24—If pump vane noise (chatter) is heard during the warm-up, the pump can be shut down and the pump head bolts tightened in 560 N·mm increments, using the same tightening sequence as described in 12.2.4, in an effort to eliminate the noise.

12.3.10 Make certain that pump speed, pump inlet temperature, and flow are at test conditions, and adjust pump outlet pressure to exactly 13.8 MPa (2000 psi).

12.3.11 Do not start the test if the pressure gage shows evidence of unusual relief valve fluctuation or pulsations, or if unusual noise or vibration are present.

12.3.12 Measure and record fluid flow rate.

12.3.13 Record clock time or adjust test system timer to zero and consider this the start of the test.

NOTE 25—It is advisable to monitor test conditions for at least the initial few hours of the test to ensure that conditions are stable. A continual drop in the flow rate indicates increasing internal leakage caused by bushing wear or improper seating of the cartridge.

12.3.14 Operate system at the following conditions uninterrupted for 100 h or until operating difficulties dictate test termination:

Pump outlet pressure: 13.8 MPa ± 0.3 MPa (2000 psi ± 40 psi)
Pump speed: 1200 r/min ± 60 r/min
Pump output: >15.0 L/min
Fluid temperature at pump inlet:
Water glycols, emulsions, and other water containing fluids:
66 °C ± 3 °C
Petroleums and synthetic fluids of ISO Grade 46 or lighter:
66 °C ± 3 °C
All other petroleum and synthetic fluids:
80 °C ± 3 °C

12.3.15 It is not acceptable to replace the ring or vanes during the test. The test should be terminated if flow drops to 15.0 L/min (4.0 gpm) or less, if system pressure cannot be maintained, or if there is excessive noise or leaking.

12.3.16 It is permissible to replace the bushings during the test if loss of flow has caused an early termination. Replace vanes in their original slots after such a rebuild. Report the bushing failure.

12.3.17 After the test has begun, it is not acceptable to add additional test fluid or water in order to make up for spillage or evaporation.

12.4 *Test Shut-Down and Final Parts Inspection:*

12.4.1 Reduce the pressure control valve setting and stop pump operation.

12.4.2 Stop the flow of the cooling water.

12.4.3 Observe and record the condition of the test fluid, noting any unusual appearance or odor.

12.4.4 Open all drain valves and drain the test system.

12.4.5 After the pump has cooled sufficiently, remove the pump head and carefully remove the test cartridge.

NOTE 26—The use of a bent piano wire inserted through an inlet or outlet port to catch and hold the inner bushing or the use of needle nose pliers to grasp the outer bushing and the rotor hub, or both, facilitates removal of the cartridge.

12.4.6 Observe and record the condition of the reservoir surfaces, noting any deposits. System preparation for additional testing can now proceed.

12.4.7 Carefully disassemble the test cartridge and inspect the individual pump cartridge parts for signs of wear, deposit formation, or discoloration. Record any observations.

12.4.8 Demagnetize the cam ring and vanes.

12.4.9 Remove all deposits from the test cartridge cam ring and vanes by thorough nonabrasive cleaning. Rinse in precipitation naphtha (**Warning—**see 7.3) or other appropriate solvent (see 7.5) and air dry.

## 13. Calculation

13.1 Determine the mass (separately) of the used cam ring and the set of twelve used vanes to the nearest milligram. Record these two masses and their total.

13.2 Subtract the after-test total mass (cam ring plus twelve vanes) from the unused mass total to determine the mass loss sustained during the run.

## 14. Report

14.1 Report the following information:

14.1.1 Mass loss of the ring and vanes in milligrams.

14.1.2 Flow rate at start and end of test.

14.1.3 Any unusual observations on wear, scuffing, deposits, cavitation damage, deterioration of seals, and bushing replacement.

14.1.4 List any modifications to the test method procedure, conditions, or apparatus, and report them as Modified Test Method D7043.

## 15. Precision and Bias

15.1 The precision of this test method is based on an interlaboratory study conducted in 2016. Each of seven laboratories tested three different hydraulic fluids. Every "test result" represents an individual determination, and all participants were instructed to report duplicate test results. Practice D6300 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. RR:D02-1863.[7]

15.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1863. Contact ASTM Customer Service at service@astm.org.

short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

15.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

$$\text{Repeatability} = 3.9983x^{0.4417} \quad (1)$$

where $x$ is the average of two results.

15.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

15.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

$$\text{Reproducibility} = 7.6870x^{0.4417} \quad (2)$$

where $x$ is the average of two results.

15.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

15.1.4 Note that there were fewer than the required 30 degrees of freedom available for analysis in the calculation of precision for this test method, and the applicability of the results of this study should be assessed accordingly.

15.1.5 Any judgment in accordance with statements 15.1.1 and 15.1.2 would normally have an approximate 95 % probability of being correct, however the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of materials tested and laboratories reporting results guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. The repeatability limit and the reproducibility limit should be considered as general guides, and the associated probability of 95 % as only a rough indicator of what can be expected.

15.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made

15.3 The precision statement was determined through statistical examination of 39 results, from seven laboratories, on three hydraulic fluids.

15.4 To judge the equivalency of two test results, it is recommended to choose the fluid closest in characteristics to your test material.

NOTE 27—The ILS did not meet the minimum sample design nor degree of freedom for reproducibility as required by Practice D6300. The total number of samples is 3, and the df achieved for R is 10.

## 16. Keywords

16.1 hydraulic fluid; vane pump; wear

## SUMMARY OF CHANGES

Subcommittee D02.N0 has identified the location of selected changes to this standard since the last issue (D7043 – 12) that may impact the use of this standard. (Approved July 1, 2017.)

*(1)* Revised Precision and Bias section.