INTERNATIONAL

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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, health, and environmental 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for Indicating Wear Characteristics of Petroleum and Non-Petroleum Hydraulic Fluids in Constant Volume Vane Pump (Withdrawn 2003)[3]

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products, Liquid Fuels, 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 *snubber, n*—fluid restricting device used to dampen pressure pulsations.

3.1.3 *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 lower viscosity. 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 fluid 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.

[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.

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[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

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

6.1.1.1 When constructing the test stand some users build the test stand using a variable speed motor so that other, similar tests such as ISO 20763 (1440 rpm) may be performed using the same apparatus.

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 Conestoga USA B1 housing is used along with internal components from Conestoga USA, Inc.[4] Vickers housings V104C and V105C are acceptable for use in this test when used with Cam Rings and Vanes from Conestoga USA, Inc. Refer to D7043 – 17 for Vickers assembly part numbers and advisories concerning their use. 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).

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. 2882-1D, bronze bushings No. 2882-4C and 2882-4E, and vane kit (12 vanes) No. 2882-V12A. Alternate bushings with a TiN coating are available (part No. 2882-4F and 2882-4G) for use where bushing wear has been a problem.

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 1—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 reservoir outlet Dimension C, Fig. 1).

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.

6.1.4.6 In the reservoir return line the drop tube end may be cut at a 45° angle for better return flow characteristics.

6.1.5 *Outlet Pressure Control Valve,* Eaton-Vickers pressure relief valve (CT-06F or CS-06F, to 10.3 MPa to 20.7 MPa) with either manual or remote control (Item 8, Fig. 1).[5]

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 3.2 mm.

6.1.7.2 The test fluid temperature shall be measured using the B1 pump sensor port. The sensing probe shall be inserted into the midpoint of flow.

NOTE 2—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 3—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 or inaccurate readings from pulsations or sudden fluctuations of system pressure.

6.1.10 *Filter Unit (Item 9, Fig. 1),* a replacable element or spin-on type filter, having a fiberglass element, are both acceptable. The element shall have a minimum Beta Ratio of 100 for 3 µm size particles ($\beta 3 = 100$, Filtration Efficiency = 99.0 %). One new filter element is required for each test.

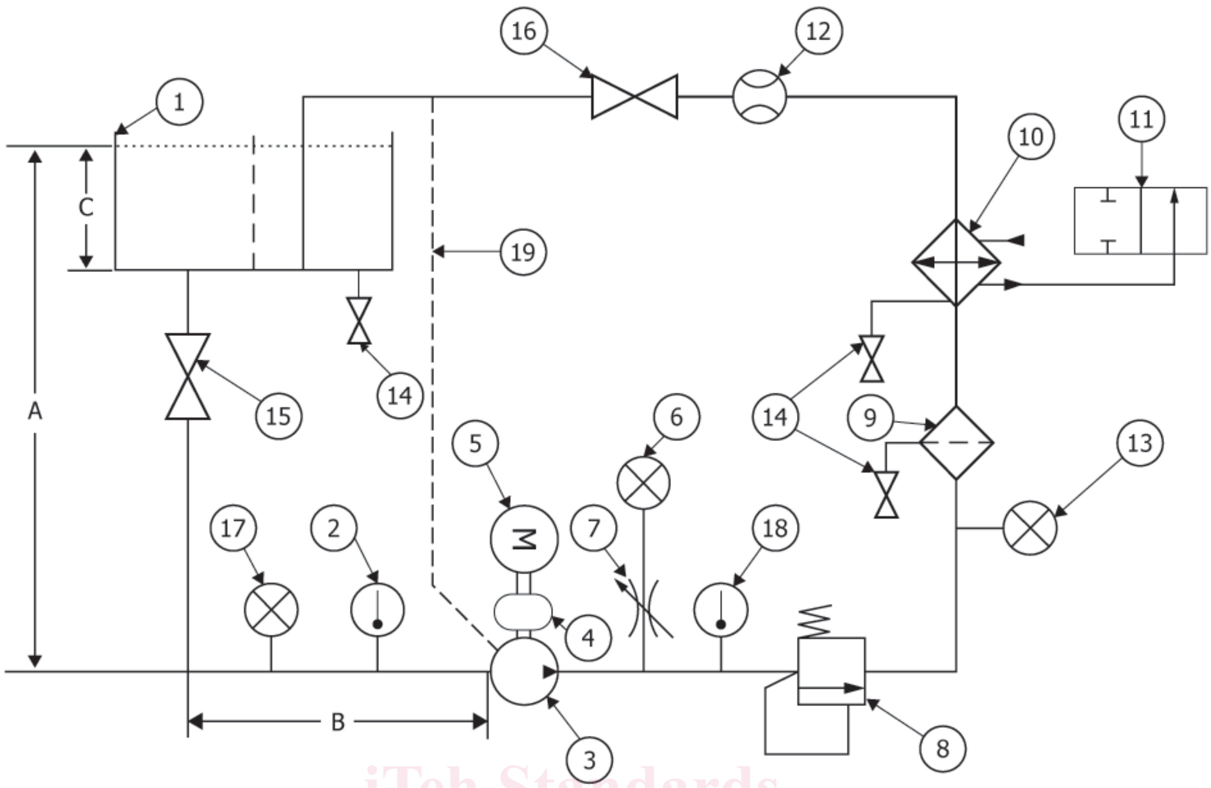
6.1.10.1 The filter housing shall be non-bypassing and shall be provided with a pressure gauge (Item 13, Fig. 1) or another suitable indicator to monitor pressure across the filter to warn of impending collapse of the element.

6.1.10.2 The rated collapse pressure of the filter element should be known. The collapse pressure should be within the range of the gauge.

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

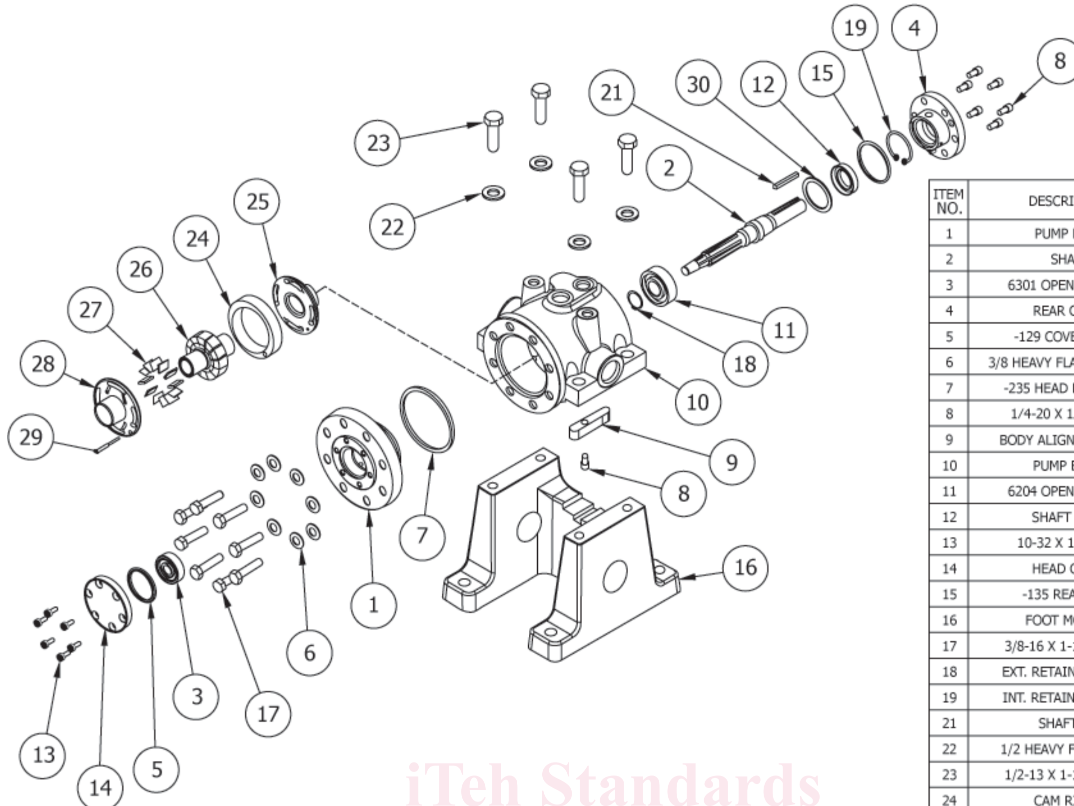
[4] The sole source of supply of the apparatus known to the committee at this time is Conestoga USA Inc., P.O. Box 3052, Pottstown, PA 19464. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration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

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



Item	Description (Required if otherwise noted)
1.	Reservoir
2.	Inlet Temperature Sensor
3.	Conestoga B1 Pump
4.	Flexible Coupling
5.	Motor
6.	High Pressure Gauge/Sensor
7.	Pulsation Dampening Valve
8.	Relief valve
9.	Filter, $\beta_{3\mu}$ = 100 Minimum Performance
10.	Heat Exchanger
11.	Temperature Control Valve
12.	Flow Meter
13.	Low Pressure Gauge/ Filter Indicator
14.	Drains
15.	Pump Inlet Valve (Not required)
16.	Return Line Valve (Not required)
17.	Inlet Vacuum Gauge/Sensor (Not required)
18.	Outlet Temperature Sensor (Not required)
19.	Case Drain for B1 pump
A.	61 to 66 cm, Vertical
B.	15 cm, Minimum Horizontal
C.	15 cm, Minimum Vertical

FIG. 1 System Schematic



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 or 2882-4F (Tin Coated)	1
26	ROTOR	2882-1D	1
27	VANE	2882-3A	12
28	OUTER BUSHING	2882-4E or 2882-4G (Tin Coated)	1
29	ALIGNMENT PIN	2882-10	1
30	W1819-020 WAVE SPRING	B1-25	1

FIG. 2 Conestoga USA, Inc., B1 Pump Assembly

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 4—The use of galvanized iron, non-anodized 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), with a minimum torque rating of 80 N·m.

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 (Item 14, Fig. 1) 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 5—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 6—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 7—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 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 8—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 9—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 2, Fig. 2), seals (Items 5, 7, 12, 15, Fig. 2), and bearings (Items 3, 11, Fig. 2) be replaced after every five runs (or sooner if high weight loss, vibration, cavitation, rotor failure, shaft seizure, or visual deterioration is encountered). It is also recommended that all seals be replaced following a solvent flush. All SAE O-ring seals should be replaced if the fitting has been removed from its mating port.

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 1, 10, Fig. 2). 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. 3) 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 head bearing (Item 3, Fig. 2) is a press fit into the head. If it is loose, discard the head.

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

NOTE 10—In some cases in which operational problems continue without apparent cause, a change of pump body, head, shaft, or all three, has been known to alleviate the problem.

8.4 Inspect the shaft (Item 2, Fig. 2).

8.4.1 Discard shafts if the rotor has worn deep marks in the splines or if the shaft seal has worn a groove onto the shaft seal surface. If the pump has been subjected to sudden seizure discard the shaft if it has become twisted due to the seizure. Discard the shaft if there has been a rotor failure or severe overheating of the pump or if the keyway has been badly damaged.

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.

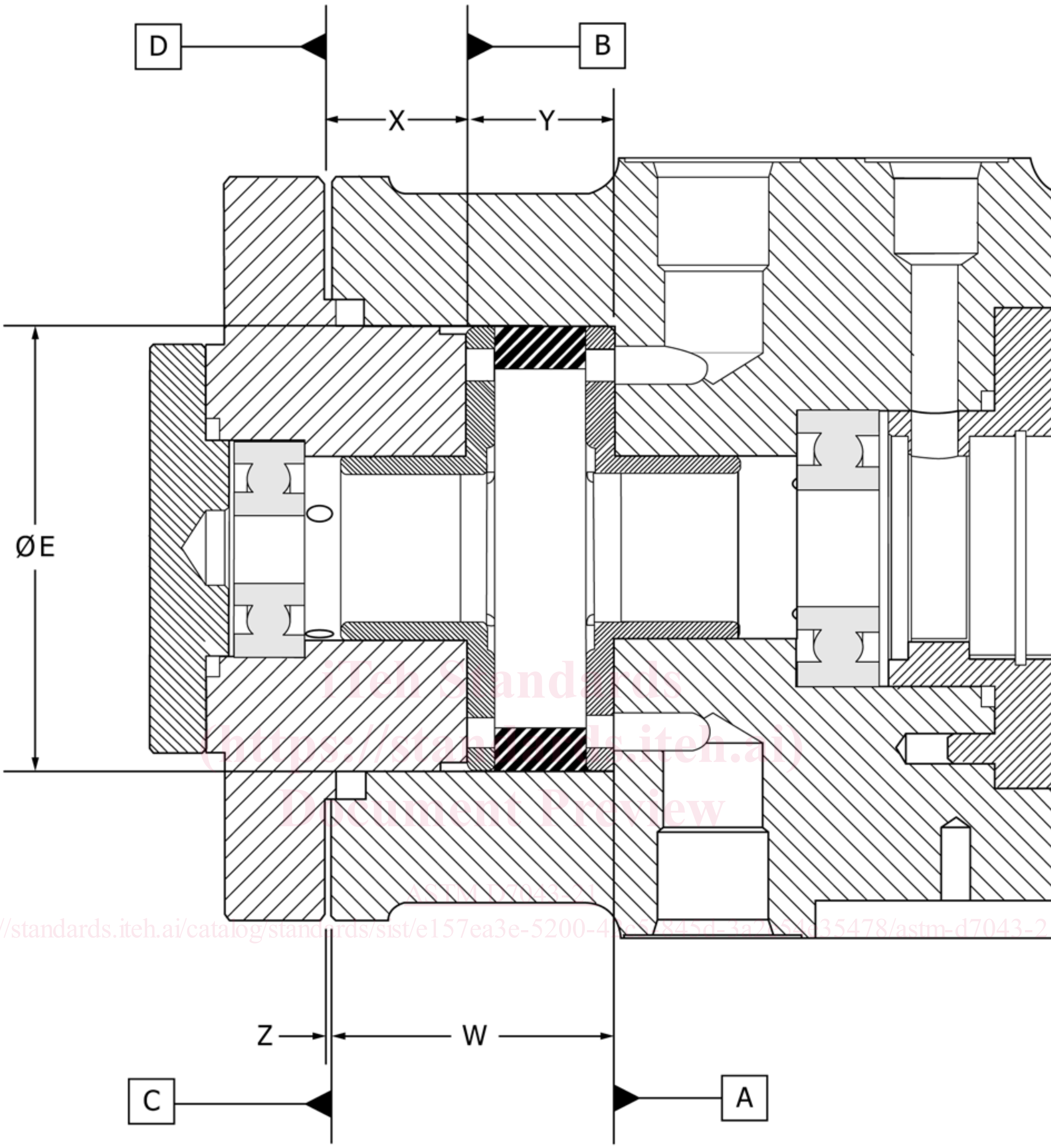
8.5.1 Alignment checks should be made with the head, shaft, and both bearings in place and with the head tightened down.

8.5.2 Using a test indicator, with the head, shaft, and both bearings in place and with the head tightened down, inspect the shaft for a bent condition by rotating it by hand with the motor coupling removed.

8.6 Periodically use a ⅜-16 (inch) tap to clean the eight tapped holes that receive the pump head bolts. Use a metal brush to clean the threads of the head bolts themselves (Item 17, Fig. 2). 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. (**Warning—**Improper reassembly of the relief valve may pose a hazard to the user.)

8.7.1 If the relief valve fails to produce system pressure check that the weep hole across the faces of the 343154 piston is not blocked.



NOTE 1—Shaft, rotor, vanes and seals not shown.

FIG. 3 Pump Housing

8.7.2 If the #262332 O-ring is damaged it may allow air to be drawn into the low pressure region behind the #290057 Piston.

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 11—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). Wipe out pump and filter housings and the reservoir and baffle.

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

10.2.3 Close all drain valves and torque the pump head. Open the pump inlet and return line valves if used (see Notes 8 and 9).

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 12—One flush of this petroleum solvent is usually sufficient to 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.

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 3), 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 3. Clean the interior of 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 13—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 14—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 Fig. 6 shows 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, alignment pin, 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, cause damage to the bushings, or interfere with accurate measurement of the rotor..

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. 4). 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.

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. 5). 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 15—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 0.025 mm to 0.030 mm less than the average ring thickness. Choose a set of vanes so that they will be 0.005 mm to 0.010 mm less than the average rotor thickness.