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RECOMMENDED PRACTICES FOR LUBRICATING OIL FILTERS, GENERAL AVIATION RECIPROCATING ENGINE (PISTON TYPE) AIRCRAFT

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PREPARED BY
SAE COMMITTEE AE-5, AEROSPACE FUEL, OIL, & OXIDIZER SYSTEMS

1. SCOPE: The recommended practice establishes the requirements for lubricating oil filters for general aviation reciprocating engine applications with lubricating oil systems normally operating in a pressure range of 345 - 689 kPa (50 - 100 psig).
2. PURPOSE: This specification defines uniform parameters for the design, manufacture and test of filters for General Aviation lubricating oil systems for aircraft type reciprocating engines.
3. APPLICABLE DOCUMENTS: The following documents form a part of this specification to the extent specified herein.
 - 3.1 Federal Standards:
FED-STD-595 - Colors
 - 3.2 Military Standards:
Ø MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-130 - Identification Marking of U.S. Military Property
MIL-STD-889 - Dissimilar Metals
 - 3.3 Military Specifications:
MIL-L-22851 - Lubricating Oil, Aircraft Reciprocating Engine
MS33540 - Safety Wiring and Cotter Pinning, General Practices For
 - 3.4 SAE Publications:
SAE J363 - Filter Base Mountings
SAE J806 - Lube Oil Filter Performance Test

AS 478 - Identification Marking Methods
AS 567 - General Practices for Use of Lock Wire, Key Washers and Cotter Pins
ARP 901 - Bubble Point Test Method
4. CLASSIFICATION OF FILTERS AND ACCESSORIES: Lubricating oil filters shall be in accordance with the following sizes and accessory categories:
 - 4.1 Category 1A: Shell and bolt types (filter assemblies with reusable housings and noncleanable filter elements).

Consists of:

1 Shell per Fig. 1
1 Bolt per Fig. 3
1 Cover Plate per Fig. 4
1 Cover to Shell Gasket per Fig. 6
1 Cover to Adapter Gasket per Fig. 5
1 Assembly Nut per Fig. 8
1 Filter Element per Fig. 2
1 Bolt to Shell Gasket per Fig. 7
1 Installation Instruction Sheet

4.2 Category IB: Replacement Filter Element Kits for Shell and Bolt Type Filter Assemblies.

Consists of:

- 1 Filter Element per Fig. 2
- 1 Cover to Shell Gasket per Fig. 6
- 1 Cover to Adapter Gasket per Fig. 5
- 1 Bolt to Shell Gasket per Fig. 7
- 1 Installation Instruction Sheet

4.3 Category II: Spin-On Types (Non-Cleanable Filter Assemblies).

4.3.1 Type A¹ Consists of:

1 Female Threaded Non-Cleanable Housing Containing Integral Filter Element and Attached Adapter-to-Filter Seal. See Fig. 9.

4.3.2 Type B¹ Consists of:

1 Male Threaded Non-Cleanable Housing Containing Integral Filter Element and Attached Adapter-to-Filter Seal. See Fig. 10.

4.4 Category III: Converter Kit - For conversion from Bolt and Shell Type Filters (Categories IA and IB) to spin-on type non-cleanable filter (Category II, Type A, Fig. 9, with Converter Kit) (Category III).

Consists of:

- 1 Converter Plate Assembly
 - 1 Converter Stud
 - 1 Instruction Sheet
- (See Interface Definition - Fig. 11)

5. REQUIREMENTS:

5.1 Design and Construction:

- 5.1.1 Shell and Bolt Type Filter Assemblies (Category IA) shall be designed and constructed such that the filter elements and housing seals may be readily removed from and replaced in the filter housing without the use of special tools.
- 5.1.2 Spin-On Type Filter Assemblies (Category II) shall be designed such that the filter housing, filter element and mounting base seal are preferably discarded as a unit.

¹For usage, refer to filter or engine manufacturers' catalogs.

- 5.1.3 The filter assemblies covered by this specification shall be of the full-flow type.
- 5.1.4 All filter assemblies shall incorporate suitable provisions for safety-wiring the filter assembly to the aircraft engine.
- 5.1.5 SAE AS 567 shall be used as a guide for safety wire requirements.
- 5.1.6 The weight of the filter assembly shall be kept to the practical minimum consistent with good design practice. The vendor shall specify the maximum weight of each filter assembly on the applicable drawing.
- 5.1.7 Wrench caps or nuts shall be designed to withstand 9.0 N·m (80 lbf·in) torque (minimum) without damage or permanent deformation (Category II Filters).

5.2 Materials:

- 5.2.1 All materials used shall be compatible with aircraft engine lubricating oil per MIL-L-22851 (or equivalent).
- 5.2.2 All materials used shall be capable of withstanding the installation, disassembly and operating loads of the filter assembly.
- 5.2.3 All materials used shall be capable of withstanding the environmental and structural conditions imposed on the filter assembly during transit, storage and operational usage.
- 5.2.4 All materials used shall be corrosion resistant or be suitably treated to inhibit corrosion (i.e., paint, rust preventives, anodize, etc.).
- 5.2.5 Plating or other surface treatments which could peel, chip, flake or otherwise deteriorate in such a way as to permit migration to the downstream side of the filter shall not be used on parts manufactured to this specification.
- 5.2.6 Whenever possible materials which encourage galvanic corrosion shall not be used in combination. MIL-STD-889 shall be the standard for this requirement.

5.3 Dimensional Requirements:

- 5.3.1 Shell and Bolt Type Filter Assemblies (Category IA) shall meet the dimensional requirements of Fig. 1.
- 5.3.2 Filter Elements (Category IB) shall meet the dimensional requirements of Fig. 2.
- 5.3.3 Spin-On Filter Assemblies (Category II, Types A and B) shall meet the dimensional requirements of Figs. 9 and 10.

5.3.4 Converter Kits for conversion from Bolt and Shell Type Filters to spin-on filters shall meet the interface requirements of Fig. 11.

5.3.5 Filter mounting bases shall meet the dimensional requirements of Figs. 12 and 13.

5.4 Convenience Devices - Optional:

5.4.1 Convenience devices, such as anti-drainback valves and standpipes, shall be considered optional except in cases where specific customer requirements exist for such devices.

5.4.2 Anti-drainback valves shall be designed to minimize lube-oil flow from the housing inlets (upstream side of filter element) when the filter housing is removed inverted (inlet and outlet down) after service.

5.4.3 A standpipe anti-drain feature shall allow no more than 20% of the downstream (or outlet) side residual oil to flow from the filter housing outlet when the filter housing is removed inverted (inlet and outlet down) after service.

5.5 Performance:

5.5.1 Performance requirements for filter assemblies and filter elements shall be as defined in the following paragraphs. Conformance to these requirements shall be verified by evidence of satisfactory performance of the filter assemblies and filter elements when subjected to the environmental conditions and qualification tests of Section 6 of this specification.

5.5.1.1 Documented results of all qualification tests as specified herein shall be kept available by each filter manufacturer.

5.5.2 Fluid Flow: Filter assemblies furnished under this specification shall be rated according to the following flow rates:

SIZE	FLOW (L/s)	(kg/s (REF)	CLEAN PRESS. DROP (MAX) (kPa)
A	0.50 (8 gpm)	² (PER FILTER MANUFACTURERS' SPECIFICATIONS)	
B	0.76 (12 gpm)	² (PER FILTER MANUFACTURERS' SPECIFICATIONS)	

5.5.3 Pressure: The filter assemblies shall perform satisfactorily when subjected to the following pressures (all pressures are gage, unless otherwise specified).

5.5.3.1 Operating Pressure: Shall be 689 kPa (100 psig).

²These values should be coordinated with the engine manufacturers' By-Pass Valve requirements.

5.5.3.2 Proof Pressure: The proof pressure requirements shall be dictated by engine oil system requirements and shall be specified by the engine manufacturer. Recommended proof pressure values are 1724 kPa (250 psig) and 2758 kPa (400 psig) minimum, respectively, for the "A" & "B" filter sizes.

5.5.3.3 Burst Pressure: The burst pressure requirements shall be dictated by engine oil system requirements and shall be specified by the engine manufacturer. Recommended burst pressure values are 2068 kPa (300 psig) and 3447 kPa (500 psig) minimum, respectively, for the "A" & "B" filter sizes.

5.5.4 Temperature: The filter assemblies shall perform satisfactorily when subjected to the following temperatures:

5.5.4.1 Fluid: -12°C to 149°C (+10°F to +300°F)

5.5.4.2 Ambient: -54°C to +121°C (-65°F to +250°F)

5.5.5 Filtration Efficiency: The filter element shall remove a minimum of 90% of the test contaminant when tested in accordance with the filtration efficiency test outline in paragraph 6.4.15.

5.5.6 Contaminant Capacity: Filters furnished under this specification shall have a minimum contaminant capacity per Table I at rated flow and 85°C (185°F) to a terminal differential pressure of 138 kPa (20 psid).

TABLE I

ELEMENT SIZE	RATED FLOW (L/s)	CONTAMINANT CAPACITY	
		ADD RATE AC COARSE DUST (GRAMS/4 MINUTES)	MINIMUM AC COARSE DUST (GRAMS)
A	0.50	2.5	50
B	0.76	3.5	70

5.5.7 Filter Element Collapse: Filter elements furnished under this specification shall have a minimum filter element collapse pressure differential of 689 kPa (100 psid).

5.5.8 Impulse Cycling: Filter assemblies furnished under this specification shall perform satisfactorily when subjected to the impulse cycling test as described in paragraph 6.4.12 of this specification.

5.5.9 Vibration: Filter assemblies furnished under this specification shall perform satisfactorily when subjected to the vibration test as described in paragraph 6.4.13 of this specification.

- 5.6 Identification and Marking of Product: Filter assemblies, replacement filter elements and accessories such as converter assemblies, bolts and converter studs furnished under this specification shall have the following minimum identification and marking characteristics whenever possible:
- 5.6.1 Manufacturer's Trademark: Filter assemblies, filter elements and accessories furnished under this specification shall have the manufacturer's trademark clearly visible on the product.
- 5.6.2 Manufacturer's Part No.: Filter assemblies, replacement filter elements and accessories furnished under this specification shall have the manufacturer's complete part number clearly visible on the product and product container.
- 5.6.3 Approvals: Filter assemblies, replacement filter elements and accessories furnished under this specification shall display the appropriate Government approval such as FAA-PMA, S.T.C. or T.S.O. (whichever is applicable).
- 5.6.4 Marking of Installation Instructions:
- A. Category IA: Shell and bolt type filter assemblies in this category shall have printed on the shell:
1. Installation Torque
 2. Replacement Element Part No.
- B. Category IB - Replacement Filter Element: Filter elements in this category shall have included in the packaging an instruction sheet describing the procedure for installing the replacement element in the shell and bolt filter assembly.
- C. Category IIA and IIB - Spin-On Filters: Filter Assemblies in this category shall have installation instructions printed on the can.
- Example:
1. Lubricate Gasket with Engine Oil Only
 2. Torque Filter to 24.4 to 27.1 N·m (18 to 20 lbf·ft)
 3. Run Engine and Check for Oil Leaks
 4. Check Oil Level
 5. Safety Wire
- 5.6.5 Installation Torque: Filter Assemblies furnished under this specification shall have the required installation torque clearly marked on the product. The maximum torque required to effect a seal between the filter assembly and the filter mounting base shall not exceed 40.7 N·m (30 lbf·ft).
- 5.6.6 Engine Application Reference: Filter Assemblies furnished under this specification shall make reference by marking on the filter assembly or by inclusion in the installation instructions to applicable catalogs and service bulletins of filter manufacturers or engine manufacturers to determine approved filter models and engine applications.

Example:

ATTENTION:

CONSULT CURRENT APPROPRIATE CATALOGS, CHARTS, SALES AND SERVICE BULLETINS OF FILTER, OR ENGINE MANUFACTURER, FOR APPROVED FILTER MODEL AND ENGINE

- 5.6.7 Date Stamp: Filter assemblies and replacement filter elements furnished under this specification shall mark the day, month and year of manufacture on the product or package. This requirement may be accomplished by the date coding processes normally employed by the individual product manufacturer.

- 5.6.8 Conformance to SAE Specification: Filter assemblies and replacement filter elements furnished under this specification shall be clearly marked to show conformance to the applicable Sections of this specification.

Example:

Manufactured in accordance with

SAE Specification _____

Category _____

- 5.6.9 Detail Parts Marking: Detail parts furnished under this specification shall be marked in accordance with AS 478 and shall, whenever possible, reflect the manufacturer's name or trademark and part number.
- 5.7 Workmanship: Workmanship of filter assemblies, replacement filter elements and accessories furnished under this specification shall be of a quality and grade necessary to ensure proper installation, functional operation and flight safety.

6. QUALITY ASSURANCE PROVISIONS:

- 6.1 Place of Tests and Test Data: All testing shall be conducted at the filter manufacturer's test laboratory or other certified laboratories. All test data shall be recorded and placed in permanent Quality Assurance Department files at the filter manufacturer's facility.

- 6.2 Test Conditions: Unless otherwise specified herein, all tests shall be conducted under the following conditions:

Test Fluid: Aeroshell W100 (SAE 50) Engine Lubricating Oil, Ashless Dispersant or equivalent (NOTE: The viscosity of the test shall be determined and recorded at the beginning of each test.)

Test Fluid Temperature: 82°C (180°F), unless otherwise specified.

Measurements: All measurements shall be made with calibrated and certified instruments.

Temperature: Unless otherwise specified, all tests shall be conducted at room ambient temperature.

6.3 Classification of Tests: The following categories of tests shall apply to this specification:

- A. Qualification Tests
- B. Acceptance Tests
- C. Sampling Tests

6.4 Qualification Tests:

6.4.1 Tests to be Performed: The following tests shall be required for Category I and Category II Filter Assemblies. Where differences in test procedures between Category I and Category II Filter Assemblies exist, the differences shall be noted. Qualification of Category III converter kit shall be included as part of the qualification tests.

<u>Ref. Para. No. Herein</u>	<u>Tests</u>
6.4.2	Examination of Product
6.4.3	Dry Weight
6.4.4	Proof Pressure and Leakage
6.4.5	Pressure Drop
6.4.6	Bubble Point ³
6.4.7	Dirt Holding Capacity
6.4.8	Oil Soak
6.4.9	Integral Stud Torque Test (Category II Filters)
6.4.10	Wrench Hex Torque Test
6.4.11	Burst Pressure
6.4.12	Pressure Impulse
6.4.13	Vibration
6.4.14	Collapse Pressure ⁴
6.4.15	Filtration Efficiency
6.4.16	Anti-Drainback Leakage Test
6.4.17	Bonding Pull Test

³On Category II, Filter Assemblies, disassembly of the spin-on housing and removal of the filter element may be required for this test. The housing should be opened at the base (slightly above the lockseam) using a can opener type tool.

⁴On Category II Filter Assemblies disassembly of the spin-on housing and removal of the filter element may be required for this test. The housing should be opened at the base (slightly above the lockseam) using a can opener type tool.

6.4.2 Examination of Product: The test unit shall be thoroughly examined and shall meet the requirements of the manufacturer's drawings and specifications with respect to dimensions, identification, general workmanship, material and finishes. For Category II spin-on filter assemblies, this examination shall include a check of thread squareness as follows:

The threads in the filter assembly base plate or the threads of the stud (whichever is applicable) shall be square with respect to the filter assembly gasket sealing surface within the limits shown in Figs. 9 and 10.

6.4.3 Dry Weight of Units: The dry weight of the test units shall be recorded.

6.4.4 Proof Pressure and Leakage: The test unit shall be installed in a test system as shown in Fig. 16 and completely filled with test fluid at room temperature. The outlet port of the fixture shall be capped. A static pressure of 1724 kPa (250 psig) or 2758 kPa (400 psig) (whichever is applicable) shall be applied at the fixture inlet port and maintained for two minutes. There shall be no visible evidence of external leakage or permanent deformation. This test shall be performed two times.

6.4.5 Pressure Drop:

NOTE: This test is based upon the procedures of SAE J806A with more specific definition. The procedures of this test are applicable to Category IA and IB (Shell and Bolt) and Category II (Spin-On) Filters.

The test unit shall be installed in a test system as shown in Fig. 15.

The following test conditions shall apply during this test:

1. Test Fluid: Aeroshell W100 (SAE 50) Engine Lubricating Oil, Ashless dispersant, or equivalent.
2. Test Fluid Temperature: $82^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($180^{\circ}\text{F} \pm 5^{\circ}\text{F}$)
3. Flow Rate: 0.50 L/s (Size A)
0.76 L/s (Size B)

6.4.5.1 Test Procedure:

NOTE: The test fluid viscosity, at the test temperature, shall be recorded at the beginning of the Pressure Drop test.

The net differential pressure across the test filter element shall be determined as follows:

- (A) Test fluid shall be flowed through the test unit at a minimum of 5 different flow rates; with flow rates above, below and at rated flow. Flow rates, fluid temperature and differential pressure across the test unit shall be recorded at each flow rate. These results shall be plotted on a graph as Flow Rate vs. Pressure Drop and considered as the "Gross" pressure drop results.

6.4.5.1 Test Procedure: (Continued)

- (B) A similar pressure drop test, as described in (A), shall be performed on the test fixture and the system connecting tubing with the test filter element, removed from the test fixture. These results shall be plotted on a graph and considered as the "Tare" pressure drop results.
- (C) The "Tare" pressure drop results obtained in (B) shall be subtracted from the "Gross" pressure drop results obtained in (A). These results shall be considered the test filter assembly "net" pressure drop results and plotted on a graph as "Flow Rate vs. Filter Element Net Pressure Drop."

6.4.6 Bubble Point (with element removed from filter housing):

Procedure - (Reference SAE ARP 901): The test filter element shall be installed in a test set-up as schematically shown in Fig. 21 herein. Fluid level shall be maintained at 12.7 ± 1.5 mm (0.500 ± 0.060 in) above the top of the element.

The test apparatus shall be installed on a solid, vibration-free base. The filter element bubble point shall be determined as follows:

1. The test element shall be completely immersed in the test fluid (Isopropanol, or other suitable test fluid), maintained at $24^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($75^{\circ}\text{F} \pm 5^{\circ}\text{F}$) and rotated until all air pockets have been eliminated.
2. The manometer shall be adjusted to zero (0); the test element shall then be connected to the air inlet line and rotated several items to ensure that no air pockets remain.
3. The air pressure shall be slowly increased while rotating the test element 360° axially. The manometer readings shall be recorded when the first bubble is emitted from the test element media. Care shall be taken to ensure that the initial bubble is from the media and not from defective end cap sealing or from seams.
4. Steps 1 through 3 shall be repeated for a total of three times and the average of the three runs shall be considered as the initial bubble point.

6.4.7 Contaminant Capacity: The filter element shall be installed in a housing and test system as shown in Fig. 14. The Dirt Holding Capacity test shall be conducted as follows:

Procedure: The test fluid and system shall be previously cleaned by fluid circulation through a 3 mm absolute filter. Throughout this test, a 3 mm absolute cleanup filter shall be used immediately upstream of the dirt loading system and another downstream of the test unit.

6.4.7 (Continued)

Test fluid at 82°C (180°F) shall be flowed at rated flow through the test unit throughout the test. A.C. Coarse Dust or equivalent shall be added at 240s intervals upstream of the test unit. Contaminant add increments shall be per Table I. Two minutes after each test dust addition, pressure differential, flow and temperature shall be recorded. Contaminant shall be added until a differential pressure across the filter element of 138 kPa (20 psig) is exceeded.

The flow through the unit shall not be stopped at any time up to 138 kPa (See paragraph 6.4.14).

The test housing and tubing pressure drop (tare) at rated flow, shall be subtracted from the gross pressure drop results of this test, and the results plotted on a graph as Filter Element Net Pressure Drop vs. Contaminant Added until 138 kPa is exceeded. The filter element shall meet the dirt holding capacity of Table I.

- 6.4.8 Oil Soak: The unit shall be installed in the test fixture and completely filled with test fluid. The fluid temperature shall be maintained at 118°C + 6°C (245°F + 10°F). The duration of the oil soak test shall be 144 h minimum. The external surfaces of the unit shall be wetted with test fluid at 24 h intervals. At the completion of this test, there shall be no evidence of deterioration resulting from this test.

Additionally, an element bond pull test shall be performed per paragraph 6.4.17 of this specification using the filter element subjected to the hot oil soak test.

- 6.4.9 Spin-On Filter Integral Stud Torque (Category II, Type B Filters Only): The filter assembly shall be installed in an anti-rotation device and the stud breakaway torque measured. The break away torque shall not be less than 47.5 N·m (35 lbf·ft).

- 6.4.10 Wrench Hex, Torque Test (Category II Filters): The filter assembly shall be installed in an anti-rotation device. A torque of 108.5 N·m (80 lbf·ft) (minimum) shall be applied to the filter wrench hex. There shall be no evidence of damage or permanent deformation as a result of this test.

- 6.4.11 Burst Pressure: The test unit shall be installed in a test system as shown in Fig. 16 and completely filled with test fluid at room temperature. The outlet port of the fixture shall be capped. Static pressure shall be applied beginning at 1724 kPa (250 psig) and increasing in increments of approximately 170 kPa. There shall be no leakage up to the rated proof pressure (Ref. paragraph 5.5.3.2).

The actual burst pressure shall not be less than the rated burst pressure of the test filter (Ref. paragraph 5.5.3.3.).

- 6.4.12 Pressure Impulse: The test unit shall be installed in a test fixture and system as shown in Fig. 19.

The following test conditions shall apply during the test:

- (a) Pressure Range: 0 to 1724 kPa (0 to 250 psig)
- (b) Temperature: $82^{\circ}\text{C} \pm 6^{\circ}\text{C}$ ($180^{\circ}\text{F} \pm 10^{\circ}\text{F}$)
- (c) Impulse Cycles: 10,000
- (d) Installation Torque: Per filter manufacturers' instructions.

- 6.4.12.1 Procedure: The filter unit shall be subjected to 10,000 pressure impulse cycles. A cycle shall be considered increasing the pressure at the inlet port from zero (0) kPa to 1724 kPa and back to zero (0) kPa with the outlet port capped. The cycling rate shall not exceed 5 per second.

During this test, the test unit shall be monitored for damage and the results recorded.

After the completion of this test, the test unit shall be disassembled and the filter element inspected for evidence of flow fatigue or other forms of media deterioration.

- 6.4.13 Vibration: The test unit shall be installed in a test fixture and subjected to the following vibration test:

The following test conditions shall apply during this test:

- (a) Vibration Levels -

<u>Frequency (Hz)</u>	<u>D.A. (mm)</u>	<u>G's</u>
20 - 40	5.1	-
40 - 200	-	18

- (b) Pressure: 241 kPa (35 psig) (applied during vibration).

- 6.4.13.1 Procedure: With the unit pressurized to 241 kPa (35 psig) the unit shall be vibrated for 20 hours in both the "X" and "Y" axes (see Fig. 20), at the vibration levels specified above.

The frequency of vibration shall be varied from 20 to 200 Hz in accordance with the vibration levels specified above with one pass of scanning at least 15 minutes duration. There shall be no evidence of structural damage or leakage during this test.

- 6.4.14 Collapse Pressure: A suitable contaminant shall be added as described in paragraph 6.4.7 (except time and contaminant quality need not be recorded) until the collapse pressure of the element is reached. The collapse pressure shall not be less than 689 kPa (100 psi) differential.

6.4.15 Filtration Efficiency: Degree of filtration (Filter element efficiency)
- The degree of filtration for filter elements shall be determined by the test specified herein. It is of primary importance that the test fluid and air used in the degree of filtration test be clean and filtered prior to test. Fig. 17 shows a degree of filtration test setup with a cleanup device attached. This test shall be performed at room ambient temperature.

6.4.15.1 System Add and Blank Values: The test specified in paragraph 6.4.15.2 with the filter element removed shall be repeated four items or four separate contaminant-add values (A in the paragraph 6.4.15.2 formula). Test fluid cleaned by a 3 mm absolute filter shall be used for each test. The contaminant collected shall be the add value and shall be used in the calculation of degree of filtration. It shall be the average of these four runs. None of the four add values shall be less than 95% by weight of the contaminant introduced. To ensure cleanliness of the system and the filter assembly, a system blank value shall be obtained by repeating paragraph 6.4.15.2(a) and (b) with the filter element installed and no contaminant added. This blank value shall be the value C in the following formula and shall be less than 0.0007 gram.

6.4.15.2 Test Procedure:

- (a) A setup shall be made as shown on Fig. 17 without installing the filter element in the test housing.
- (b) Flush 2,000 cm³ of prefiltered test fluid at room temperature through the contaminant mixing chamber and the filter housings, and discard. This operation shall be repeated.
- (c) Add 2,000 cm³ of previously filtered test fluid at room temperature through plug valve A. The element shall be installed in the filter housing.
- (d) Valve B shall be closed.
- (e) A 5 cm³ slurry containing contaminant, in accordance with Table I, shall be added to the test fluid through a small funnel inserted in the plug valve A. The contaminant shall be APM F-13 beads or equivalent.
- (f) The contaminant shall be distributed uniformly by churning the test fluid with an agitator for three minutes.
- (g) Plug valve A shall be closed and the glass chamber containing the test fluid and contaminant shall be pressurized using the air regulator. The air regulator is used to maintain rated flow.

6.4.15.2 Test Procedure:

- (h) Valve B shall be opened and air pressure shall force the test fluid containing the contaminant through the sample filter assembly. This filtrate shall be collected in a clean, 4,000-cm³ beaker. Using a suitable wash bottle, 750 cm³ of petroleum ether [boiling point (b.p.) 35° to 54°C or other suitable fluid] shall then be washed through the contaminant mixing chamber and test filter assembly. The wash fluid shall be collected in the same 4,000-cm³ beaker.
- (i) A membrane filter 47-mm diameter disk, absolute 0.8 mm type AA Millipore, or equivalent, shall be washed with 200 cm³ of prefiltered petroleum ether or other suitable fluid and dried to constant weight at 52°C (125°F). The weight shall be accurate to 0.1 milligram. The disk shall be heated at 52°C for 30 minutes and then cooled 30 minutes in a dessicator.
- (j) The weighed filter membrane shall be assembled into the filter holder assembly (see Fig. 18) and fitted to a 4,000 cm³ vacuum flask connected to a suitable vacuum (minimum 635 mm of Hg vacuum).
- (k) All test fluid passed through the test filter is filtered through the membrane disk. The 4,000 cm³ beaker shall be washed with 500 cm³ of prefiltered naptha and 500 cm³ of prefiltered petroleum ether (b.p. 35°C to 54°C) and fluid from the washed beaker shall be passed through the membrane. The filter funnel shall also be washed down with 100 cm³ of prefiltered naptha and 100 cm³ of prefiltered petroleum ether.
- (l) Maintaining vacuum, the top half of the filter funnel assembly shall be removed. The membrane filter shall now be exposed for further washing.
- (m) With a wash bottle of prefiltered petroleum ether (b.p. 35° to 54°C) or other suitable fluid, the rim of the membrane filter shall be gently washed to remove traces of test fluid, being careful not to disturb the cake. Vacuum shall be maintained during this operation.
- (n) The vacuum shall be shut off and the membrane filter removed. It shall be dried to a constant weight at 52°C and weighed to 0.1 of a milligram.

6.4.15.2 (Continued):

The difference between the membrane filter weights before and after the above procedure is the weight of contaminant passing through the test filter, B in the following formula:

$$\text{Filter element efficiency} = \frac{A - (B - C)}{A} \times 100$$

Where:

- | | |
|-------------------------|---|
| A = (add value) | = Amount of test contaminant passed through system when there is no filter element in the filter housing. |
| B = (Contaminant Value) | = Amount of test contaminant passed through the test filter assembly (element installed). |
| C = (blank value) | = Amount of contaminant attributed to the test system and test filter assembly when no test contaminant has been added. |

The filter element efficiency shall be 90% minimum.

6.4.16 Anti-drainback Valve Leakage Test: The test filter shall be installed in a test system as described in SAE J806, Chapter 6.

The temperature for this test shall be $21^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($70^{\circ}\text{F} \pm 5^{\circ}\text{F}$).

The test fluid for this test shall be Mentor No. 28 (Esso) or equivalent with a 38-45 SSU viscosity at 21°C and be equivalent in flow characteristics to SAE #10.

The test filter shall be purged by opening the necessary valves and pumping test fluid through the filter until the fluid is free of air bubbles.

The anti-drainback valve shall be actuated a minimum of five times during the purge cycle by stopping and restarting the flow through the filter.

After purging the filter, the sump return line shall be closed and the valve to the graduated column opened.

The graduated column shall be filled to slightly above the 610 mm mark.

After the column is filled, the filter inlet valve shall be closed and the pump shut off.

The cap from the leakage drain tube shall now be removed and the trapped fluid allowed to drain for two minutes.

6.4.16 (Continued)

The pressure head shall now be adjusted and maintained at 610 mm throughout the test.

At the end of the two minute residual drain period, a graduate beaker shall be placed under the drain tube and the leakage rate recorded in millimeters at ten minute intervals for the first hour and hourly thereafter. Allowable leakage rates shall be specified by the particular engine manufacturer involved.

- 6.4.17 Bonding Pull Test - (With Element removed from filter housing): Filter elements from the hot oil soak test (paragraph 6.4.8) shall be bubble tested (per paragraph 6.4.6) and installed in a fixture or holding device such that a separating force may be applied to both end caps simultaneously. The separating force shall be applied in approximately 45 N increments until failure occurs.

The result of this test should be such that the filter media tears or separates before the end cap bonding fails.

6.5 Acceptance Testing:

Ref. Paragraph
No. Herein

Tests

6.5.1

Examination of Product

6.5.2

Leakage Test & Thread
Squareness Verification

- 6.5.1 Examination of Product: Same as paragraph 6.4.2 except thread squareness check not required.

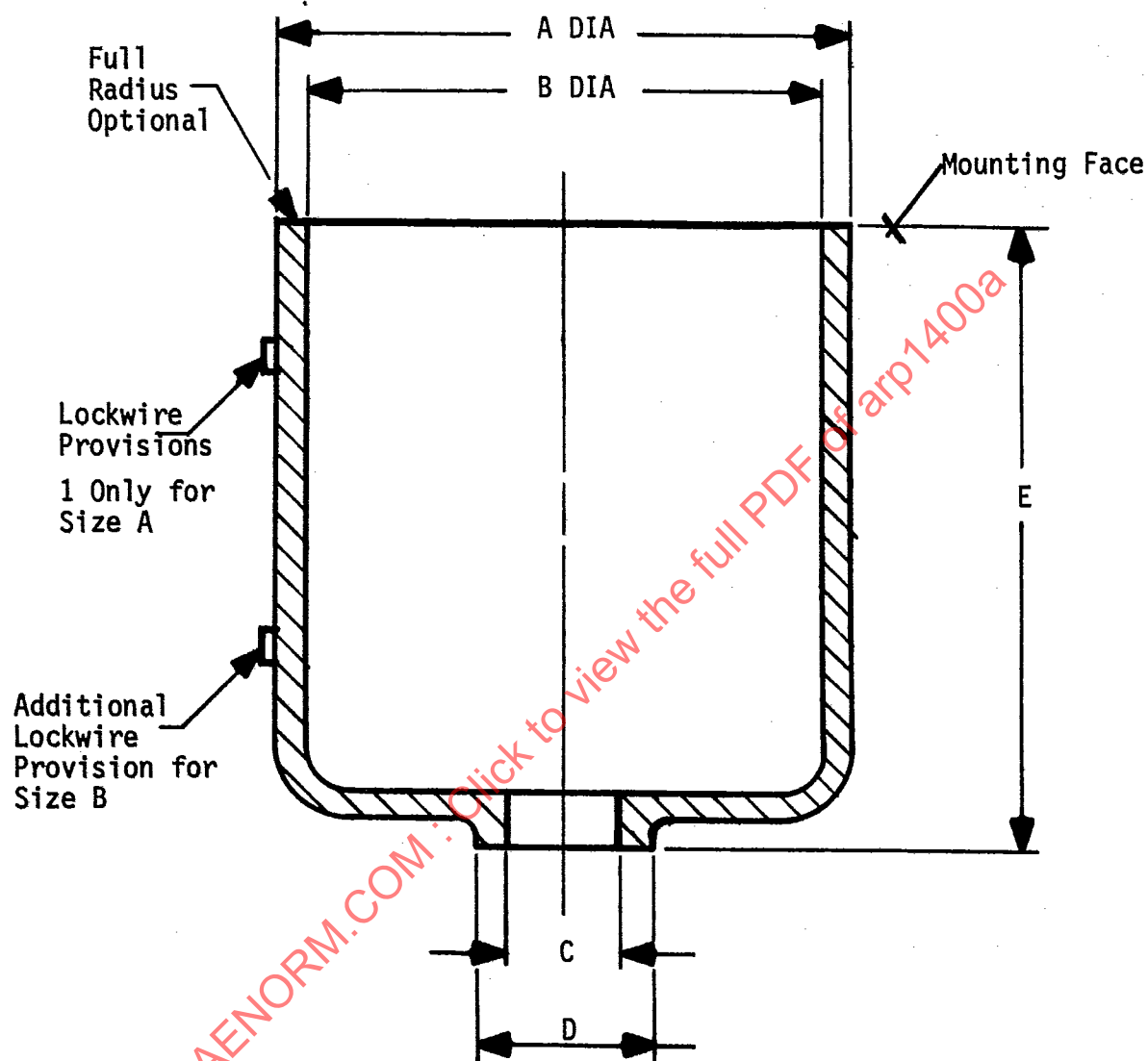
- 6.5.2 Leakage Test & Thread Squareness Verification: Each filter assembly shall be pressurized to 689 kPa (100 psig) for at least 5 seconds. There shall be no evidence of external leakage or deviation from the thread squareness requirements of Figs. 9 and 10.

- 6.6 Sampling Tests: Sampling tests shall be performed periodically during each production run of filters and filter assemblies in order to monitor and maintain product integrity after qualification. The testing shall be performed per the procedures of this specification. Sampling plan procedures, when acceptable, shall be specified by the purchaser.

7. PACKAGING: All packaging shall be standard commercial quality sufficient to prevent damage during normal commercial carrier shipment and handling.

8. ORDERING INFORMATION: When ordering filter assemblies, replacement filter elements or accessories furnished under this specification, specify the following:

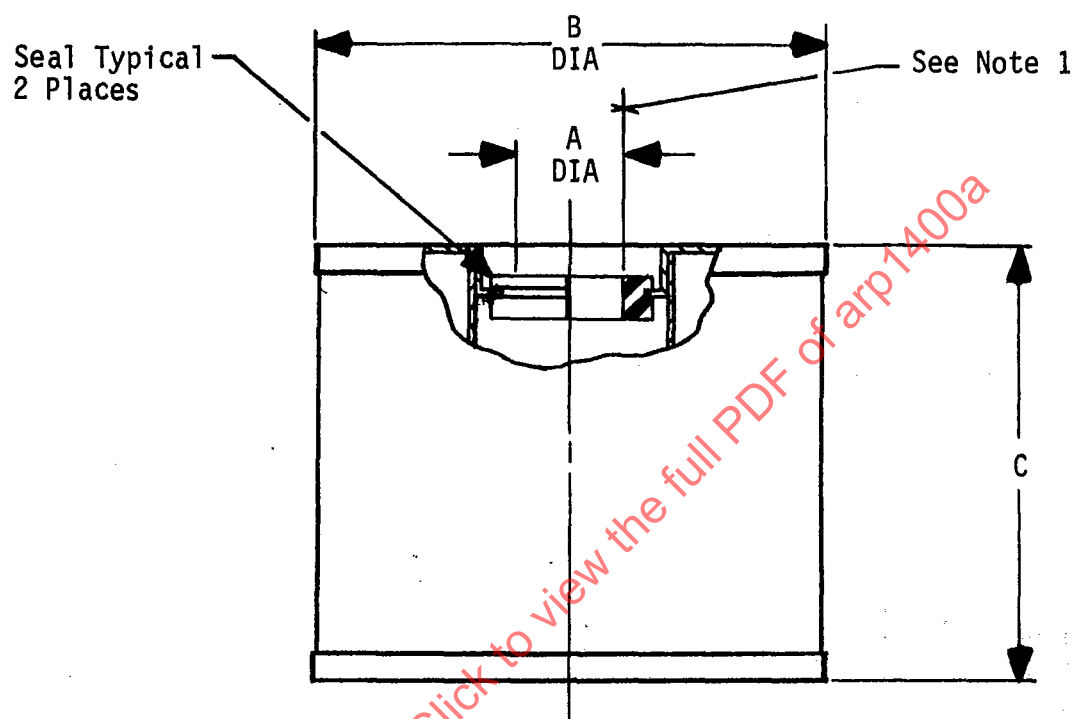
Manufacturer's Part No.
SAE Specification No.
Category No.
Convenience Devices Desired.



DIMENSION	mm				
	A(MAX.)	B	C	D	E
Size A	101.1	92.7	$20.32^{+.25}_{-.13}$	30.2	110.2
Size B	101.1	92.7	$20.32^{+.25}_{-.13}$	30.2	150.9

SHELL (BOLT-ON TYPES) CATEGORY IA

Ø FIGURE 1



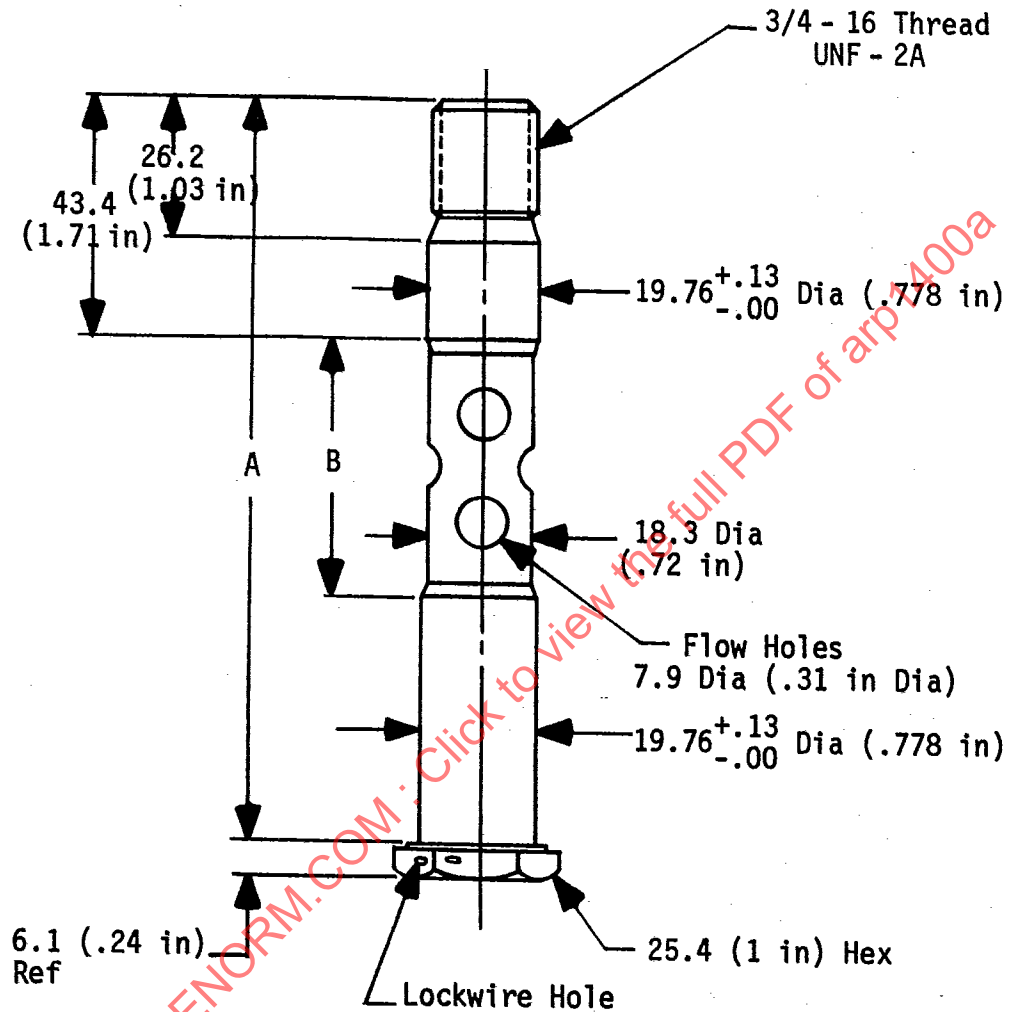
Note 1: This installed seal diameter shall permit assembly on bolt per Figure 3 when lubricated with SAE 40 or 50 wt. aviation oil without extrusion or undue force. An oil tight seal shall be established between bolt and filter element.

Note 2: End caps must be square with filter media to within 3.2 mm over length of filter element.

DIMENSION	mm		
	A DIA.	B DIA.	C
Size A	19.30 ± .13	87.9 ± 1.0	74.9 ± 1.5
Size B	19.30 ± .13	87.9 ± 1.0	116.1 ± 1.5

FILTER ELEMENT (CATEGORIES IA & IB)

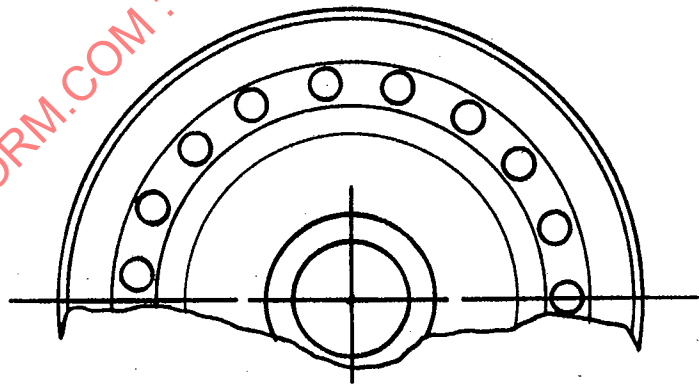
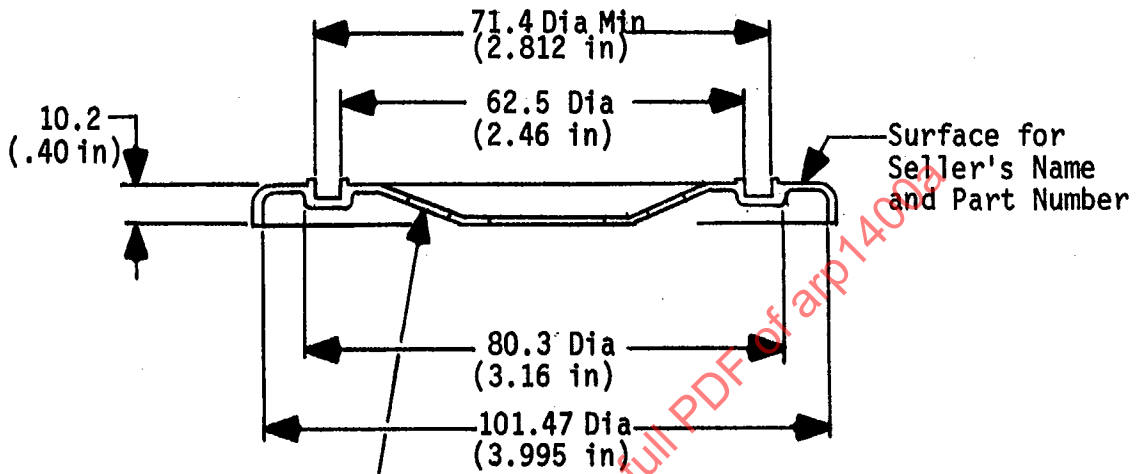
Ø FIGURE 2



DIMENSION	A (mm)	B (mm)
Size A	131.8	45.2
Size B	172.5	85.9

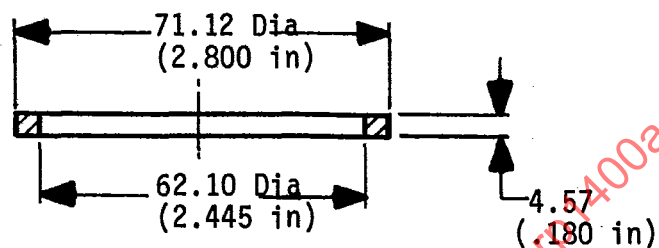
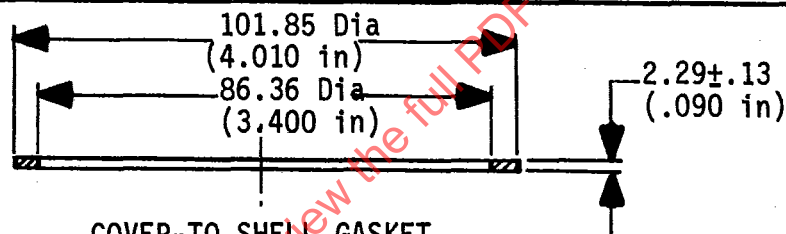
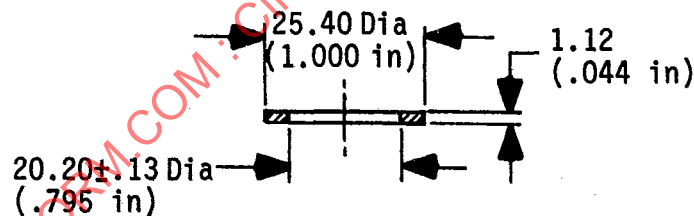
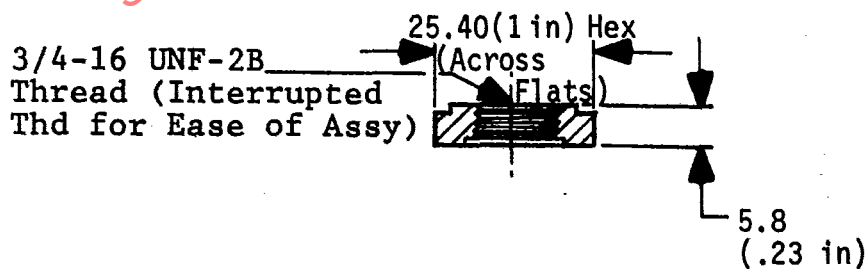
BOLT
(For Shell & Bolt Style Filters)

FIGURE 3



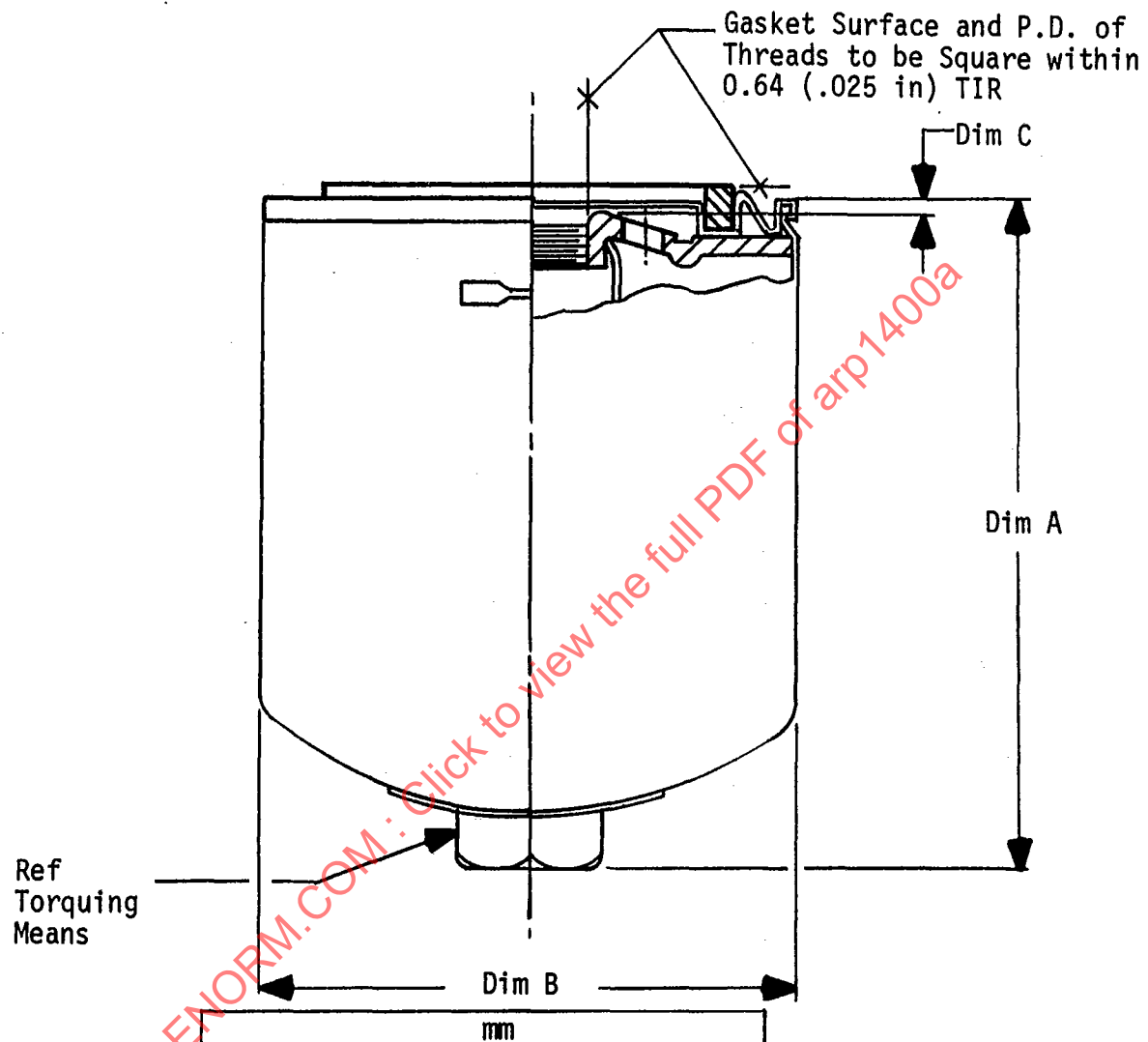
COVER PLATE (CATEGORY IA)

Ø FIGURE 4

COVER-TO-ADAPTER GASKET
FIGURE 5COVER-TO-SHELL GASKET
FIGURE 6BOLT-TO-SHELL GASKET
FIGURE 7

ASSEMBLY NUT

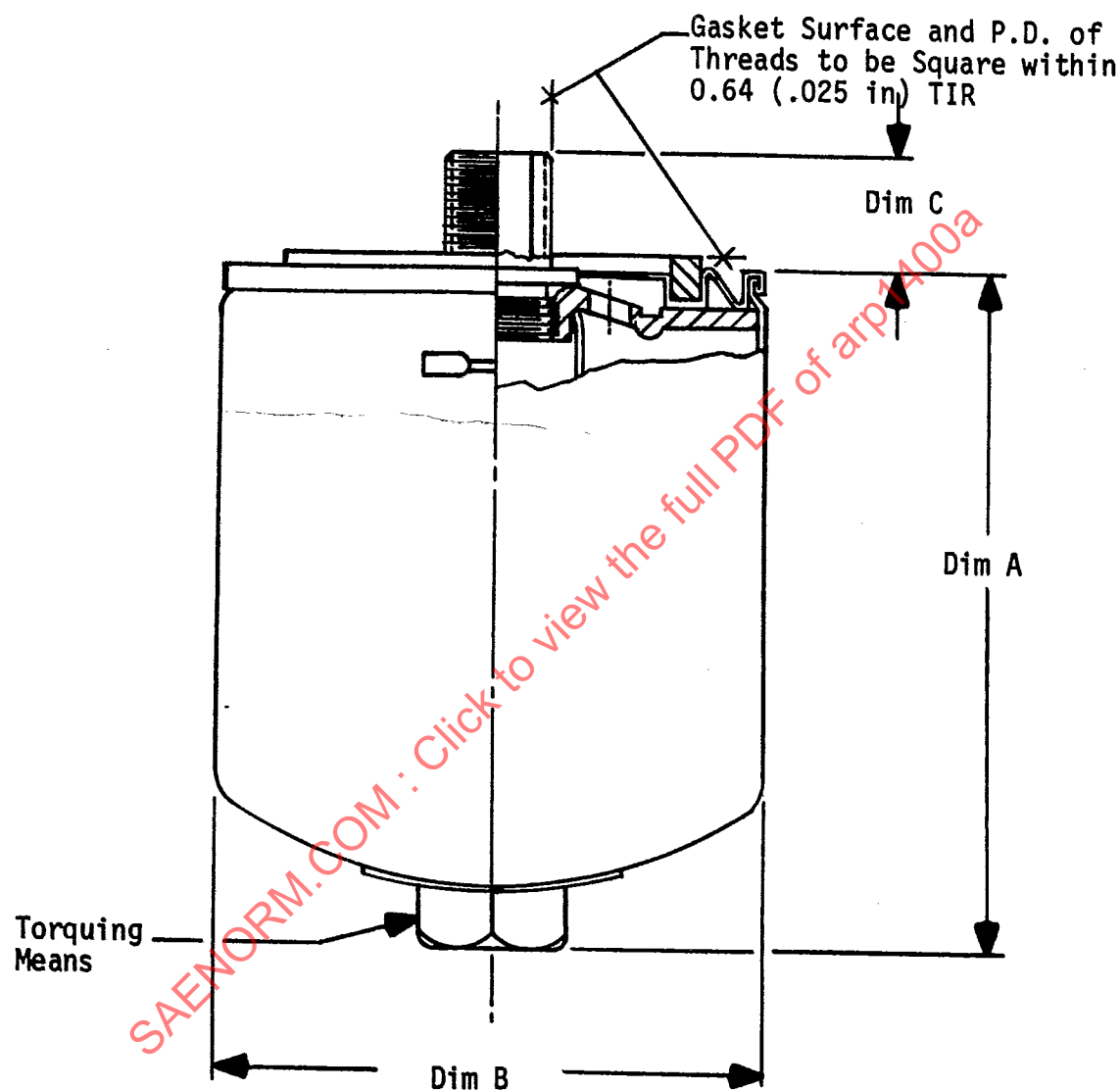
Ø FIGURE 8



DIMENSION	A (MAX)	B DIA (MAX)	C (REF)	RECOM. THD SIZE
Size A	124.0	99.1	4.06	3/4-16 UNF-2B
Size B	165.1	99.1	4.06	3/4-16 UNF-2B

SPIN-ON FILTER ASSEMBLY (CATEGORY IIA)
 MIN RATED PROOF PRESSURE - 1724 kPa GAGE (250 PSIG)
 OR 2758 kPa GAGE (400 PSIG)

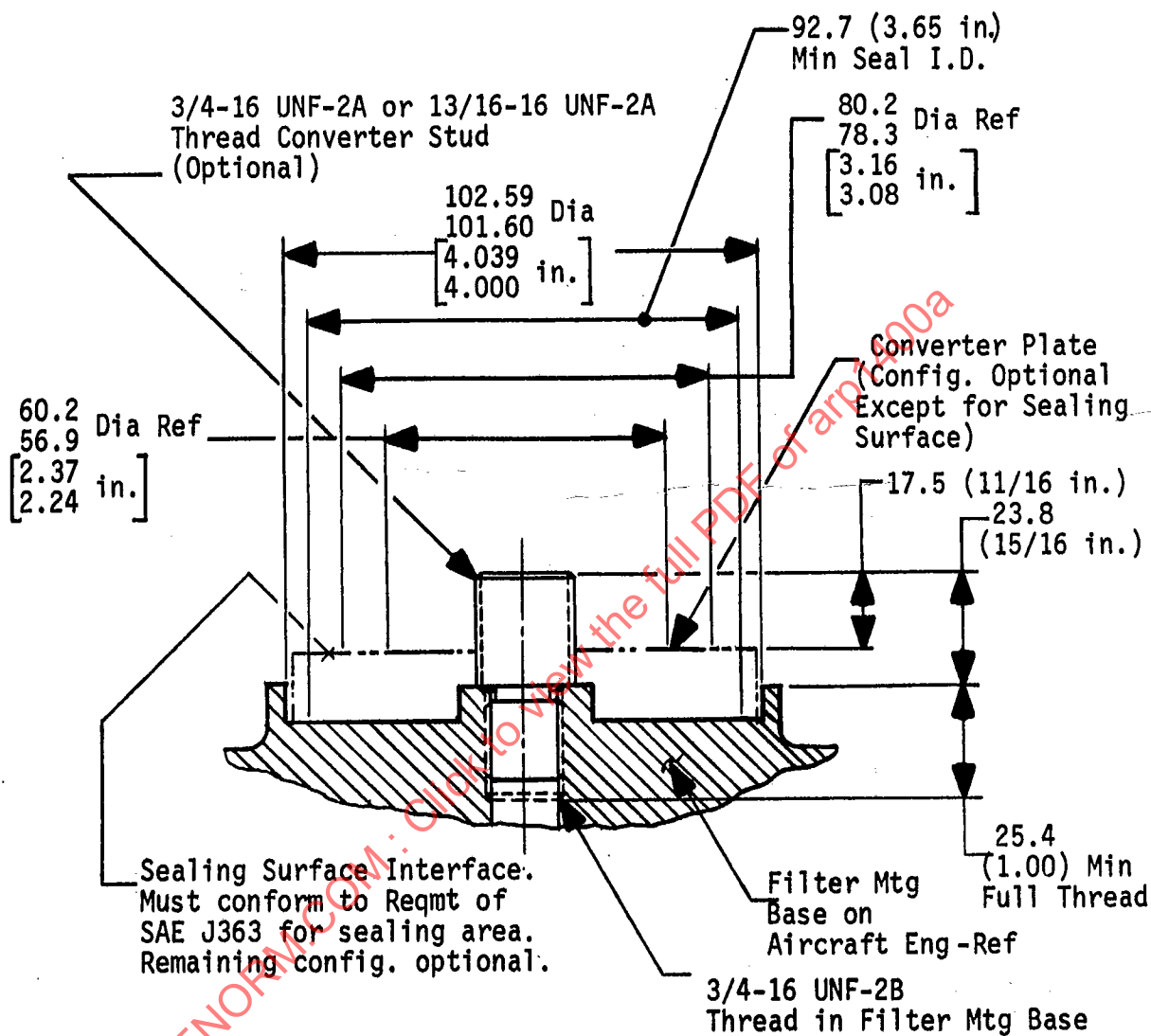
Ø FIGURE 9



DIMENSION	A (MAX)	B DIA (MAX)	C (REF)	RECOM. THD SIZE
Size A	124.0	99.1	17.3	3/4-16 UNF-2A
Size B	165.1	99.1	17.3	3/4-16 UNF-2A

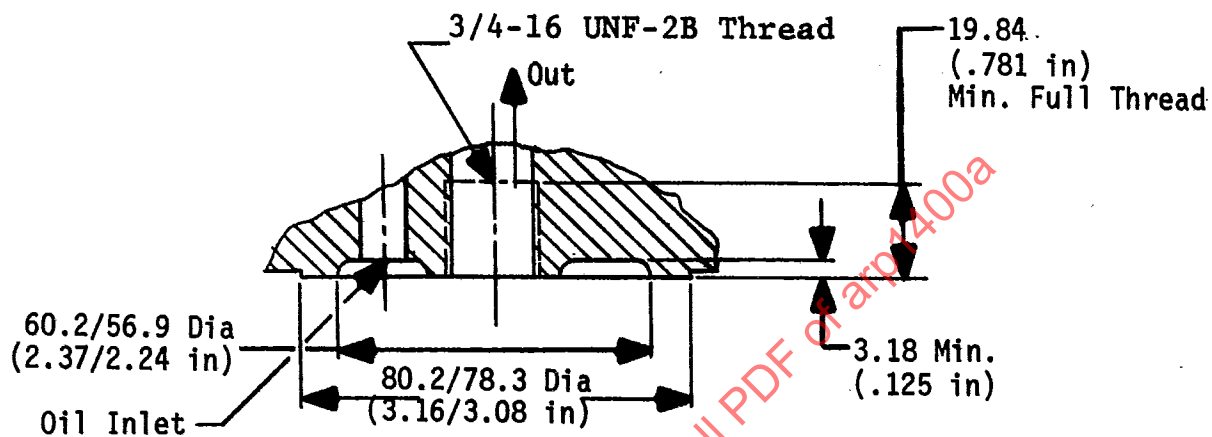
SPIN-ON FILTER ASSEMBLY (CATEGORY IIB)
 MIN RATED PROOF PRESSURE - 2758 kPa GAGE (400 PSIG)

Ø FIGURE 10



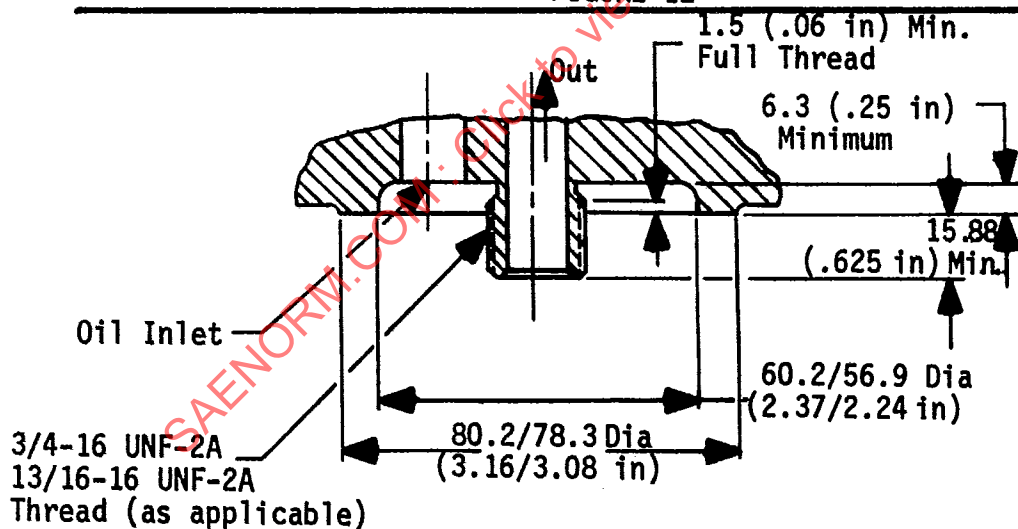
INTERFACE DEFINITION FOR CONVERSION
TO SPIN-ON FILTERS
(From Shell & Bolt Filter Assy's)

Ø FIGURE 11



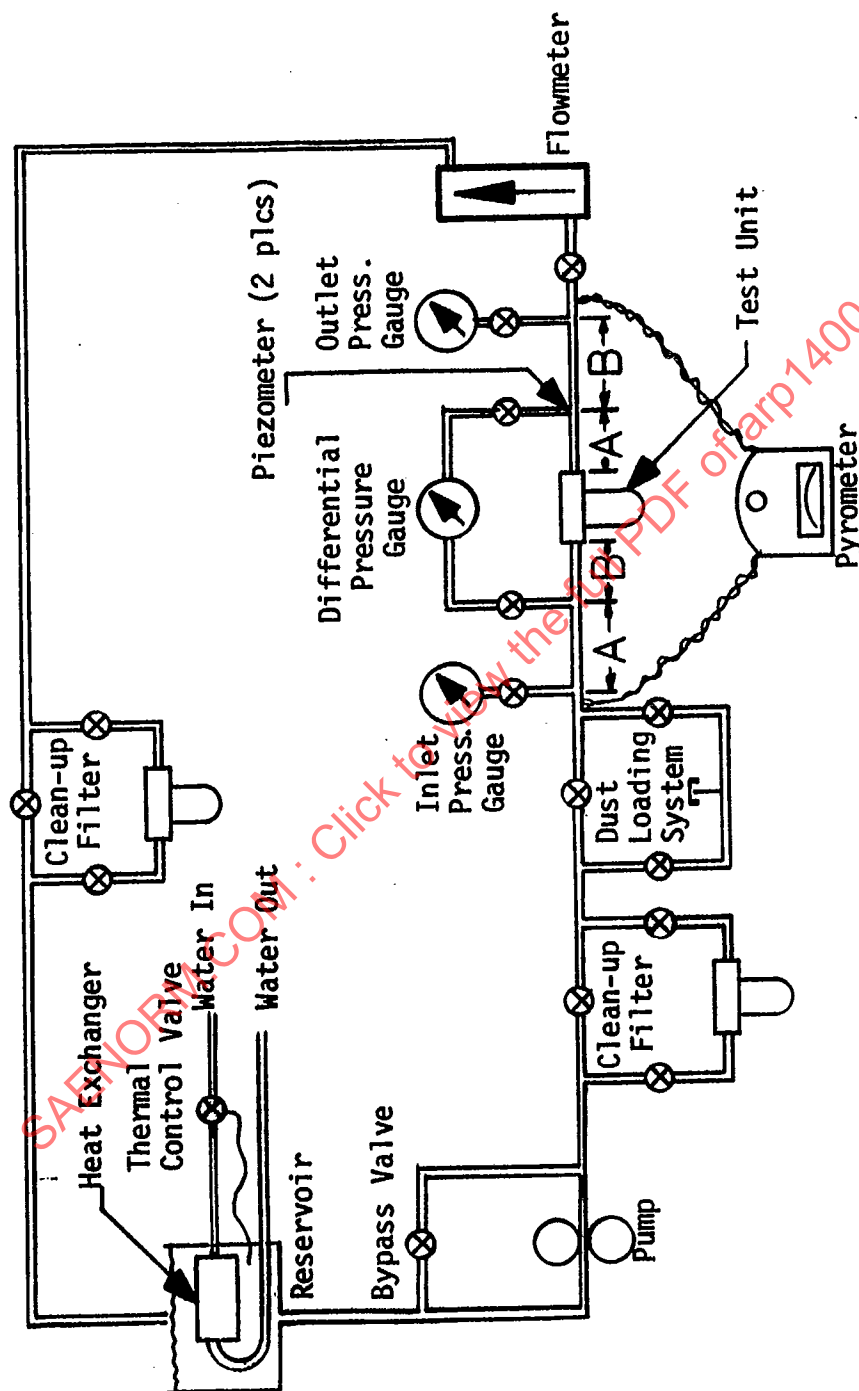
FILTER MOUNTING BASE FOR CATEGORY
IA WITH COVER PLATE AND IIB

Ø FIGURE 12



FILTER MOUNTING
BASE CATEGORY IIA

Ø FIGURE 13

**LEGEND**

A 15 Tube Dias min.

B 4 Tube Dias min.

⊗ Shutoff Valve

SCHEMATIC - CONTAMINANT CAPACITY AND COLLAPSE
PRESSURE TEST SYSTEM (Typical Setup)

FIGURE 14