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SELECTION AND APPLICATION OF POLYTETRAFLUOROETHYLENE (PTFE OR TFE) BACKUP RINGS FOR HYDRAULIC AND PNEUMATIC FLUID POWER APPLICATIONS

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1. SCOPE:

The backup ring is defined. The various types designed for use with O-rings in MIL-G-5514 packing glands, and MS33566 and MS21344 universal fitting installations are described.

Guidelines are included for selecting backup rings and backup ring materials. Backup ring installation procedures and precautions are described.

1.1 Purpose:

The purpose of this document is to provide information that will aid design engineers and maintenance personnel in the selection and use of TFE backup rings (retainers) and backup ring materials for aircraft and aerospace hydraulic and pneumatic fluid power applications.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS683	Installation Procedures and Torques for Fluid Connections
ARP1231	Gland Design, Elastomeric O-ring Seals, General Considerations
AIR1186	Installation and Use of Equilateral Triangle Cross-Section Hydraulic O-ring Seal Backup Rings (Dyna-Bak)

2.2 Military Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-5440	Hydraulic System; Aircraft, Types I and II, Design and Installation Requirements for
MIL-G-5514	Gland Design; Packings, Hydraulic, General Requirements for
MIL-R-8791	Retainer; Packing, Hydraulic and Pneumatic, Tetrafluoroethylene Resin
MIL-R-8791/1	Retainer; Packing, Hydraulic and Pneumatic, Polytetrafluoroethylene Resin (Single Turn)
AN6289	Nut; Universal Fitting
MS21344	Fittings; Installation of Flared Tube, Straight Threaded Connections, Design Standard for
MS27595	Retainer; Packing Backup, Continuous Ring, Tetrafluoroethylene
MS28773	Retainer; Packing Backup, Tetrafluoroethylene Straight-Thread Tube Fitting Boss
MS28774	Retainer; Packing Backup, Single-Turn Tetrafluoroethylene (This document is inactive for new designs after 25 March 1989. Use MIL-R-8791/1.)

2.2 (Continued):

MS28782	Retainer; Packing Backup, PTFE
MS28783	Ring; Gasket Backup, PTFE
MS33566	Fittings; Installation of Flareless Tube, Straight-Thread Connectors
MS33649	Bosses; Fluid Connection, Internal, Straight-Thread

3. BACKUP RING FUNCTION AND USE:

3.1 O-rings Extrude:

O-rings will extrude under adverse conditions of pressure, temperature, fluid compatibility, and diametral extrusion clearance (Figure 1).

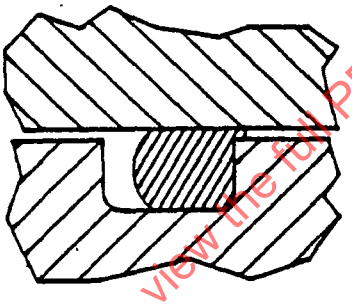


FIGURE 1 - Extrusion of an Unprotected O-ring at High Pressures

3.2 Backup Rings Prevent Extrusion:

TFE backup rings used in conjunction with elastomeric O-ring seals are antiextrusion devices which deform under pressure to maintain essentially zero diametral extrusion clearance for the O-ring and prevent its extrusion (Figure 2). They are effective for this purpose under both dynamic and static conditions. TFE backup rings are also effective in hostile environments, that may reduce the ability of the O-ring to resist extrusion as a result of temporary or permanent change in the physical properties of the elastomer.

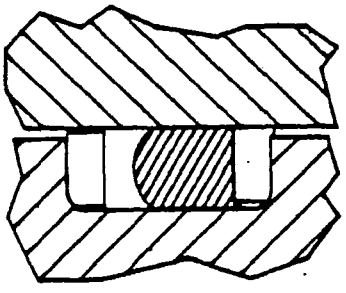


FIGURE 2 - Backup Rings Protect O-rings From Extrusion at High Pressures

3.3 Standard O-ring Glands:

Dimensional details of standard glands for use with O-rings and backup rings are described in MIL-G-5514. Installation details for universal fittings installed in bosses are described in MS33566 and MS21344.

3.3.1 MIL-G-5514 Glands: O-ring glands are identified either as a NO backup ring gland, a ONE backup ring gland, or a TWO backup ring gland (Figure 3), and as an internal gland (for I.D. or rod sealing) or an external gland (for O.D. or piston sealing). The diametral extrusion clearances resulting from using the standard dimensions and tolerances are intended for sealing with normal hydraulic operating pressures up to 3000 psi, and with hydraulic fluid temperatures within the range of -65 to +275 °F when used with backup rings. The NO backup ring gland configuration may be used at pressures below 1500 psi. Higher pressures and/or higher temperatures may require extrusion clearances that are less than those provided by the standard dimensions of MIL-G-5514, and/or special backup ring configurations and materials.

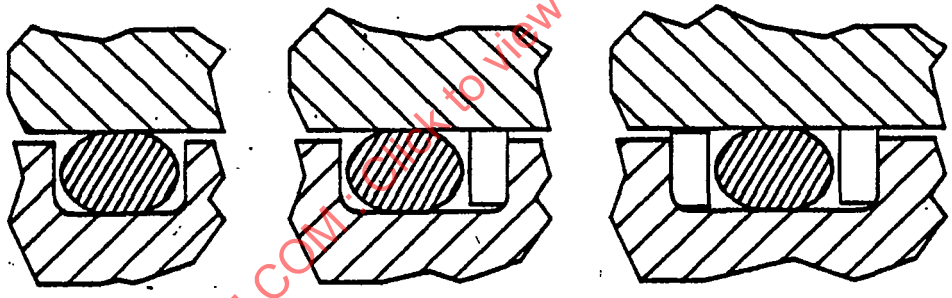


FIGURE 3 - Backup Rings

3.3.2 MS21344 and MS33566 Fitting Installation Standards Pertaining to Universal Fittings: Universal fittings are rarely used in new design. MIL-H-5440 requires special approval for the use of universal fittings. Universal fittings per MS21344 and MS33566 are installed as shown in Figure 4.

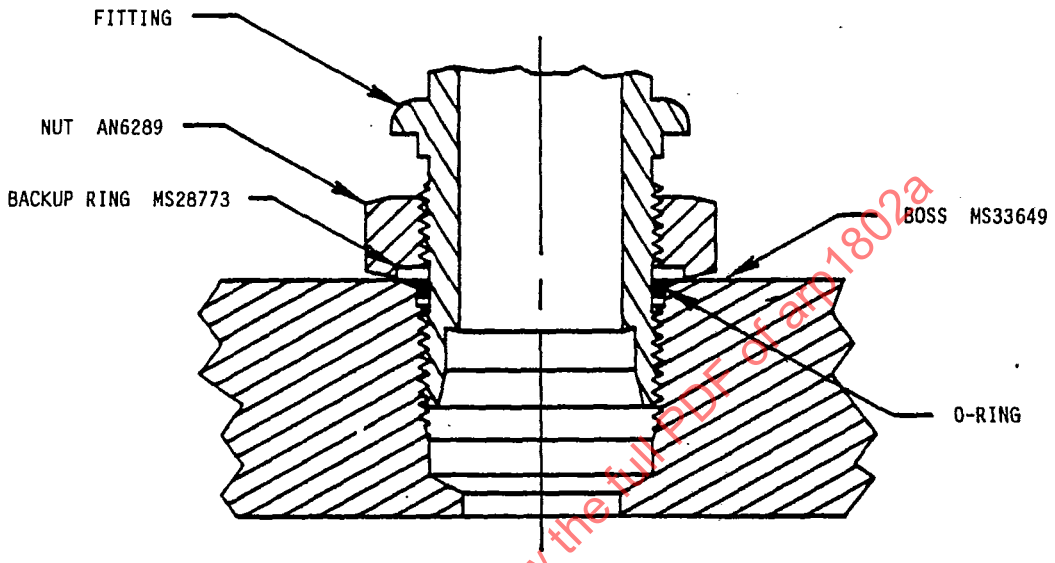


FIGURE 4 - Universal Fitting Installation

4. BACKUP RING CONFIGURATIONS:

4.1 Basic Types:

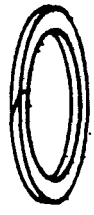
There are three basic types of backup rings in use (Figure 5). Dimensional details and material vary depending upon whether the ring is manufactured to a military standard or to one of the many commercial standards.

These three types of military and commercial standard backup rings are installable in all MIL-G-5514 gland revisions. Some restriction should be noted for differences between the glands (see 6.1). An exception is MS28773 backup ring, which is used as a universal fitting seal backup ring per MS21344 or MS33566.

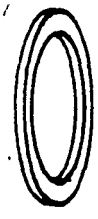
4.2 Special Types:

In addition to the three basic types of backup rings, right triangle backup rings and camming backup rings are available for special purpose applications (Figure 6).

SPIRAL-CUT BACKUP RING
MS28782 AND MS28783

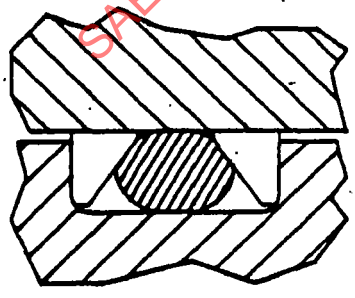


SINGLE-TURN BACKUP RING
MS28773, MS28774, AND
MIL-R-8791/1

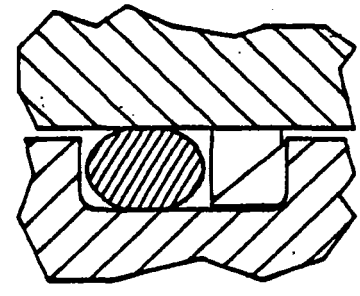


CONTINUOUS UNCUT BACKUP RING
MS27595

FIGURE 5 - Three Types of Backup Rings



RIGHT TRIANGLE BACKUP RINGS



CAMMING BACKUP RINGS

FIGURE 6 - Special Purpose Application Backup Rings

4.3 Heavy-Duty Backup Rings:

Spiral-cut, single-turn, and continuous (uncut) backup rings are available from commercial sources in so-called heavy-duty versions. Heavy-duty backup rings offer greater resistance to extrusion.

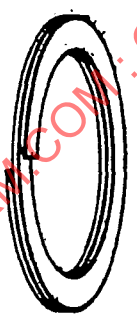
4.4 Equilateral Triangle Backup Rings:

Equilateral triangle backup rings are available as commercial standard items, as both uncut and scarf-cut backup rings. This backup ring configuration requires a modification of the MIL-G-5514 gland, and, therefore, is not discussed in detail herein. For further information on this backup ring configuration and usage, refer to AIR1186.

5. SPIRAL-CUT BACKUP RINGS:

5.1 Spiral Backup Rings MS28782 and MS28783:

Spiral-cut backup rings (Figure 7) provide excellent extrusion protection for many O-ring applications. They are recommended for Type I (-65 to +160 °F) Class 1 (1500 psi) and Class 2 (3000 psi) hydraulic systems per MIL-H-5440, but are not recommended for Type II (-65 to +275 °F) Class 1 and 2 hydraulic systems or for use with universal fittings (MS21344 or MS33566). Further information on gland comparisons can be found in 6.1.



SPIRAL-CUT BACKUP RING
MS28782 AND MS28783

FIGURE 7 - Spiral-Cut Backup Rings

5.2 Advantages of Spiral Backup Rings:

5.2.1 Gapping of the rings at the cut ends cannot occur.

5.2.2 Spiral backup rings can be used in the field on nonstandard diameters. Spiral backup rings are readily sized on installation by clipping the ends to correct for overlap. Therefore, an oversized ring can be "fitted" when the exact diameter ring, to match the gland, is not available. Spacing of the end should be controlled to minimize the gap. Correct underlap shown in Figure 8 is required above 1500 psi.

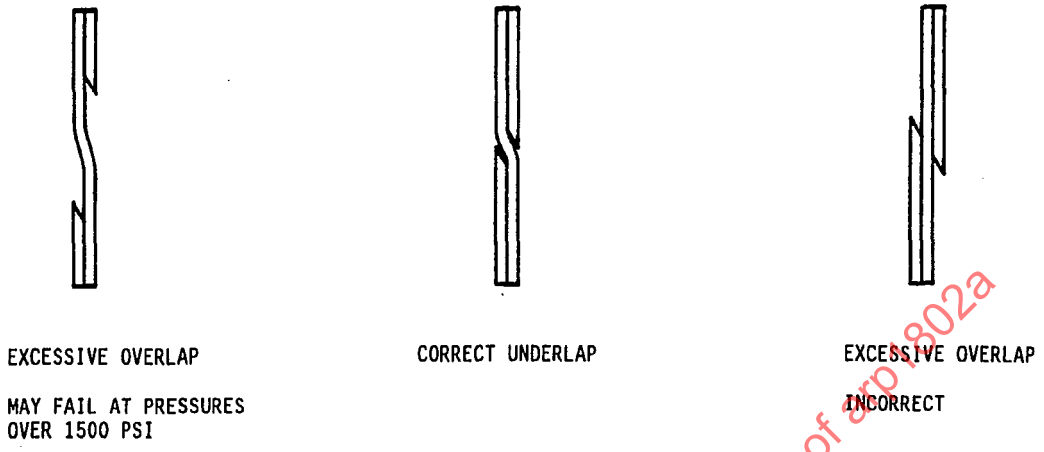


FIGURE 8 - Underlap of Backup Rings

5.3 Installation:

5.3.1 The spiral-cut backup rings, while less resistant to extrusion, provide greater ease of installation than the single-turn backup rings. This is of special importance for very small sizes, where a single-turn, scarf-cut backup ring can be structurally damaged when being fitted into the groove.

5.3.2 Care must be taken during assembly of hydraulic or pneumatic components fitted with spiral backup rings to prevent "shearing" of one end of the ring as the ring engages the rod or cylinder bore. See Figure 9.

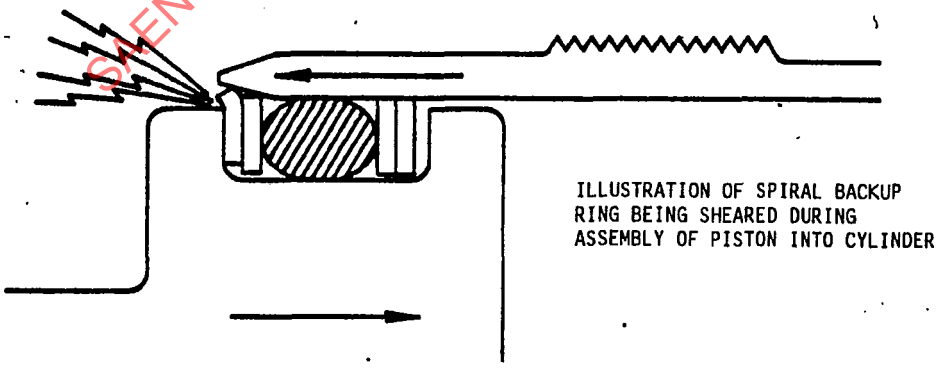


FIGURE 9 - Spiral Backup Rings

5.3.3 It is sometimes advantageous to install spiral-cut backup rings in a reverse wound condition, as indicated by Figure 10, especially for threaded installation. This installation method causes clockwise rotation, between the two ends, to tighten the coil of the backup ring during the threaded installation.

NORMAL CONFIGURATION
OF SPIRAL BACKUP RING

REVERSE WOUND CONFIGURATION
OF SPIRAL BACKUP RING

FIGURE 10 - Spiral-Cut Backup Rings in a Reverse Wound Condition

6. SINGLE-TURN, SCARF-CUT BACKUP RINGS:

6.1 Single-Turn Backup Rings:

Single-turn backup rings (Figure 11), per MS28773, MS28774, and MIL-R-8791/1 are recommended for Type I (-65 to +160 °F) and Type II (-65 to +275 °F) Class 1 (1500 psi) or Class 2 (3000 psi) hydraulic systems per MIL-H-5440.

MIL-R-8791/1 backup rings were developed to provide a better fit for the MIL-G-5514 glands of revisions C, D, E, and F. Problems were reported by users with regard to using the MS28774 backup rings in these later glands. As the data shows, there was an overlap present when installing the MS28774 backup rings into the revision C and later glands. This overlap made it very difficult to install these rings and some even resorted to trimming to make the rings fit. The MIL-R-8791/1 rings have some diametrical clearance on the O.D. that greatly reduces the effort required for installation. The I.D. of the MIL-R-8791/1 rings also provides a better fit than is possible with the MS28774 rings.

The MIL-R-8791/1 rings cannot be used in earlier versions (revisions A and B) of MIL-G-5514 because of the large interference present at the I.D. Also, while the MS28774 rings can be used in the later versions of MIL-G-5514, this is not recommended due to the problems previously discussed.

It should also be noted that the MIL-R-8791/1 rings are configured with a greater "T" (axial thickness) dimension. This extra thickness provides more extrusion protection for the O-rings.

FIGURE 11 - Single-Turn Backup Rings MS28773, MS28774, and MIL-R-8791/1

6.2 Advantages:

The relatively greater axial thickness compared to the thickness of each turn of a spiral-cut backup ring provides a more rigid structure to resist extrusion of the backup ring itself. This is particularly important at elevated temperatures and pressures. The thickness is approximately the same as two turns of a spiral ring. (See "T" dimension of MS28774, MS28782, and MIL-R-8791/1.)

The single-turn construction of the backup ring resists "shearing" during assembly of hydraulic components.

6.3 Installation:

Slight overlapping of the ends of MS28774 and MIL-R-8791/1 backup rings at room temperature is a design feature necessary to accommodate circumferential contraction at low temperature. The designed overlap does not interfere with O-ring performance (Figure 12).

Excessive overlap, however, can cause installation difficulties and O-ring damage (Figure 13). The practice of "sizing" MS28774 and MIL-R-8791/1 backup rings by clipping the ends to prevent overlap may cause underlap and is not recommended.

It is not uncommon to find underlap (gapping) of single-turn rings that have been in service. Underlap can cause premature extrusion failure of the O-ring Figure 14).

Underlap is caused by:

a. The use of an incorrect ring
b. Circumferential shrinkage of rings made from material that has not been stress relieved
c. Excessive clipping to reduce overlap at room temperature

FIGURE 12 - Slight Overlap Required to Minimize Gapping at Low Temperatures

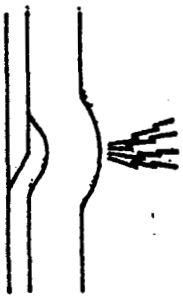


FIGURE 13 - Excessive Overlap

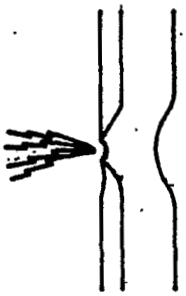


FIGURE 14 - Gapping

7. CONTINUOUS (UNCUT) BACKUP RINGS:

7.1 Uncut Backup Rings:

The uncut backup ring MS27595 (Figure 15) provides more reliable antiextrusion protection for O-rings than the spiral-cut or single-turn backup rings. They are recommended for Type I (-65 to +160 °F) Class 1 (1500 psi) and Type II (-65 to +275 °F) Class 1 and 2 (3000 psi) hydraulic system. In addition, they are preferred for Type II when pressures are expected to exceed 3000 psi. A concern is that a solid ring can act as a seal and cause pressure entrapment between the backup and its seal. The use of solid rings must take into account the resultant friction and stress which may be caused by entrapment.

FIGURE 15 - Continuous Uncut Backup Ring MS27595

7.2 Advantages:

Uncut backup rings overcome the problems of "shearing", overlap, and gapping often associated with conventional spiral-cut and single-turn rings. They have none of the disadvantages of the spiral-cut and the single-turn backup rings, but may be more difficult to install.