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ARP 1802

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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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ARP 1802

1. PURPOSE: The purpose of this report 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. SCOPE:
 - 2.1 The backup ring is defined. The various types designed for use with O-rings in MIL-G-5514 packing glands, and MS 33566 and MS 21344 universal fitting installations, are described.
 - 2.2 Guide lines are included for selecting backup rings and backup ring materials.
 - 2.3 Backup ring installation procedures and precautions are described.
3. REFERENCE DOCUMENTS:
 - 3.1 Government Publications, Military Specifications:

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
 - 3.2 Government Publications, Military Standards:

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

MS28782 Retainer; Packing Backup, Teflon*

MS28783 Ring; Gasket Backup, Teflon*

MS33566 Fittings; Installation of Flareless Tube, Straight-Thread Connectors

MS33649 Bosses; Fluid Connection, Internal, Straight-Thread
 - 3.3 Society of Automotive Engineers (SAE), Documents:

AS 683 Installation Procedures and Torques for Fluid Connectors

ARP 1231 Gland Design, Elastomeric O-Ring Seals, General Considerations

AIR 1186 Installation and Use of Equilateral-Triangle Cross-Section Hydraulic O-Ring Seal Backup Rings

*DuPont Trademark

4. BACKUP RING FUNCTION AND USE:

- 4.1 O-Rings Extrude: O-rings will extrude under adverse conditions of pressure, temperature; fluid compatibility and diametral extrusion clearance (Figure 1).
- 4.2 Backup Rings Prevent Extrusion: TFE backup rings used in conjunction with elastomeric O-ring seals are anti-extrusion 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.

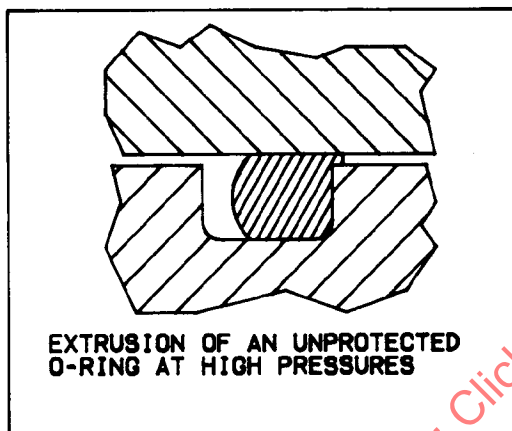


FIGURE 1

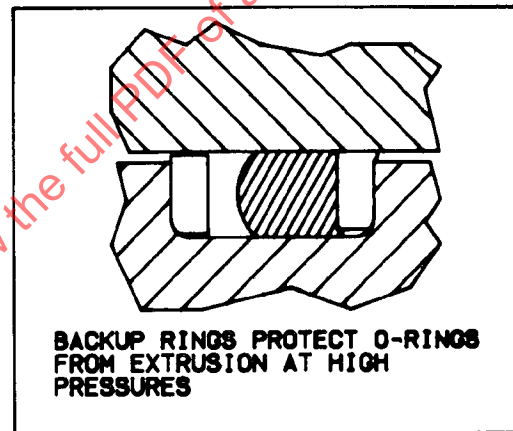


FIGURE 2

- 4.3 Standard O-Ring Glands: Dimensional details of standard glands for use with O-Rings and Backup Rings are described in specification MIL-G-5514. Installation details for universal fittings installed in bosses are described in standards MS33566 and MS21344.
- 4.3.1 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°F 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 may require special backup ring configurations and materials.

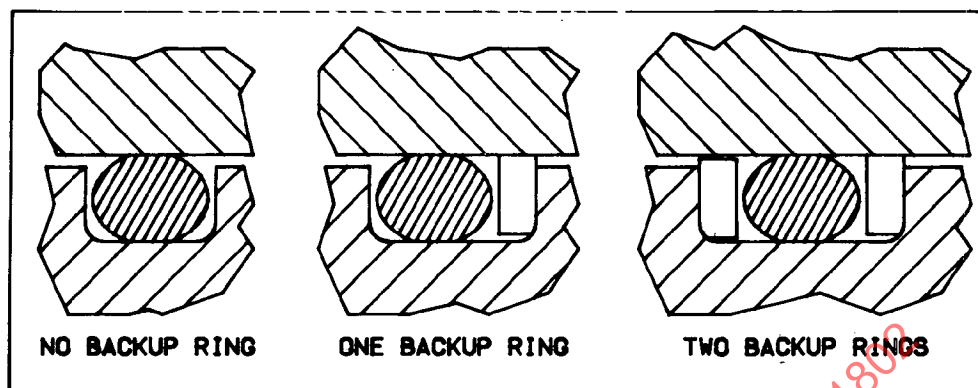


FIGURE 3

4.3.2 MS21344 and MS33566 Fitting Installation Standards Pertaining to Universal Fittings: Universal fittings are rarely used in new design. When used, MS21344 and MS33566 (Figure 4) are the design guide for MIL-H-5440 hydraulic systems. It is noted that MIL-H-5440F paragraph 3.11.10.1 states, "universal fittings shall not be used in hydraulic systems unless written approval is obtained from procuring activity."

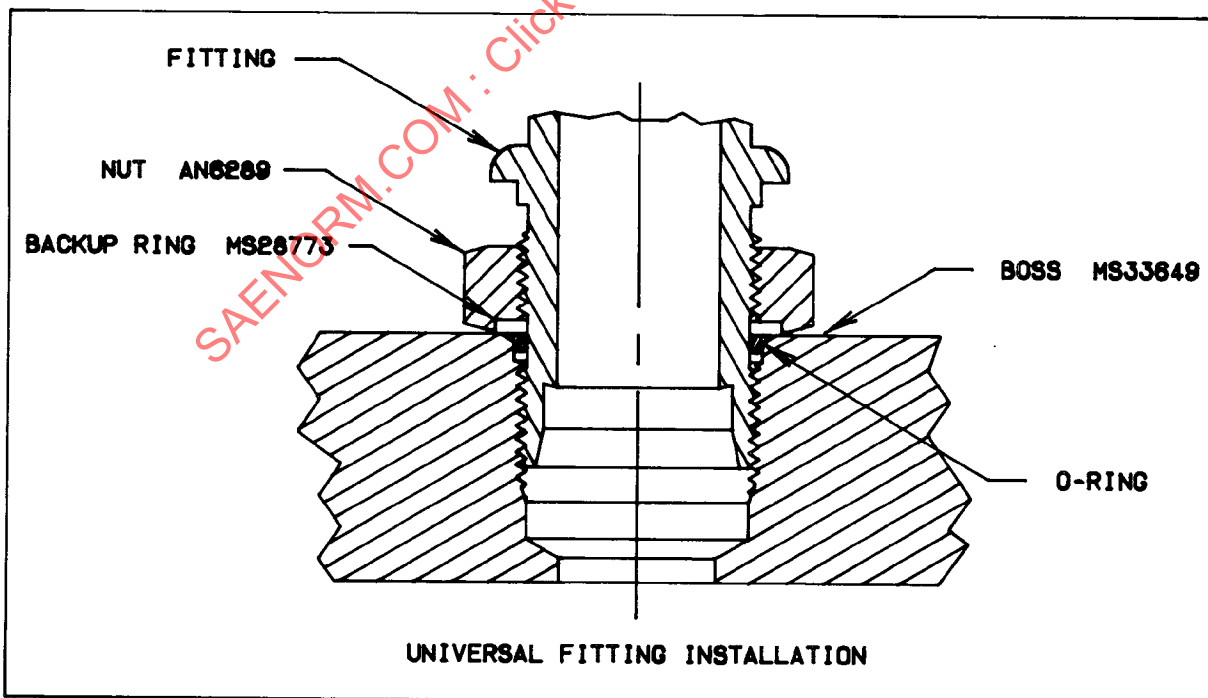


FIGURE 4

5. BACKUP RING CONFIGURATIONS:

- 5.1 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 (MS) or to one of the many commercial standards.

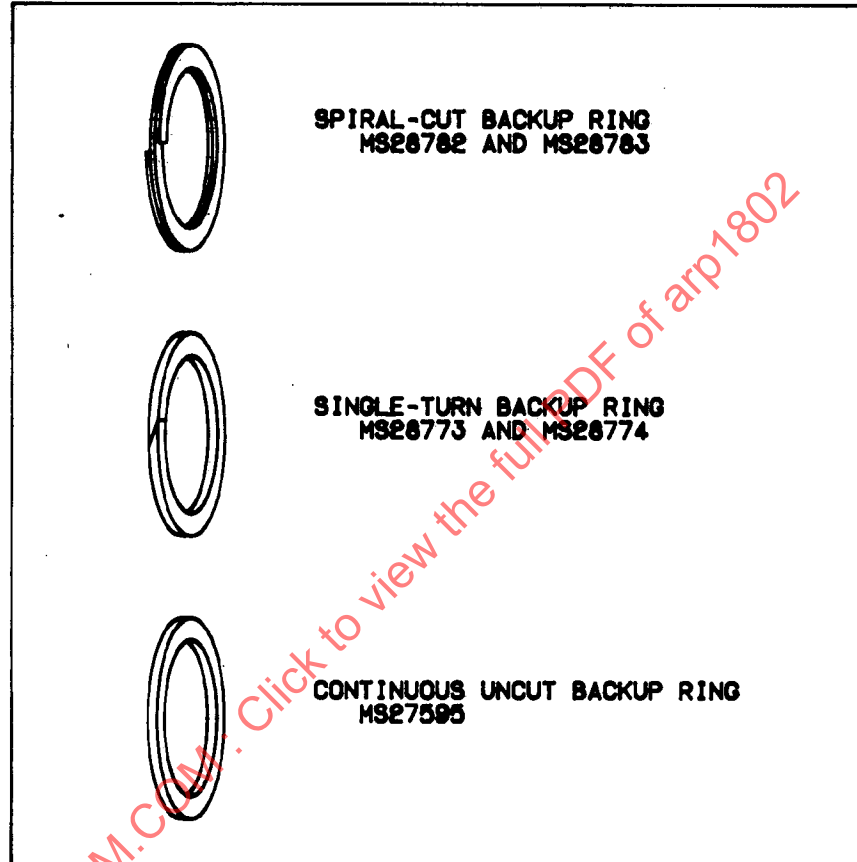


FIGURE 5

These three types of military and commercial standard backup rings all are installable in MIL-G-5514 glands. An exception is MS28773 backup ring, which is used as a universal fitting seal backup ring per MS21344 or MS33566.

- 5.2 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).

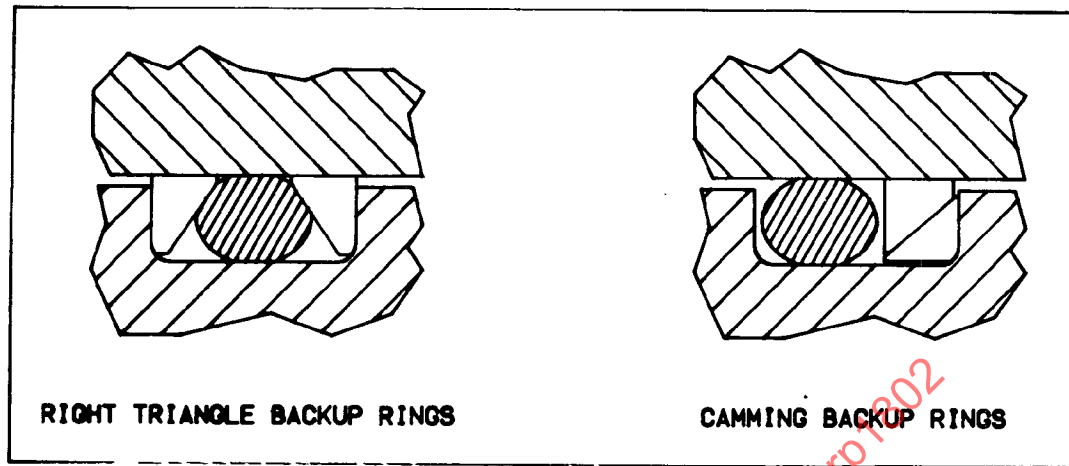


FIGURE 6

- 5.3 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.
- 5.4 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 AIR 1186.
6. SPIRAL-CUT BACKUP RINGS:
- 6.1 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°F 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°F to +275°F) Class 1 and 2 hydraulic systems or for use with universal fittings (MS21344 or MS33566).

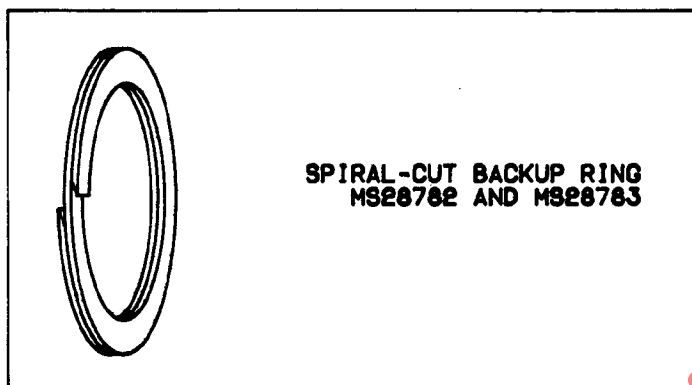


FIGURE 7

6.2 Advantages of Spiral Backup Rings:

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

6.2.2 Spiral backup rings can be used in the field on non-standard 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. Minimum underlap shown in Figure 8 is required above 1500 psi.

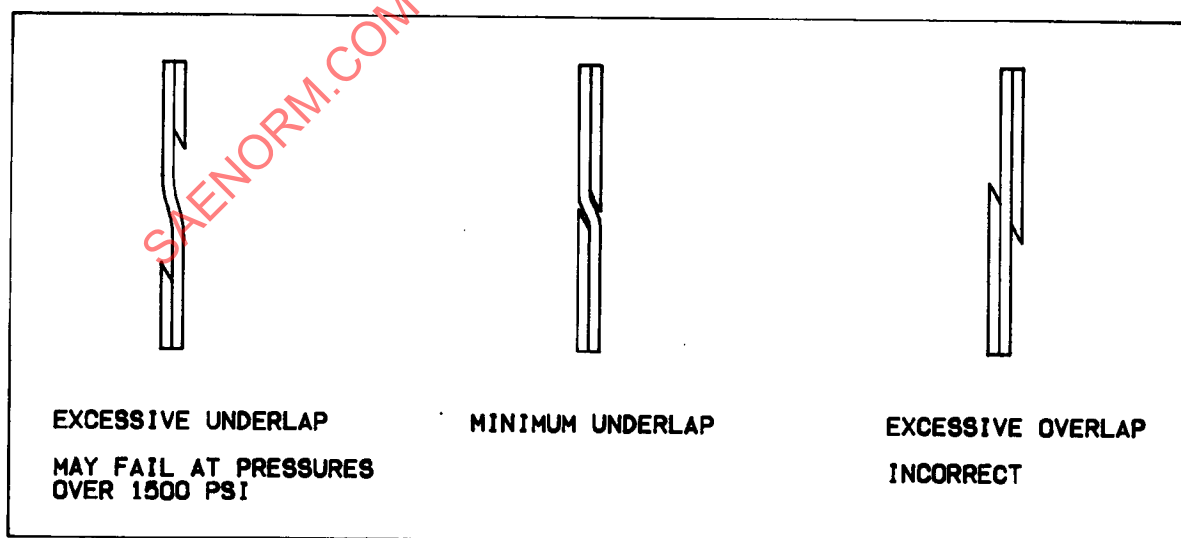


FIGURE 8

6.3 Installation:

6.3.1 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.

6.3.2 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.

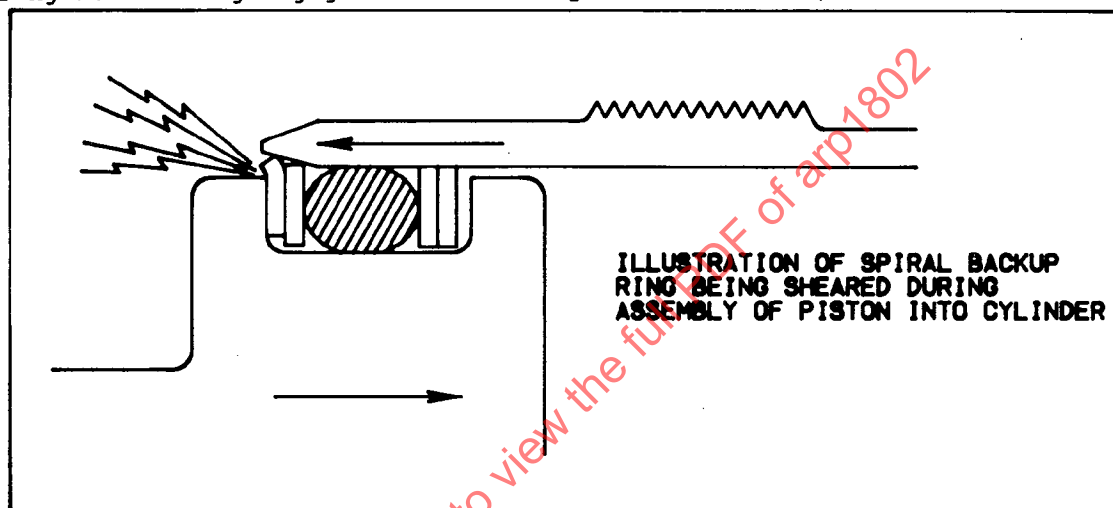


FIGURE 9

6.3.3 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.

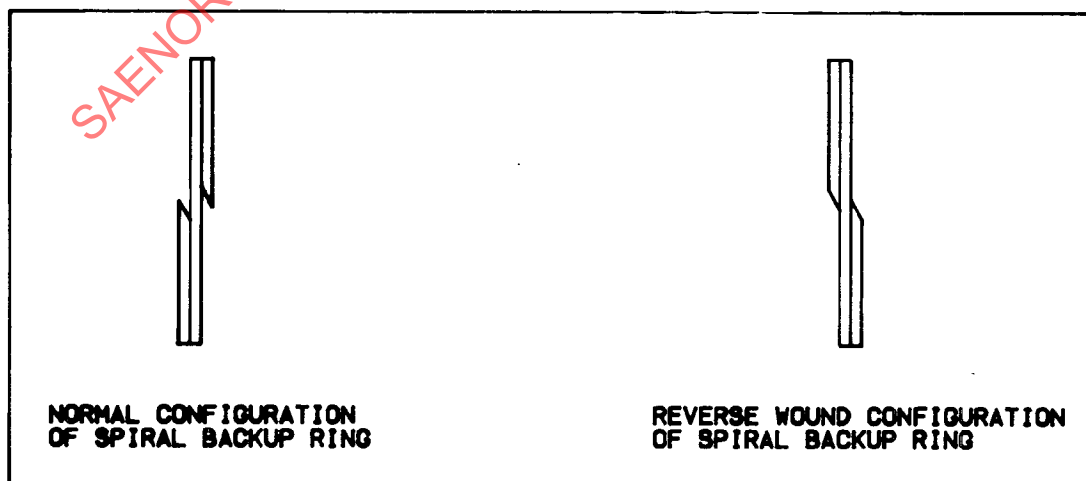


FIGURE 10

7. SINGLE-TURN SCARF-CUT BACKUP RINGS:

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

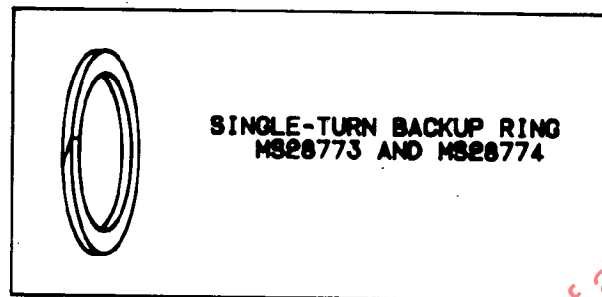


FIGURE 11

- 7.2 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 and MS28782.)

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

- 7.3 Installation: Slight over-lapping of the ends of MS28774 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 backup rings by clipping the ends to prevent overlap may cause underlap and is not recommended.

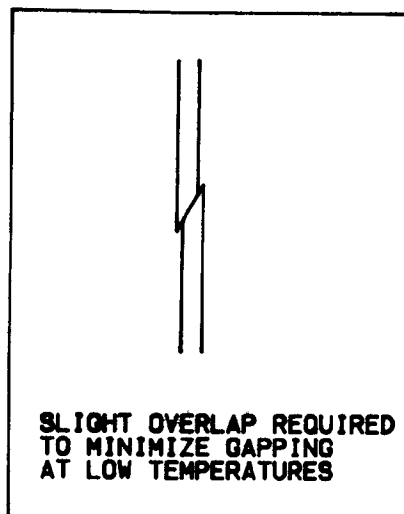


FIGURE 12

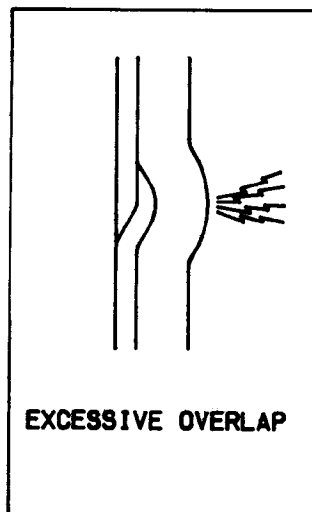


FIGURE 13

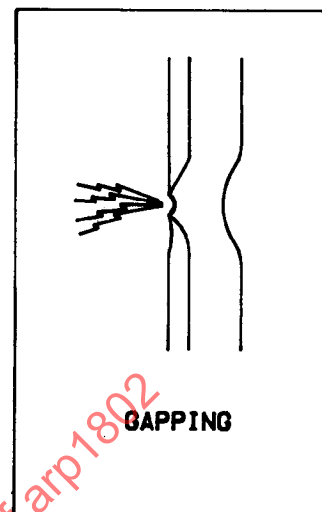


FIGURE 14

7.3 (Continued):

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:

- (1) the use of an incorrect ring.
- (2) circumferential shrinkage of rings made from material that has not been stress relieved.
- (3) excessive clipping to reduce overlap at room temperature.

8. CONTINUOUS (UNCUT) BACKUP RINGS:

- 8.1 The uncut backup ring MS27595 provides more reliable anti-extrusion protection for O-rings than the spiral-cut or single-turn backup rings. They are recommended for Type I (-65°F to +160°F) Class 1 (1500 psi) and Type II (-65°F to +275°F) Class 1 and 2 (3000 psi) hydraulic system. In addition, they are preferred for Type II System when pressures are expected to exceed 3000 psi.

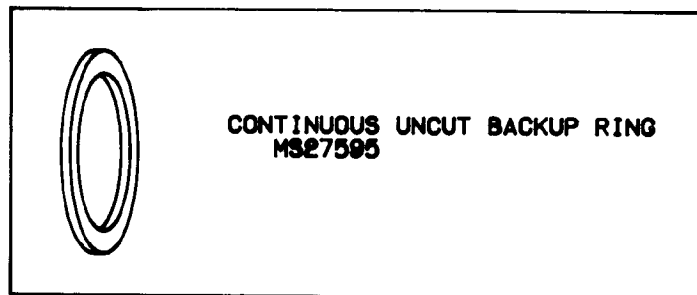


FIGURE 15

8.2 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.

8.3 Installation: It is usually advantageous to install these backup rings before fitting the O-ring to the groove. For O.D. piston applications, unless two-piece glands are used, they must be stretched into place and usually sized to correct for the distortion during installation. Special tools are required for O.D. piston installations as indicated by Figures 16 and 17.

For I.D. rod applications, unless two-piece glands are used, the uncut backup ring must be temporarily distorted into a kidney shape and then fitted into the groove. This is usually quite simple to do after the skill is developed. No special tools are required for I.D. rod applications unless access is limited or the groove is remote.

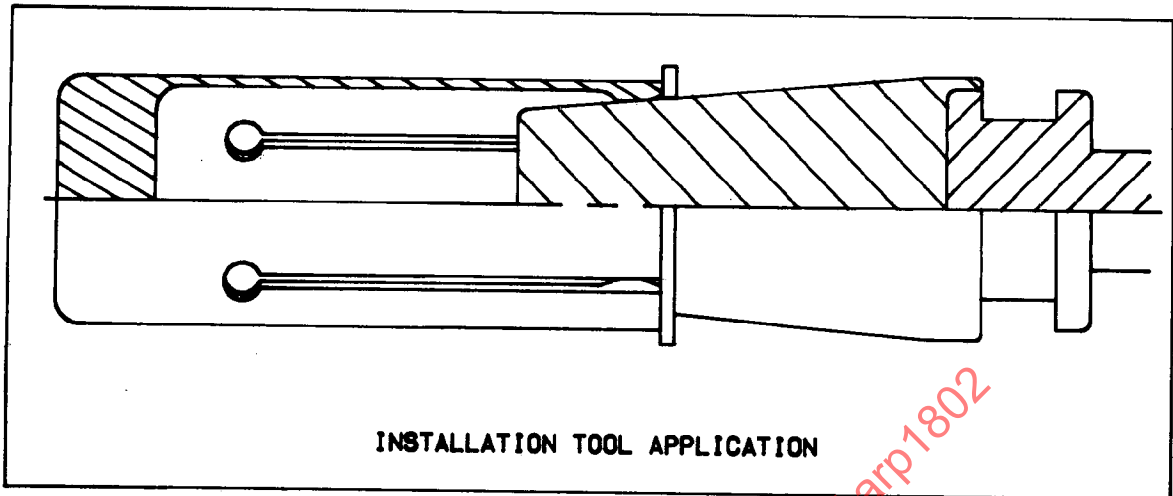


FIGURE 16

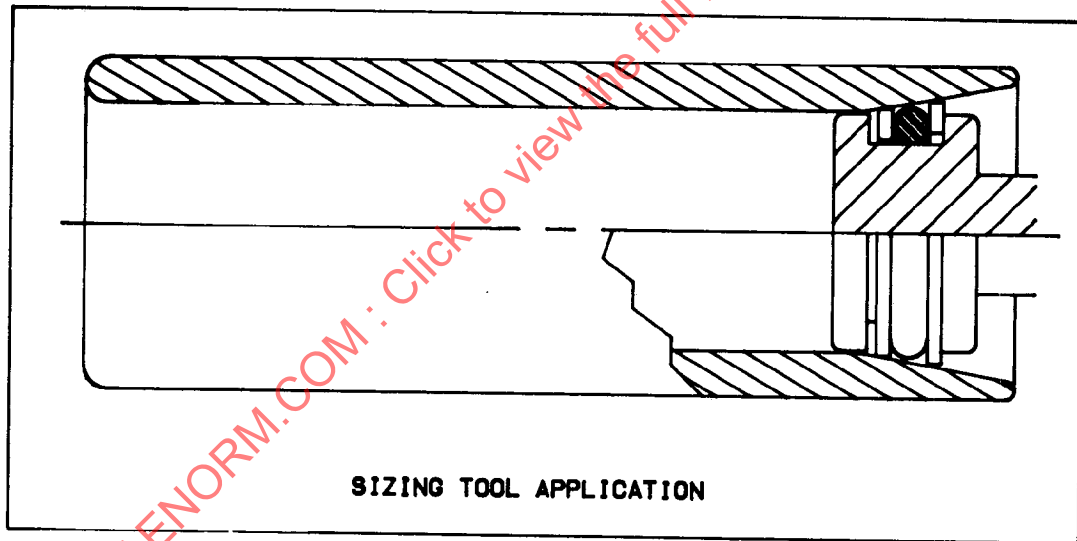


FIGURE 17

8.3 (Continued):

Warming the rings to approximately 100°F makes the rings significantly more flexible and eases the installation effort.

9. RIGHT TRIANGLE BACKUP RINGS:

- 9.1 Right triangle rings either scarf-cut or uncut are available to commercial standards. There is no Military Standard for right triangle backup rings.