MIL-STD-1599
NOTICE 2
30 April 1986

MILITARY STANDARD

BEARINGS, CONTROL SYSTEM COMPONENTS, AND ASSOCIATED HARDWARE USED IN THE DESIGN AND CONSTRUCTION OF AEROSPACE MECHANICAL SYSTEMS AND SUBSYSTEMS

TO ALL HOLDERS OF MIL-STD-1599:

1. REPLACE OR ADD THE FOLLOWING PAGES TO MIL-STD-1599:

NEW PAGES	DATE	SUPERSEDED PAGES	DATE
iii thru iv	30 April 1986	iii thru iv	31 Jan 80
v thru vi	30 April 1986	v thru vi	7 Ott 82
106.1	30 April 1986	N/A	
108.1 thru 108.5	30 April l986	N/A	
205.1	30 April 1986	N/A	
208.1 thru 208.8	30 April 1986	N/A	
304.1	30 April 1986	N/A	
305.1	30 April 1986	N/A	
311.1	30 April 1986	N/A	
401.1 thru 401.9	30 April 1986	N/A	
603.1 thru 603.3	30 April 1986	N/A	

2. RETAIN THIS NOTICE AND INSERT BEFORE TABLE OF CONTENTS.

3. Holders of MIL-STD-1599 will verify that page changes and additions indicated above have been entered. This notice page will be retained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or cancelled.

Custodians:
Army - AV
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Review activities:
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Preparing activity:
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Project 31GP-0017

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<u>DISTRIBUTION STATEMENT A.</u> Approved for public release; distribution is unlimited.

FOREWORD

The purpose of this standard is to establish requirements for the selection and use of bearings, control system components, and associated hardware. The existing documentation on these components covers a great variety of configurations, stress, internal structure, performance variations, materials, and finishes. Of these varieties, many duplicate the fulfillment of design and construction needs for a given application in an aerospace mechanical system, but none has application interchangeability or substitutability. This leads to proliferation of parts. Manufacturers, designers, engineers, and project officers often have problems in the selection of bearings control system components and associated hardware because of lack of knowledge of existing specifications or standards, or application, or where to locate them if they do exist. Additionally, the methods of installation and use of these components vary because of lack of standardized usage criteria and as a result, associated components must vary. The basic objectives of this standard can be summarized as:

> “To select from available standards and standardized methods of usage those bearings, control system components and associated hardware which will optimize performance and reliability of future aerospace mechanical systems while minimizing the logistic consideration of such things as cost, inventory, procurement, and maintenance."

It is also the purpose of this document to limit the selection of items and methodology to that specified herein; however, provisions for use of non-approved parts are covered in Section 100. Requirement 101 is for release for use of components not listed in Section 100, Requirement 102 is for approval of methodology not specifically allowed herein, when required for new design and construction or when maintainability or life cycle cost benefits justify their use.

Selections and procedures are limited to those listed herein.

Supersedes page iii of 31 January 1980

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*Requirement not as yet published
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SECTION 200 - GENERAL DESIGN REQUIREMENTS

SECTION 300 - AIRFRAME BEARINGS

SECTION 400 - BEARING RETAINER RINGS, WASHERS, NUTS

* Requirement not as yet published
**New in this issue
1/ Due to the length of this requirement, a table of contents is included for convenience.

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SECTION 600 - CONTROL, CABLE SYSTEMS

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* Requirement not as yet published
**New in this issue

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TESTING

The quality and reliability of bearings used in aerospace mechanical systems is directly related to the testing of those components to verify their capability to perform as required.

SCREW THREADS, APPLICATIONS IN AIRFRAMES AND SYSTEMS

1. Scope. Thread forms and specifications defined as standards approved herein or in specifications cited by standards approved herein, or specifically directed by other requirements herein shall apply as specified. This requirement establishes criteria for the selection and use of thread forms, specifications, and applications for use in design or modification of bearings, rod ends, and control system hardware and directly mating components, and in the selection of mating components.

2. Documents applicable to Requirement 108

MIL-S-7742	Screw Threads, Optimum Selected Series
MIL-B-7838	Bolt, Internal Wrenching, 160 KSI FTU
MIL-S-8879	Screw Threads, Controlled Radius Root
FED-STD-H28/2	Screw-Thread Standards for Federal Services
MIL-STD-1312	Fasteners, Test Methods
MS 14198	Lock, Rod End, Extra Strength, High Profile Lug
NAS 513	Washer, Rod End Locking
NAS 1348	Threaded Alloy Steel

3. Requirements

3.1 Basic thread data

3.1.1 Standard, Optimum selected series. Basic data for standard, optimum selected series shall be as specified in MIL-S-7742 and FED-STD-H28/2.

3.1.2 Controlled radius root with increased minor diameter. Basic data for controlled radius root with increased minor diameter shall be as specified in MIL-S-8879.

3.1.3 External threads

3.1.3.1 External thread generation. External threads on solid shank rod ends, links and control rods made of material with strength levels of 150 KSI or greater shall be rolled in accordance with 3.1.3.4 and shall conform to MIL-S-8879. External threads of bearing races, retaining nuts and hollow shank rod ends shall be in accordance with MIL-S-7742 or preferably MIL-S-8879, and shall be machined or ground. External threads on materials with strength levels of less than 150 KSI may be rolled in accordance with 3.1.3.4 or machines to form. Machined threads shall be smooth and devoid of abrupt tool marks. For future standards preparation, consideration may be given to rolling all external threads in accordance with MIL-S-8879 regardless of strength levels.

3.1.3.2 Lead threads. The threaded end of the rod or shank shall be flat. and chamfered approximately 0.5 pitch. The lead threads may be less than the minimum diameter size limits of the thread form for a length not to exceed two pitches including the lead chamfer as specified in MIL-B-7838 (see figure 108-1).

3.1.3.3 Thread run-out(imperfect threads). Run-out threads are permissible next to grip section. Run-out shall fair into the shank or fillet, eliminating an abrupt change in the cross-sectional area, and shall terminate not less than 0.25 pitch from the grip dimension, as specified in MIL-B-7838 and MIL-S-7742 (see figure 108-1). If fatigue failure may be considered a probability, a thread relief with generous radii should be used.

3.1.3.4 Thread rolling. Rolled threads shall be fully formed by a single rolling process, at room temperature or elevated temperature compatible with material properties, after all thermal treatment except the bake after plate as specified in MIL-B-7838.

3.1.3.5 Rolled thread discontinuities. Multiple laps are not permissible regardless of location. A single lap is permissible on either the pressure or nonpressure flank if it is above the pitch diameter and extends toward the thread crest. A single crest lap is permissible (figure 108-2). Maximum permissible depth of discontinuities is shown in table 108-1.

3.1.3.6 Grain flow. The grain flow in the threads shall be continuous and shall follow the general thread contour with the maximum density at the root radius, as specified in MIL-B-7838 (see figure 108-3).

3.1.4. Internal threads

3.1.4.1 Internal thread generation. Internal threads shall conform to MIL-S-8879. Flanks and roots shall be smooth and free of abrupt tool marks.

3.1.4.2 Thread depth. The internal thread entry surface shall be chamfered 1 to 2 pitches deep. Blind threads shall have 1.5 to 2 runout threads at the bottom of the hole, extending beyond the required perfect thread depth requirement.

3.1.5 Load determination. Load determination shall be as specified in MIL-STD-1312.

3.1.6 Tensile stress areas. Tensile stress areas for MIL-S-8879 threads on solid shanks for external threads shall be as specified in NAS 1348. Tensile stress areas for MIL-S-7742 threads shall be in accordance with FED-STD-H28.

3.1.7 Metallurgical examination. Metallurgical examination shall consist of macro or micro examination of threads as follows:

Thread grain flow	Micro 50X or greater
Discontinuities	Micro 50X or greater

3.1.8 Threaded keyways. Threaded keyways shall conform with table 108-II and shall meet requirements of NAS513 and MS14198.

3.1.8.1 Keyways in external threads shall be generated after threading is complete and shall be deburred to allow free passage into receiving member without catch or bind.

4. Selection

4.1 External threads. External threads shall conform to 3.1.3.1.

4.2 Internal threads. Internal threads shall conform to 3.1.4.1 and 3.1.4.2.

4.3 Exceptions

4.3.1 Threaded components of assemblies. Threaded components of assemblies used on or attached to the airframe or systems of the aircraft may be to the standard of the manufacturer of the assembly if such threads are not subjected to the stresses impressed directly on the airframe or system. This exception applies to such articles as electrical switch gear or flight instruments.

4.3.2 Other thread forms. Special thread forms, multiple threads not conforming with MIL-S-7742 or MIL-S-8879, as noted in 4.1, 4.2, and 4.3.1, used directly in structures or systems shall require approval of the prime contractor.

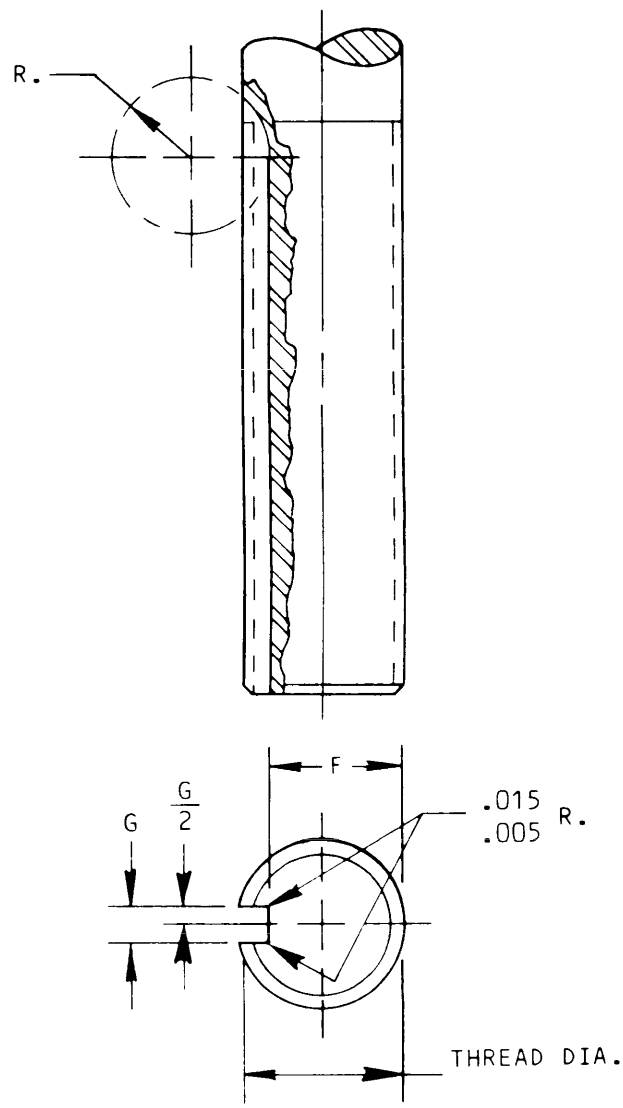
4.3.3 Ground equipment and structures. Unless otherwise specified, ground equipment and structures shall not be bound by this requirement.

TABLE 108-I. Permissible discontinuities.

Thread size	Max depth normal to surfaces						
	.1300 to .1900	.2500 to .3750	.4375 to .5000	.5625 to .6250	.7500 to	.8750 to	1.000 & larger
Depth	.004	.005	.006	.007	.008	.009	.011

TABLE 108-II. Threaded rods or shanks using NAS 513 lock washer

Thread Dia. (Ref)	G +.005 -.000	F +.000 -.005	R
.250	.062	.201	1/4
.312	.062	.260	1/4
.375	.093	.311	1/4
.437	.093	.370	1/4
.500	.093	.436	1/4
.562	.125	.478	1/4
.625	.125	.541	1/4
.750	.125	.663	1/4
.875	.156	.777	5/16
1.000	.156	.900	5/16
1.125	.187	1.010	3/8
1.250	.187	1.136	3/8
1.375	.250	1.236	7/16
1.500	.250	1.361	7/16
1.625	.250	1.477	7/16
1.750	.312	1.589	1/2
1.875	.312	1.714	1/2
2.000	.312	1.839	1/2
2.125	.312	1.955	1/2
2.250	.312	2.080	1/2



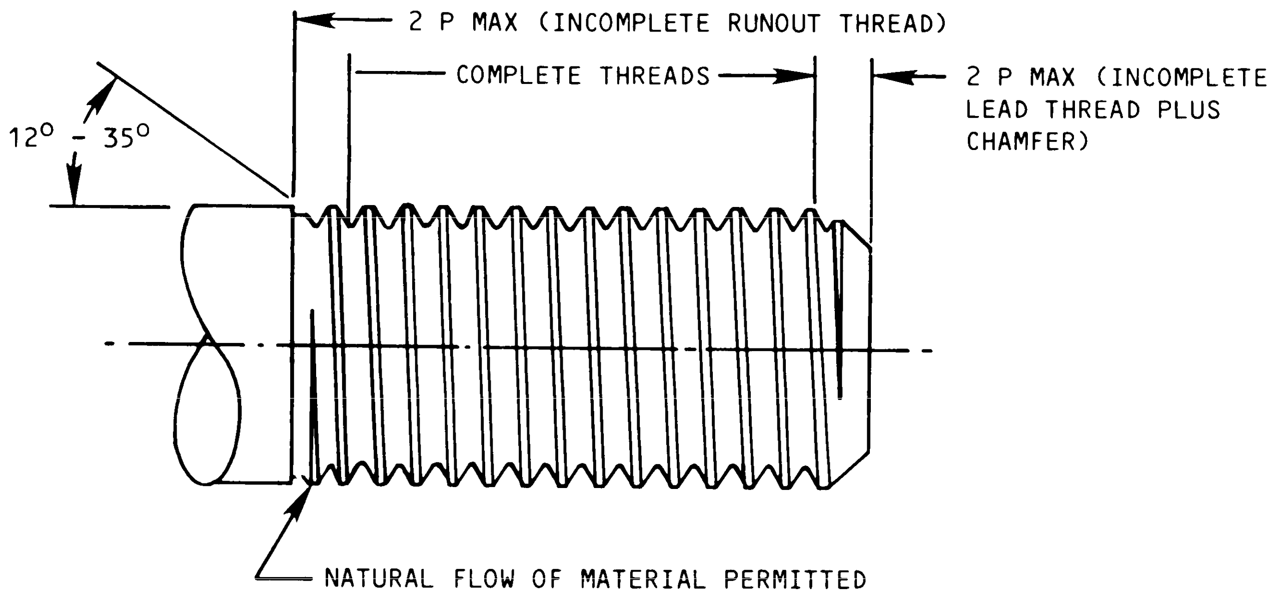


FIGURE 108-1. Thread pitch.

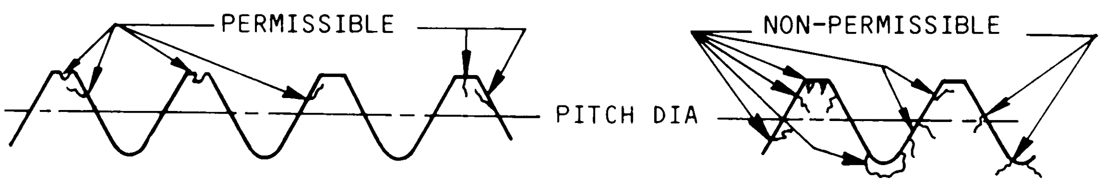


FIGURE 108-2. Laps and surface discountinuities.

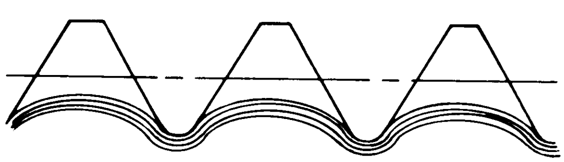


FIGURE 108-3. Rolled thread flow lines.

BALL SCREW USAGE

Although initially included in this military standard, ball screw usage has been determined to be outside the scope of this document. Ball screws are an actuation system rather than a component. They provide power to cause the translation or rotation of other components. Accordingly, they are an "active" system rather than a "passive" component. This document is for passive components which transmit power or motion in aircraft control systems but which do not produce power.

PUSH-PULL CONTROLS SYSTEMS DESIGN REQUIREMENT

1. Scope

1.1 Scope. This requirement establishes engineering criteria and requirements for the selection and application of push-pull controls systems of the flexible inner member types and of the special case of control cables used through rigid or flexible conduits for pull operation only. Approved components, where applicable, are listed in Requirement 601 and 606.

1.2 Classification. Push-pull controls covered by this requirement are of the following types:

a. Type I, rolling element type

b. Type II, compound: helical wrapped inner member

c. Type III, compound: flat wrapped inner member

d. Type IV, compound: beaded inner member

e. Type V, single or multiple wire under member

f. Type VI, pull cable type

2. Documents applicable to Requirement 208:

QQ-C-320	Chromium Plating (Electrodeposited)
QQ-P-416	Plating, Cadmium (Electrodeposited)
MIL-F-7179	Finishes and Coating: Protection of Aerospace Weapons for Systems, Structures, and Parts, General Specification for
MIL-C-7958	Controls, Push-Pull, Flexible and Rigid
MIL-G-23827	Grease, Aircraft and Instrument, Gear and Actuator Screw
MIL-G-81322	Grease, Aircraft, General Purpose Wide Temperature Range
MIL-W-83420	Wire Rope, Flexible, for Aircraft Control
MIL-STD-810	Environmental Test Methods
MIL-STD-1515	Fastener Systems for Aerospace Applications
ASTM-B633	Zinc on Iron and Steel, Electrodeposited Coatings of - 31 Mar 78

3. Construction, design, and usage requirements

3.1 Construction. The term push-pull control as used herein refers to an assembly generally consisting of a flexible, moving inner member which may consist of, but not be limited to, a solid, stranded, wrapped strand, of beaded construction, enclosed in a rigid or flexible metallic outer member of solid, stranded, or interlocked construction. The control assembly is positioned in the desired configuration and the outer member fastened to the structure. The outer member usually does not move. The inner member is connected to an input and output fitting or device at its ends in such manner that a tension or compression load applied to the inner member will effect a linear motion and force transmission through the control assembly to the attached mechanism at the opposite end.

3.1.1 Types. There are six basic constructions of push-pull controls which may be used for various tasks. For ease of reference, these have been assigned “types" and these designations are intended only for reference and clarity in this document, and are not intended for use in industry catalogs or other similar literature. Combinations of features from the various types may be used in a single control system to compensate for application peculiarities.

3.1.1.1 Type I, rolling element type. The rolling element type basically consists of a flexible inner member and a flexible or rigid outer member, and uses balls or rollers regularly spaced throughout its length, supporting the inner member from line contact with the outer member; thereby providing for rolling friction when the inner member is moved or stroked to do its work (figure 208-1).

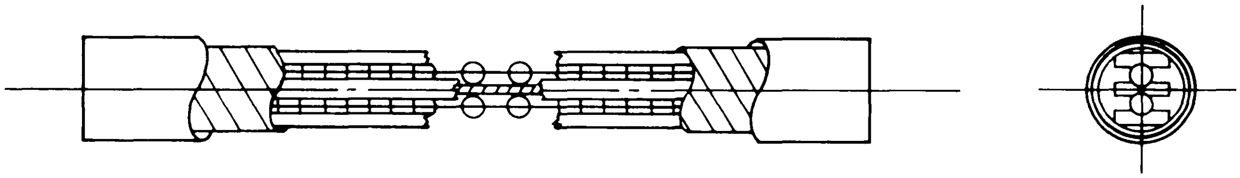


FIGURE 208-1. Typical type I rolling element type.

3.1.1.2 Type II, compound: helical wrapped inner member. The compound, helical wrapped type basically consists of an inner member fabricated of one or more metallic members, usually wrapped with a round metallic strand in a helical form resulting in a “worn gear" configuration. This is then enclosed in a flexible or rigid outer member. The inner surface of the outer member may or may not be coated with a self-lubricating liner such as teflon or dry film lubricant (figure 208-2).

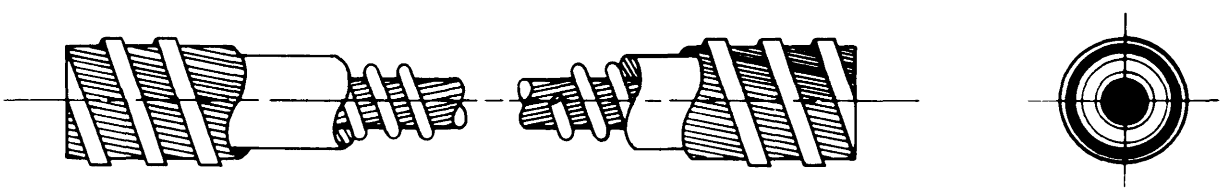


FIGURE 208-2. Typical type II helical wrapped inner member type.

3.1.1.3 Type III, compound; flat wrapped inner member. The compound, flat wrapped helical type, basically consists of an inner member fabricated of one or more metallic members wrapped with a flat metallic band in a helical fashion throughout its length. This element is enclosed in a flexible or rigid outer q ember. A liner consisting of a material with natural lubricity may or may not be used to improve friction characteristics (figure 208-3).

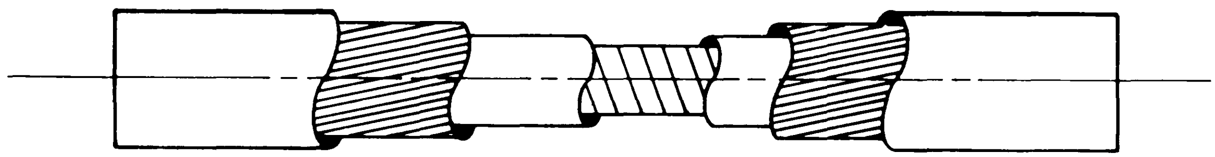


FIGURE 208-3. Typical type III flat wrapped inner member.

3.1.1.4 Type IV, compound: beaded inner member. The compound, beaded inner member type basically consists of a solid or stranded inner member on which are strung beads or shells which may be round, ovular, or "dog bone" in shape. The beads or shells are permanently fixed to the inner cable. The beads or shells may be all the same size or alternately sized throughout its length. This element is then enclosed in a flexible or rigid conduit which may be lined with an anti-friction material or other permanent type of solid lubricant, to aid friction characteristics (figure 208-4).

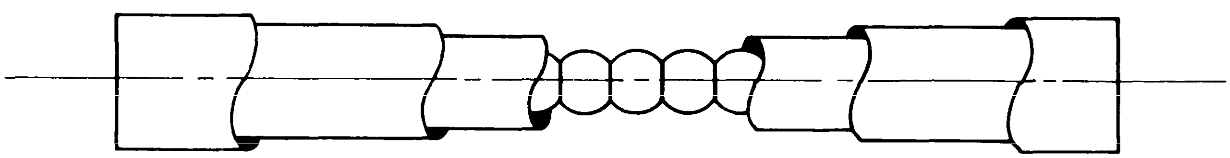


FIGURE 208-4. Typical type IV compound: beaded inner member type.

3.1.1.5 Type V, single or multiple wire inner member type. The single or multiple wire inner member type consists of a single or multiple twisted metal wire, or wires, as the inner member. The outer member can be flexible or rigid of metallic, metallic and synthetic, or synthetic material construction. The inner or outer member may or may not be lubricated (figure 208-5).

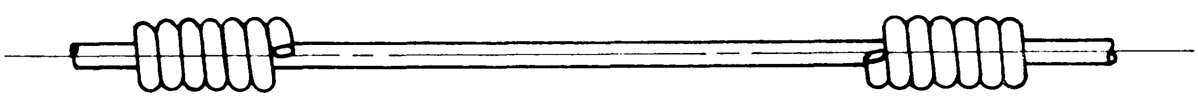


FIGURE 208-5. Typical type V single wire inner member or multiple wire inner member type.

3.1.1.6 Type VI, pull cable type. The pull cable type consists of a standard wire rope inner member per MIL-W-83420, which may or may not be sheathed with a synthetic material. The outer member may be rigid or flexible metallic or non-metallic casing. This type is to be used only in pull or tension applications, the return stroke usually being provided by a spring or other device at the output end. Fabrication from standard AN components is preferable but not mandatory (figure 208-6).

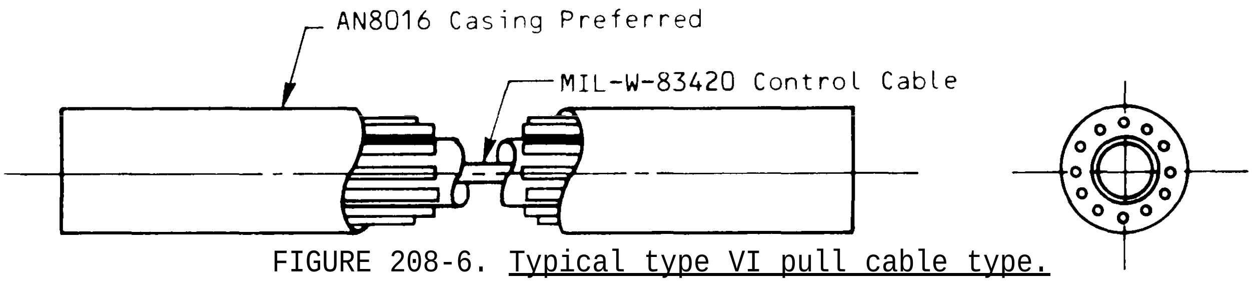


FIGURE 208-6. Typical type VI pull cable type.

3.1.2 Construction options. At the option of the designer, combinations of features of the various types may be used in a single control system to compensate for peculiarities of design or installation.

3.2 Design and usage

3.2.1 Push-pull controls design requirements

3.2.1.1 Materials and environmental factors

3.2.1.1.1 Materials. Push-pull controls shall be fabricated or materials consistent with the requirements of the specific acquisition document. Generally, the assemblies shall be manufactured from steel, aluminum, or steel and aluminum, as determined by the design requirements. Non-metallic materials used for casing, encasing the conduit, seals or other components shall be compatible with the environment and other requirements of the specific acquisition document. These materials shall be of such composition as to not require age control. The contracting agency shall specifically define the environment to which the push-pull controls will be subjected including salt fog exposure, high and low temperature extremes, altitude, vibration, sand and dust , shock and acceleration as defined in MIL-STD-810.

3.2.1.1.2 Finishes and corrosion protection. Finishes, platings and coatings shall be in agreement with the specific aircraft model specification or equivalent as defined in MIL-F-7179. Steel components which are exposed to the environment shall be corrosion resistant steel, chrome, or cadmium plated alloy steel. Cadmium plating shall be in accordance with QQ-P-416, type II, class 2. Zinc plating shall be in accordance with ASTM B633. Chrome plating shall be in accordance with QQ-C-320. Protective finishes applied to aluminum components shall be in accordance with the specific acquisition documents.

3.2.1.1.3 Lubrication and sealing. Whenever possible, push-pull controls shall be designed in such a manner as to not require lubrication or be lubricated for life. These controls may utilize the lubricant and method of lubrication selected by the control manufacturer unless otherwise specified by the acquisition agency or contractor. Control assemblies which, with the approval of the acquisition agency or contractor, require lubrication in service shall utilize MIL-G-23827, MIL-G-81322, or equivalent grease. Lubricated controls shall provide the means to entrap lubricant and prevent entry of contaminants commensurate with design requirements.

3.2.1.1.4 Encasement of outer member. Outer member may be encased with nonmetallic material as desired by the contractor or acquisition agency for the purpose of aesthetics, isolation from electrical equipment, protection from moisture or foreign material entry, or abrasion resistance.

3.2.1.2 End fittings.

3.2.1.2.1 Fittings. Type I, II, III, and IV control assemblies shall be furnished with telescopic type fittings attached to each end of the assembly. These fittings may be threaded, clevis, eyes, knobs, handles or other configurations applicable to the specific needs of the control installation. Wherever possible, end fittings should conform to industry standards. End fittings for types I, II, III, and IV push-pull controls shall be capable of sustaining loads as specified by the design documents or the acquisition agency. Telescoping units on types II, III, and IV units shall be capable of conical misalignment of 4 degrees minimum from theoretical center throughout full design travel. Type I controls shall be applied to the application in such a manner that misalignment of end fittings to the connecting devices is suitably accommodated. The cable assembly portion of type VI controls shall conform to Requirement 206 for control cable assemblies. Type V controls may be connected to equipment by a clip which slides onto the wire. The clip shall be capable of the maximum load which will be applied to operate the system without sliding off the wire.

3.2.1.2.2 Outer member mounting provisions. The area of the control which will be attached to bracketry or a bulkhead shall be suitably threaded to accept jam nuts and lockwashers on both sides of the bracket or bulkhead. The length of mounting thread shall be sufficient to provide adjustment of the end fitting position to the extent required by the acquisition agency. Push-pull controls may be mounted in flanged devices which will attach to brackets or bulkheads by means of screws, nuts and lockwashers or bolts and lockwashers. Clamp type fittings which engage into an undercut area of the mounting sleeve are premissible provided the mount is capable of sustaining the maximum load which will be applied to the system.

3.2.1.2.3 Knobs and handles. Knobs and handles which are used in conjunction with push-pull controls shall be of sufficient size, shape, and strength to allow manual operation of the control at maximum load. Knobs and handles shall be removable and replaceable without distortion or destruction of any element for purposes of replacement installation and maintenance.

3.2.2 Usage

3.2.2.1 System restrictions. The application of push-pull controls in primary controls, secondary controls, or auxiliary systems shall be at the discretion of the acquisition agency based upon qualification by test or similarity to other qualified or certified applications. Type V controls are limited to auxiliary, noncritical application.

3.2.2.2. Usage factors

3.2.2.2.1 Attachment to equipment. End fittings may be attached by rod end bearing or clevis and eye with bolts or screws and nuts per the requirements of MIL-STD-1515. Ends shall be threaded through a bell crank or similar component and secured with a nut per MIL-STD-1515 and a locking device per MIL-STD-1515 or MIL-STD-1599.

3.2.2.2.2 Friction. Resistance to motion caused by friction is a significant concern when designing a push-pull control into a system. System efficiency, output versus input, is affected by the number of bends, bend radii and overall length of the various types of push-pull controls. The anti-friction characteristics of the various types of push-pull controls should be considered when designing for a particular system. Utilization of a specific type control shall be determined by the functional requirements of the acquisition agency's specifications.

3.2.2.2.3 Backlash. Backlash in a particular control assembly is an accumulation of various assembly construction factors. These lost motion factors include mechanical clearance, necessary to minimize friction effect, manufacturing tolerances and elastic properties of the materials used in the control. Backlash is the total accumulation of these factors and this condition must be considered when designinq a system. Backlash varies with the various types in generally increasing order from type I through type VI.

3.2.2.2.4 Loading. Push-pull controls vary in load transmission capability, a consideration which must be reviewed when designing a system. Various factors affect the input force required to accomplish a given load transmission through a push-pull control stroke. These include overall length, bend radii, number of bends, friction, and output load. Review of these factors during the design stage will allow the design activity to choose the type control best suited to a given system. Where possible, push-pull controls should be utilized with the predominant load transmission being accomplished while the control is in tension. Mounting brackets or other structure to which the controls will be attached must be of sufficient rigidity and strength to react to all the forces transmitted by the control.

3.2.2.2.5 Travel. The travel of a push-pull control is the linear motion transmitted from the input to the output. Control travel or stroke must include the actual output stroke required plus the lost motion of the control assembly. Control travel should not significantly exceed the system requirement because of major effects on end fittinqs and control performance.

3.2.2.2.6 Overall length. There is no restriction on overall length of push-pull controls. Generally, friction buildup will limit the lengths of types II through VI. Type I controls are recommended for long runs.

3.2.2.2.7 Safetying. Where practical, push-pull control assemblies shall be so constructed that external safety wiring or clips are not required to maintain integrity. Safetying of nuts, bolts, etc., at attaching points to structure or functioning equipment shall be as required by the overall control system and Requirement 204.

3.2.2.3 Mounting. Both ends of the conduit of types I, II, III, and IV push-pull controls shall be mounted to structure of sufficient strength and rigidity to prevent deflection of the conduit axially or radially when the control is operated at maximum load. The control assembly shall be clamped to a structure of sufficient strength and rigidity within 6 inches of each tangency point of curves and shall be further clamped to structure at least each two feet of straight length. Clamps shall be so located that deflection of the control during operation will not cause the assembly to contact the structure of functional equipment or move into the envelope of motion of moving equipment. Clamps shall be sized such that they do not squeeze or distort the control conduit. Clamps shall be of the same type used for electrical conduits or plumbing tubing on the airframe design. Type V shall be connected to the structure at the handle end and may or may not be connected at the other end. Type VI shall be clamped as necessary. Note that type I controls require special considerations relative to bend planes and installation sequence.

3.2.2.4 Routing. In addition to the avoidance of equipment and structure noted in 3.2.2.3, routing shall be such that radii of bends are at least as large as recommended by the control manufacturers, but not less than 12 times the outer member diameter and in no case less than 3 inches. Even these minimum radii should be avoided near the ends of the system to minimize friction buildup. Bends in type I controls may require large radii.

3.2.2.5 Type selection data. The application requirements of load, friction, backlash, type of attachments, routing, weight, cost, etc., determine the type of push-pull control necessary for proper and reliable functioning of the system. Trade-offs between types may be necessary for optimization of the system. Table 208-1 has been provided herein as a guide to initial consideration for design selection. Table 208-1 presents several guidelines as to controls applicability. It is not intended to limit application.

4. Quality assurance

4.1 Control testing. Testing shall be accomplished at the contractor's discretion or as required in the specific acquisition document. The contractor is responsible for the integrity of the push-pull controls for defined system requirements. MIL-C-7958 shall be considered in developing test requirements.

TABLE 208-I. Design selection data.

	EFFICIENCY	BACKLASH	FRICTION	LOAD CAPABILITY	WEIGHT	COSTS	RUGGEDNESS	PRECISION	BEND CAPABILITY	COMMENTS	SUITABLE USAGE: Primary	SUITABLE USAGE: Secondary	SUITABLE USAGE: Auxiliary	SUITABLE USAGE: Ground Equipment
TYPE I	H	L	L	M	M	M/H	M	H	M	Good for Long runs	P	P	A	A
TYPE II	M	L	M	M	M	M/H	M	M/H	M		A	P	A	A
TYPE III	M	M/L	M	H	M/H	M	H	M	M		A	A	P	A
TYPE IV	M	M/L	M	M	M/H	M	M/H	M	M	Good compressive capability	A	P	A	A
TYPE V	L	L	M/L	L	L	L	M	L	H		N	P	A	A
TYPE VI	L	L	H	L	L	L	L	L	H	Tension Applications Only	A	A	A	A

H = High
M = Moderate
L = Low

P = Preferred
A = Acceptable
N = Not acceptable (should not be used)

MINIATURE ANTI-FRICTION BEARINGS

Miniature anti-friction bearinqs are not ordinarily used as airframe bearings. Consequently, no parts are listed for use in this requirement. Unless specifically prohibited by Requirement 201, the usage of this type of bearing as an airframe bearing shall be governed by the application of the procedures described in Requirements 101 and 102.

A miniature ball bearing is defined as one having an outside diameter less than 0.375 inch or 9 mm, but in recent years they have been treated as instrument bearings rather than as a separate category (see Requirement 201). Uses of this type bearing as an airframe bearing in an aerospace vehicle is limited.

For further information regarding instrument/miniature ball bearings, see MIL-B-81793, Bearings, Ball, Precision, For Instruments and Rotating Components.

FLUID FILM BEARING

Fluid film bearings are not ordinarily used as airframe bearings. Consequently, no parts are listed for use in this requirement. Unless specifically prohibited by Requirement 201, the usage of this type bearing as an airframe bearing shall be governed by the application of the procedures described in Requirements 101 and 102.

LINEAR MOTION ANTI-FRICTION BEARINGS

Linear motion anti-friction bearings are not ordinarily used as airframe bearings. Consequently, no parts are listed for use in this requirement. Unless specifically prohibited by Requirement 201, the usage of this type of bearings as an airframe bearing shall be governed by the application of the procedure described in Requirements 101 and 102.

A linear ball bearing is described as a cylindrically configured bearing containing three or more oblong shall circuits (see Figure 201-1). The ball circuits are arranged so that the balls may roll longitudinally between the inner surface of the bearing sleeve and the surface of the shaft. The load and motion are sustained by the balls in the contact portion of each circuit while the balls in the return portion of each circuit circulate freely and “refill" the contact zone. This design permits unlimited linear travel along the axis of the supporting shaft.

To date, there has been no known use of a linear ball bearings as an airframe bearing in an aerospace vehicle. There are no standards for these bearings at this time.

RETAINING RINGS

1. Scope. This requirement establishes the approved retaining rings for use in bearing and seal retention other than seals integral within a bearing assembly.

2. Documents applicable to Requirement 401

GGG-P-840	Pliers, Retaining Ring, Hog Ring Staple (Upholsterer S), Brake Repair Brake Spring and Hose Clamp (Wire)
MIL-R-21248	Rings, Retaining (Tapered and Reduced Section)
MIL-R-27426	Ring, Retaining, Spiral (Uniform Cross Section)
MS3215	Ring, Retaining, External, E Reinforced (Reduced Section Type)
MS3216	Ring, Retaining, External, Prong Lock (Reduced Section Type)
MS3217	Ring, Retaining, External, Heavy Duty (Tapered Section Type)
MS16624	Ring, Retaining, External, Basic (Tapered Section Type)
MS16625	Ring, Retaining, Internal, Basic (Tapered Section Type)
MS16626	Ring, Retaining, External, Inverted (Tapered Section Type)
MS16627	Ring, Retaining, Internal, Inverted (Tapered Section Type)
MS16628	Ring, Retaining, External, Bowed (Tapered Section Type)
MS16629	Ring, Retaining, Internal, Bowed (Tapered Section Type)
MS16630	Ring, Retaining, External, Beveled (Tapered Section Tape)
MS16631	Ring, Retaining, Internal, Beveled (Tapered Section Tape)
MS16632	Ring, Retaining, External, Crescent (Reduced Section Tape)
MS16633	Ring, Retaining, External, E (Reduced Section Type)
MS16634	Ring, Retaining, External, Bowed E (Reduced Section Type)
MS90707	Ring, Retaining, External, Grip
MS90708	Ring, Retaining, External, Interlocking

3. Design of retaining rings

3.1 Approved retaining rings. All retaining rings listed in Section 2 of this requirement are approved for use in appropriate applications for bearing and seal retention in aerospace vehicle or ground support equipment. Retaining rings which are an integral component of a bearing assembly or other part supplied as a non-repairable part are not intended to be controlled by this requirement. All retaining rings used for component retention which are of the reduced (tapered) or spiral (uniform) section type shall conform to the requirements of MIL-R-21248 or MIL-R-27426 as specified on the applicable military standard listed in Section 2.

3.2 Retaining ring usage. Usage requirements for bearing retention in a housing or on a shaft are-specified in Requirement 202. The following are supplemental requirements relative to retaining ring usage.

3.2.1 Shaft and housing design. Design of shafts or housings and grooves for retaining rings shall be in accordance with conditions specified in the applicable military standards.

3.2.2 Bearing. Retaining rings which bear against the inner or outer race of bearings shall be of such width $\frac{(0.D. - I.D.)}{2}$ that at lease 50 percent of this width is in contact with the bearing after the groove and bearing chamfer or radius is considered.

3.2.3 Sealing. When retaining rings are used for seal retention, the seal not being an integral part of the bearing, the assembly shall not be designed so that deflection of the retaining ring under load will reduce the extent to which the seal is compressed or squeezed.

3.2.4 Loading

3.2.4.1 Allowable axial load. Retaining rings shall not be subjected to loads exceeding either the recommended allowable thrust load capability for the retainer per the military standard or 50 percent of the shear capacity of the retainer, whichever is lower.

3.2-4.2 Shock loads. Retaining rings shall not be used in applications that subject them to shock loads unless the installation has been tested for these shock loads and fatigue life is proven satisfactory.

3.2.4.3 Allowable bending load. Retaining rings shall not be subjected to bending loads during installation sufficient to yield the ring. Yielding by bending is indicated by play between the groove diameter and the inside ring diameter after installation.

3.3 Relative rotation. Retaining rings shall not be used in bearing retention applications where relative rotation between the ring and the portion of the bearing contacted by the ring is a requirement of the functional system as designed. Incidental relative rotation should be kept minimal or avoided where possible.

3.4 Checking of ring assembly. Adherene to requirements for checking proper ring assembly (dimension K) on the applicable military standard is required.

3.5 Temperature limits

3.5.1 Cadmium plated steel rings. Cadmium plated steel rings shall not be used at temperatures which exceed 450°F.

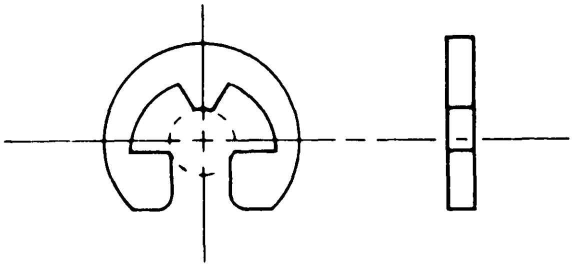
3.5.2 Corrosion-resistant steel rings. Corrosion-resistant steel rings shall not be used at temperature which exceed 700°F.

4. Retaining ring selection. Retaining rings shall be selected, and specified by part number, from the standards or specifications listed in table 401-1. The intended use is briefly specified for use in selection considerations. MS16624, MS16625, MIL-R-27426, type A, class 2, and MIL-R-27426, type B, class 2, are the preferred series and should be used whenever they meet design requirements.

5. Tools. Retaining pliers and other specifically designed installation tooling shall be used for installation and removal of retaining rings in accordance with GGG-P-480.

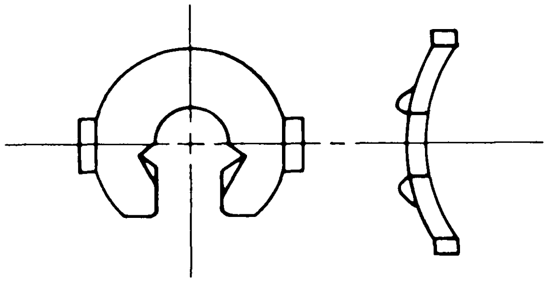
TABLE 401-1. Retaining ring selection.

MS3215 - Ring, Retaining, External, E Reinforced (Reduced Section Type)



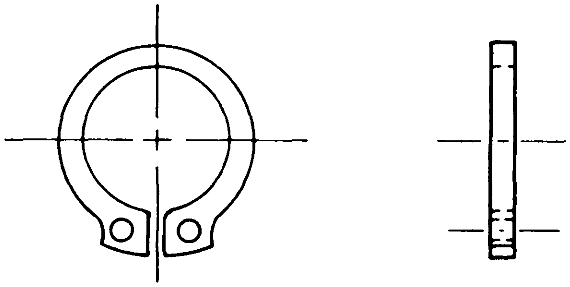
Intended use: To provide unusually large shoulders for positioning and maintaining machine components on shafts. They are applied radially and withstand strong pushout forces resulting from heavy vibrations and shock loads, high rotational speeds, or relative rotation between the retained parts. They are of further advantage where axial assembly of a retaining ring is not possible and where fast assembly for mass production lines is essential.

MS3216 - Ring, Retaining, External, Prong-Lock (Reduced Section Type)



Intended use: To provide large shoulders for positioning and maintaining machine parts. They are applied radially and are locked positively in their grooves by means of two prongs extending from the inner circumference to the open end. They withstand high thrust loads and relative rotation between the retained parts. Their bowed construction provides resilient end-play take up in axial direction; however, they are not intended to take axial loads.

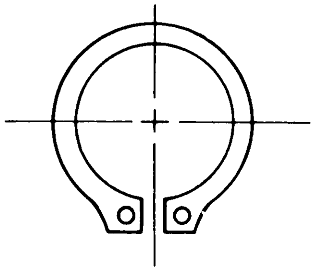
MS3217 - Ring, Retaining, External, Heavy Duty (Tapered Section Type)

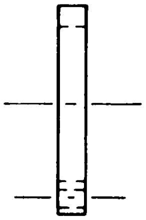


Intended use: To provide large shoulders for positioning and retaining machine components under heavy loading conditions on shafts, even if components to be secured have large corner radii or chamfers abutting the rings. They withstand comparatively heavy lock loads and high rotational speeds. They eliminate the need for separate thrust washers.

TABLE 401-I. Retaining ring selection. - Continued

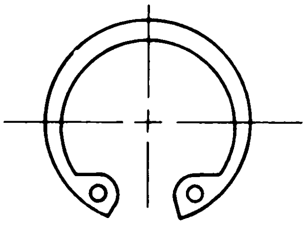
MS16624 - Ring, Retaining, External, Basic (Tapered Section Type)

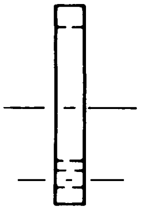




Intended use: To provide shoulders for positioning and retaining machine components on shafts. Tapered design principle permits rings to maintain practically constant circularity and pressure against bottom of groove, counteracting considerable centrifugal force. Rings for shaft diameters over 4 inches are specially dimensioned to maintain balance in rotation.

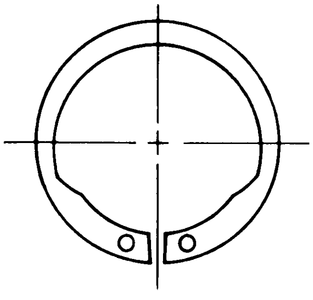
MS16625 - Ring, Retaining, Internal, Basic (Tapered Section Type)

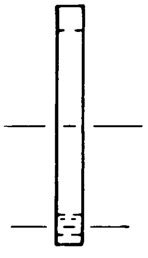




Intended use: To provide shoulders for positioning and retaining machine components in housings (bores). Tapered design principle permits rings to maintain constant circularity and pressure against bottom of groove.

MS16626 - Ring, Retaining, External, Inverted (Tapered Section Type)

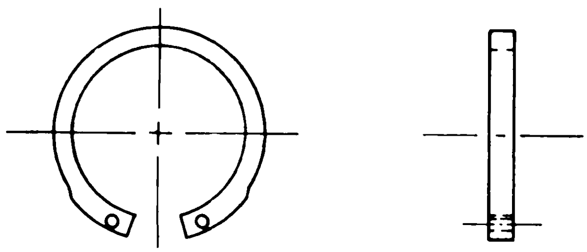




Intended use: To provide uniform protruding shoulders for positioning and retaining machine components on shafts. Tapered design principle permits rings to maintain practically constant circularity and fit securely against bottom of groove, counteracting considerable centrifugal force. Especially suited for locating and retaining machine parts having curved abutting surface.

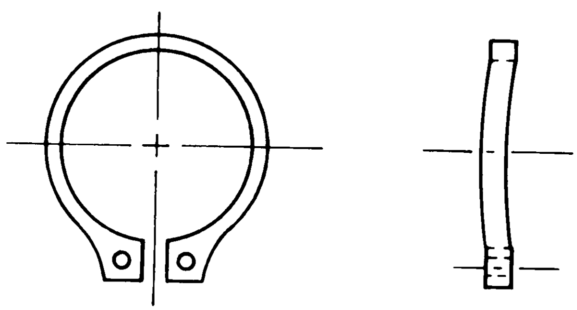
TABLE 401-I. Retaining ring selection. - Continued

MS16627 - Ring, Retaining, Internal, Inverted (Tapered Section Type)



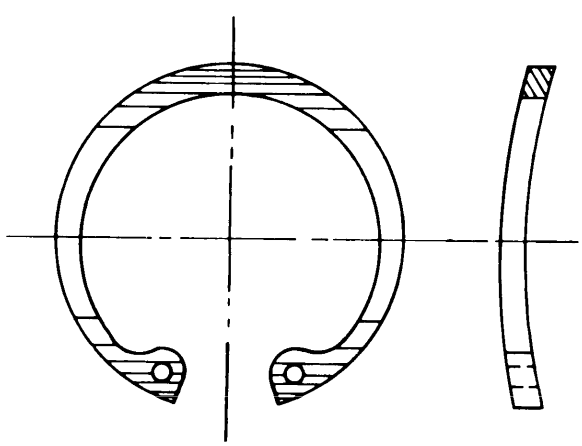
Intended use: To provide uniform protruding shoulders for positioning and retaining machine components in housings (bores). Tapered design principle permits rings to maintain practically constant circularity and fit securely against bottom of the groove. Especially suited for locating and retaining machine parts having curved abutting surfaces.

MS16628 - Ring, Retaining, External, Bowed (Tapered Section Type)



Intended use: To provide shoulders for positioning and retaining machine components on shafts. The rings are bent like a bow out of plane. Free ends and opposite edge abut machine part, mid-section of rings abuts outer groove wall. The ring will counteract considerable centrifugal forces. Ring will take up end play resiliently.

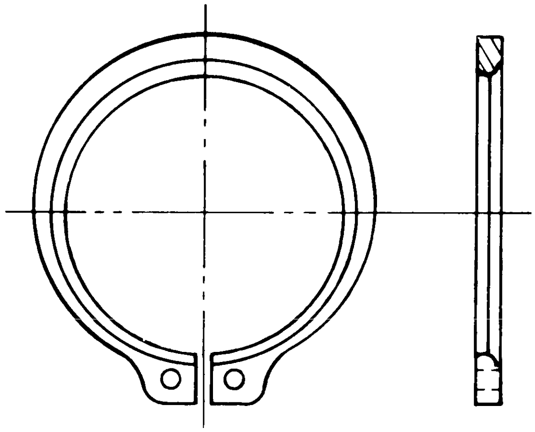
MS16629 - Ring, Retaining, Internal, Bowed (Tapered Section Tape)



Intended use: To provide shoulders for positioning and retaining machine components in housings (bores). The rings are bent like a bow out of plane. Free ends and opposite edge abut outer groove wall. Mid-section of ring abuts machine part. Ring will take up end play resiliently.

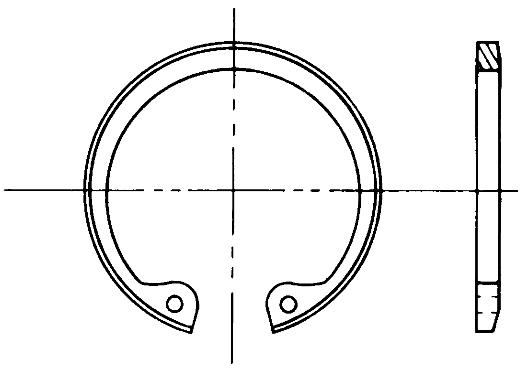
TABLE 401-I. Retaining ring selection. - Continued

MS16630 - Ring, Retaining, External, Beveled (Tapered Section Type)



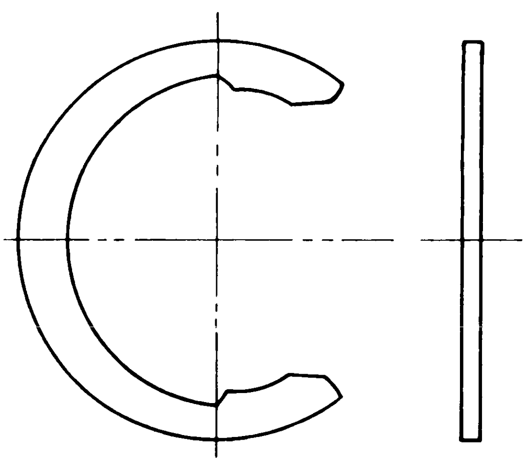
Intended use: To provide shoulders for positioning and retaining machine components on shafts. Tapered design principle permits a rings to maintain practically constant circularity within the limits of expansion in normal use. The rings with bevel in inner circumference and when spring into groove with tapered outer wall corresponding to ring bevel, will self adjust and provide secure pressure fit axially to take up end play. The ring will counteract considerable centrifugal forces and will be secure against high rpm's.

MS16631 - Ring, Retaining, Internal, Beveled (Tapered Section Tape)



Intended use: To provide shoulders for positioning and retaining machine components in housings. Tapered design principle permits ring to maintain practically constant circularity. The rings with bevel on outer circumference and when sprung into groove with tapered outer wall corresponding to ring bevel will self adjust and provide secure pressure fit axially to take up end play.

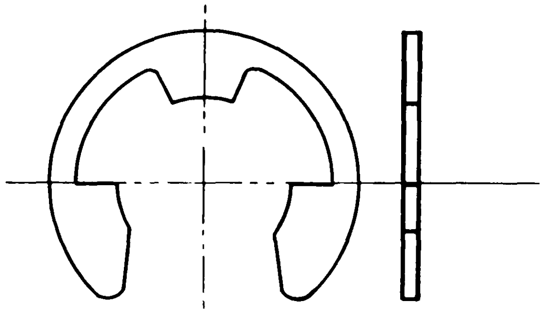
MS16632 - Ring, Retaining, External, Crescent (Reduced Section Type)



Intended use: To provide shoulders for positioning and maintaining machine parts on shaft which are axially inaccessible in assembly. They are applied radially and, because of deep grooves, have high thrust capacity. They are of advantage where fast assembly for mass production lines is essential and where comparatively small clearance diameters are desirable.

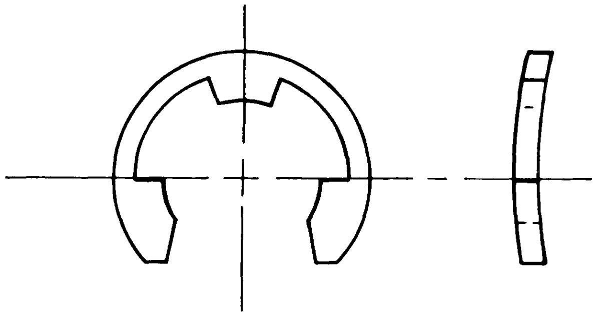
TABLE 401-I. Retaining ring selection. - Continued

MS16633 - Ring, Retaining, External, E (Reduced Section Type)



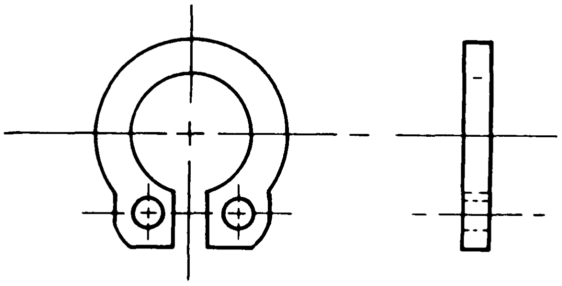
Intended use: To provide unusually large shoulders for positioning and maintaining machine components on shafts. They are applied radially and withstand considerable thrust load. They are advantageous where axial assembly of a retaining ring is not possible and where fast assembly for mass production lines is essential.

MS16634 - Ring, Retaining, External, Bowed E (Reduced Section Type)



Intended use: To provide usually large shoulders for positioning and maintaining machine components on shafts. They are applied radially and withstand considerable thrust load. The rings are bent like a bow out of plane. Free ends and opposite ends abut the machine part, midsection of ring abuts outer groove wall. Ring will take up end play resiliency. They are of advantage where axial assembly of a bowed retaining ring is not possible.

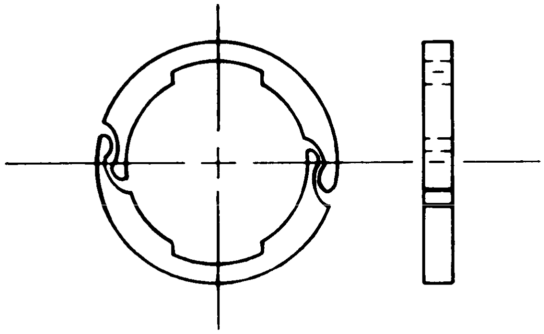
MS90707 - Ring, Retaining, External, Grip



Intended use: To provide shoulders for positioning and retaining machine components on ungrooved shafts, tubes, bosses, studs, etcetera. Friction force caused by heavy spring pressure of ring on shaft makes a fastener secure against axial displacement from either direction under moderate thrust or vibration. The rings are adjustable on the shaft and are reusable following disassembly. The rings will withstand high rotational speeds.

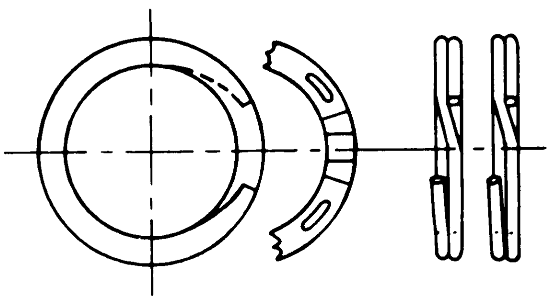
TABLE 401-I. Retaining ring selection. - Continued

MS90708 - Ring, Retaining, External, Interlocking



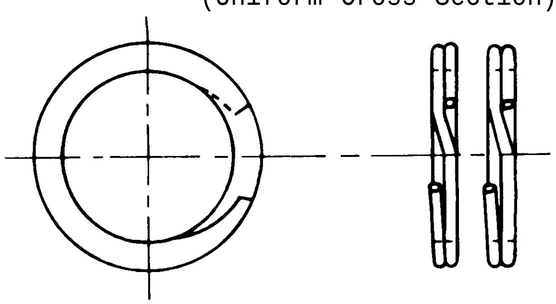
Intended use: To provide high circular shoulders for positioning and retaining machine components on shafts. The identical semicircular halves held together by the interlocking prongs form a balanced ring concentric with the shaft which will withstand high rotational speeds.

MIL-R-27426, type A, class 1 - Ring, Retaining, Spiral, External, Light Series (Uniform Cross Section)



Intended use: To provide shoulders for positioning and retaining components on shafts. Provides a continuous uniform retaining shoulder. No special tools required to install or remove rings. Moderate thrust capacity.

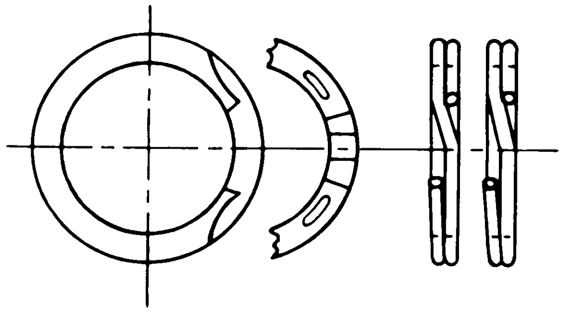
MIL-R-27426, type A, class 2 - Ring, Retaining, Spiral, External, Heavy Series (Uniform Cross Section)



Intended use: To provide shoulders for positioning and retaining components on shafts. Provides a continuous uniform retaining shoulder. No special tools required to install or remove rings. High thrust capacity.

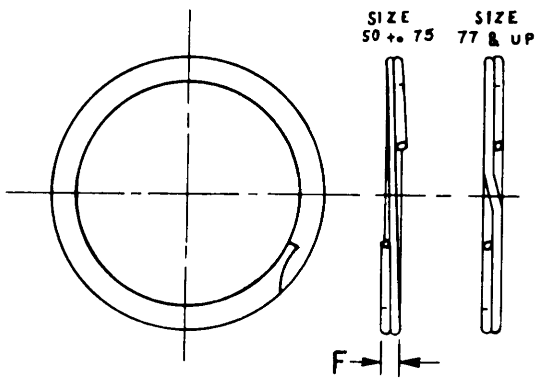
TABLE 401-I. Retaining ring selection. - Continued

MIL-R-27426, type B, class 1 - Ring, Retaining, Spiral, Internal Light Series (Uniform Cross Section)



Intended use: To provide shoulder for positioning and retaining components in housing or bores. Provides a continuous uniform retaining shoulder. No special tools required to install or remove rings. Moderate thrust capacity.

MIL-R-27426, type B, class 2 - Ring, Retaining, Spiral, Internal, Heavy Series (Uniform Section Type)



Intended use. To provide shoulder for positioning and retaining components in housing or bores. Provides a continuous uniform retaining shoulder. No special tools required to install or remove rings. High thrust capacity.

PULLEYS, GROOVE, ANTIFRICTION BEARING, GREASE LUBRICATED, AIRCRAFT

1. Scope

1.1 Scope. This requirement establishes criteria and information covering metallic and nonmetallic pulleys intended for use in aircraft control systems, brake installations and such other places where pulleys of this type are covered. Pulleys identified herein are approved parts as covered by MIL-P-7034 and applicable standards and shall be given priority in design or modification programs.

1.2 Unapproved parts. When applications require pulleys not conforming to MIL-P-7034, refer to Requirements 101, 102, and 103.

2. Documents applicable to Requirement 603:

QQ-A-225/6	Aluminum Alloy Bar, Rod and Wire, Rolled, Drawn, or Cold Finished, 2024
TT-P-1757	Primer Coating, Zinc Chromate, Low Moisture, Sensitivity
MIL-P-7034	Pulleys, Groove, Antifriction Bearing, Grease Lubricated, Aircraft
MIL-B-7949	Bearing, Ball, Airframe, Antifriction
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-W-83420	Wire Rope, Flexible, for Aircraft Control
MS20219	Pulleys, Groove, Secondary Control, Aircraft
MS20220	Pulley, Groove, Flight Control, Aircraft
MS20221	Pulley, Groove, Heavy Duty Control, Aircraft
MS21443	Bearing, Ball, Airframe, Antifriction, Pulley Type
MS24566	Pulley, Control, Antifriction Bearing

3. Material requirements

3.1 Nonmetallic sheave, type I. Nonmetallic pulley sheaves shall be manufactured from fabric or equivalent reinforcing material impregnated with a phenolic condensation product. The pulley shall be subjected to a suitable combination of temperature and pressure for producing a finished pulley with uniform strength. The material shall have non-afterglow properties and shall show no afterglow after ignition and flame extinction. The non-afterglow additive shall not bleed from the sheave material. The sheave material shall not corrode carbon steel wire rope coated with tin or zinc. The pulley shall not be adversely affected by fungus growth such as is encountered in tropical climates. Sheave material used shall be approved by the qualifying agency.

3.2 Metallic sheave, type II. Metallic sheaves shall be manufactured from aluminum alloy conforming to QQ-A-225/6, temper T351. Aluminum sheaves shall be anodized in accordance with MIL-A-8625, type II, before installing the bearing.

3.3 Bearings. Ball bearings shall conform to MIL-B-7949 and MS21443.

4. Workmanship

4.1 Dimensions, weights, and tolerance. Dimensions, weights, and tolerance shall conform to MIL-P-7034.

4.2 Sheaves, types I and II. The sides of all pulleys shall have a smooth surface without spokes or holes. Aluminum bore surfaces shall be coated with zinc-chromate primer in accordance with TT-P-1757 before bearings are installed. The bearing shall be installed while primer is wet.

4.3 Identification of pulley. Metal stamping shall not be used for identification of pulley.

5. Performance

5.1 Eccentricity and wobble clearance. Eccentricity and wobble clearance shall conform to MIL-P-7034.

5.2 Proof loads. Proof loads under static testing covering bearing bond, flange strength, sheave strength, and static friction torque shall conform to MIL-P-7034.

5.3 Endurance testing procedures. Endurance testing procedures shall conform to MIL-P-7034.

6. Design requirements

6.1 Single groove pulleys. The pulleys furnished under MIL-P-7034 are intended for use with 1/16 inch through 1/4 inch flexible wire rope conforming to MIL-W-83420 as used in aircraft secondary control systems, flight control systems, and for heavy duty control applications. For recommended wire rope sizes and allowable limit loads of all pulleys, see MS20219, MS20220, MS20221 and MS24566. Both pulley and wire rope life shall be considered in designing the system.

6.2 New pulley design. For new design, the wire rope diameter, pulley groove diameter, groove configuration, and the radial limit load capacity of the bearing shall determine the maximum load of the pulley.

6.3 Quality assurance testing. Test pulleys shall be endurance tested a minimum of 50,000 revolutions using the largest diameter wire rope intended for the application, 90 degree wrap angle, 20 inch wire rope travel, and wire rope tension at 25 percent of the limit load. Test pulleys shall be sheave tested with wire rope or pressure plate equal to the diameter of the wire rope. Wrap angle shall be 120 degrees and the minimum test load shall be twice the limit load of the pulley. Flange proof loads shall be not less than 75 pounds for 3/32 inch wire rope, 175 pounds for 3/16 inch wire rope, and 250 pounds for 1/4 inch wire rope. Test procedures shall be in accordance with MIL-P-7034.

7. Notes

7.1 Intended use. This requirement, MIL-P-7034, and the supporting documents are intended as an outline of the availability and requirements for control pulleys used in aircraft.

7.2 Limitaions. This requirement covers only grooved pulleys containing grease lubricate; antifriction bearings. Several pulleys maly be used as fairleads. Many fairlead pulleys and fairlead strips are of special design and are not covered by military specifications.

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