The Engineering Society For Advancing Mobility Land Sea Air and Space®

400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE RECOMMENDED PRACTICE

ARP 584

Issued 3-1-60
Revised 11-87

REV. A

Submitted for recognition as an American National Standard

COILED TUBING, CORROSION RESISTANT STEEL, HYDRAULIC APPLICATIONS

THIS REVISION CONTAINS ONLY EDITOPIAL CHANGES

1. PURPOSE:

The purpose of this recommended practice is to provide a convenient method for the engineer or draftsman to use in designing metal tubing configurations that will provide for large relative motion between contiguous points in fluid system piping.

2. SCOPE:

This recommended practice encompasses design, analysis, fabrication, and installation of pressurized plain metal tubing used in fluid power systems to provide relative motion.

Specific data given are for MIL-T-6845 tubing ranging from 1/4 inch to 1 inch dia. used in 3000 psi hydraulic or pneumatic systems, Types I, II, III or IV applied to any type of vehicle.

The flexible configurations of plain metal tubing are intended for application to actuators that oscillate about a pivot, to areas of large structural deflection such as reservoirs installation, and to areas of extreme environment where flexible hose could not survive.

3. APPLICABLE DOCUMENTS:

MIL-H-5440 - Hydraulic System; Design, Installation and Tests of Aircraft (General Specification For)
MIL-P-5518 - Pneumatic System; Design, Installation and Test in Aircraft
MIL-T-6845 - Tubing; Steel, Corrosion-Resisting, (18-8) Aircraft, Hydraulic System
AND-10104 - Tubing, Steel, Corrosion-Resistant, Round, Standard Dimensions for

3. (Continued):

MS 33611 - Tube Bend Radii
WADC Tech. Report 55-121
WADC Tech. Report 57-507 Parts I & II

4. CONFIGURATIONS:

All configurations may be classified as one of the three styles listed below and may be treated in accordance with the following instructions:

Style A "Helical Configuration" (Standard Version Fig. 1)

This consists of a 540 degree (1-1/2 turn) helix with a straight section projecting from each end. Style A operates principally in bending and allows 13 degree angular motion of one end with respect to the other about the helix axis in a plane perpendicular to the helix axis.

Style B "Torsion Tube" (Standard Version Fig. 2)

This consists of three straight sections separated by two 90 degree bends all in one plane. The middle straight section is twisted in operation, allowing one end to rotate about the centerline of the middle straight section. (See Section 5)

Style C "Non-Standard Configurations"

Where Styles A & B are not applicable, an infinite variety of special configurations may be designed to accommodate particular space or deflection requirements. These may be modifications of Styles A & B or more elaborate combinations of straights, curves, and helical section elements which are otherwise consistent with the specifications of Style A & B. All Style C configurations should be designed, analyzed and tested in accordance with the recommendations in WADC Technical Report 57-507 Part I & Part II (ASTIA Document AD 142251) in addition to the recommendations herein.

5. GENERAL REQUIREMENTS:

The recommended maximum deflection for the various temperature ranges as shown in Figs. 2 and 3 are as follows:

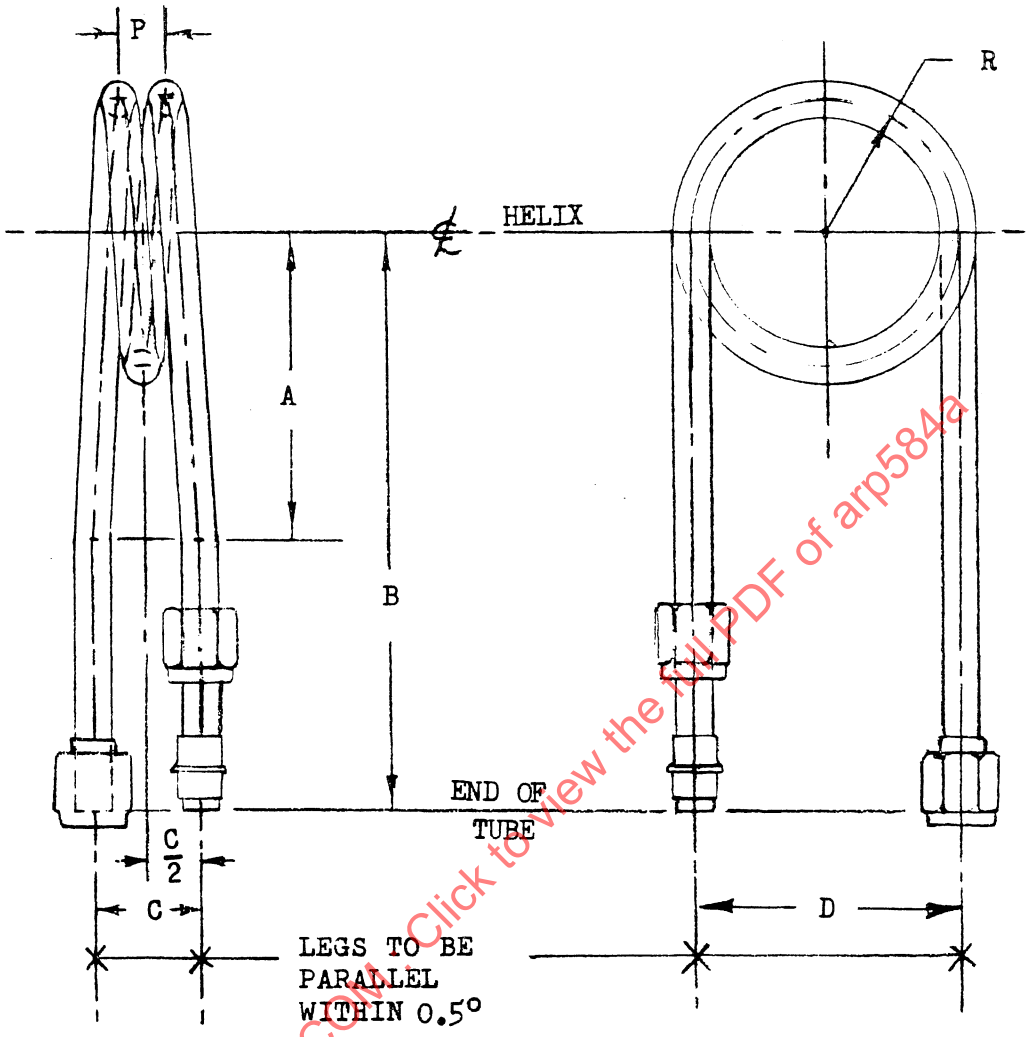
System Type	Temperature Range	Angular Deflection Ø Degrees, Maximum
Type I	-65° to +160°F	13
Type II	-65° to +275°F	12.3
Type III	-65° to +400°F	11.3
Type IV	-65° to +600°F	10

Where deflection requirements exceed the allowable maximum Ø, a non-standard configuration, Style C, must be used.

6. MATERIALS:

The tubing should be Corrosion Resistant Steel (18-8) Aircraft Hydraulic System Tubing in accordance with MIL-T-6845. It is recommended that 100% quality control be applied to inside and outside surface smoothness. The wall thicknesses specified on pages 2 & 4 are consistently higher than normally used for fixed tubing to provide the necessary stress margins for flexure plus internal pressure.

Steel fittings (nut, sleeve and mating fittings) in accordance with current Military Standards either flared or flareless types should be used. Aluminum alloy fittings can withstand the loads but will be difficult to properly install, will severely distort when tightened against the thick wall steel tubing and may require occasional retightening to eliminate seep leakage.



Linear dimensions in inches

FLARED OR FLARELESS TYPE FITTINGS

FIGURE 1 - Style A "Helical Configuration"

TABLE I

TUBE OD	WALL THICKNESS NOM	R ±0.047	P PITCH	A ±0.032	B ±0.032	C ±0.032	D ±0.032
0.250	0.028	1.000	0.375	3.000	6.000	0.906	2.000
0.313	0.035	1.125	0.438	3.000	6.000	1.032	2.250
0.375	0.042	1.375	0.500	3.250	6.000	1.125	2.750
0.500	0.058	1.750	0.625	4.000	7.000	1.375	3.500
0.625	0.078	2.250	0.750	5.000	9.500	1.656	4.500
0.750	0.083	2.625	0.875	6.000	12.000	1.938	5.250
1.000	0.120	3.500	1.125	7.000	14.000	1.406	7.000

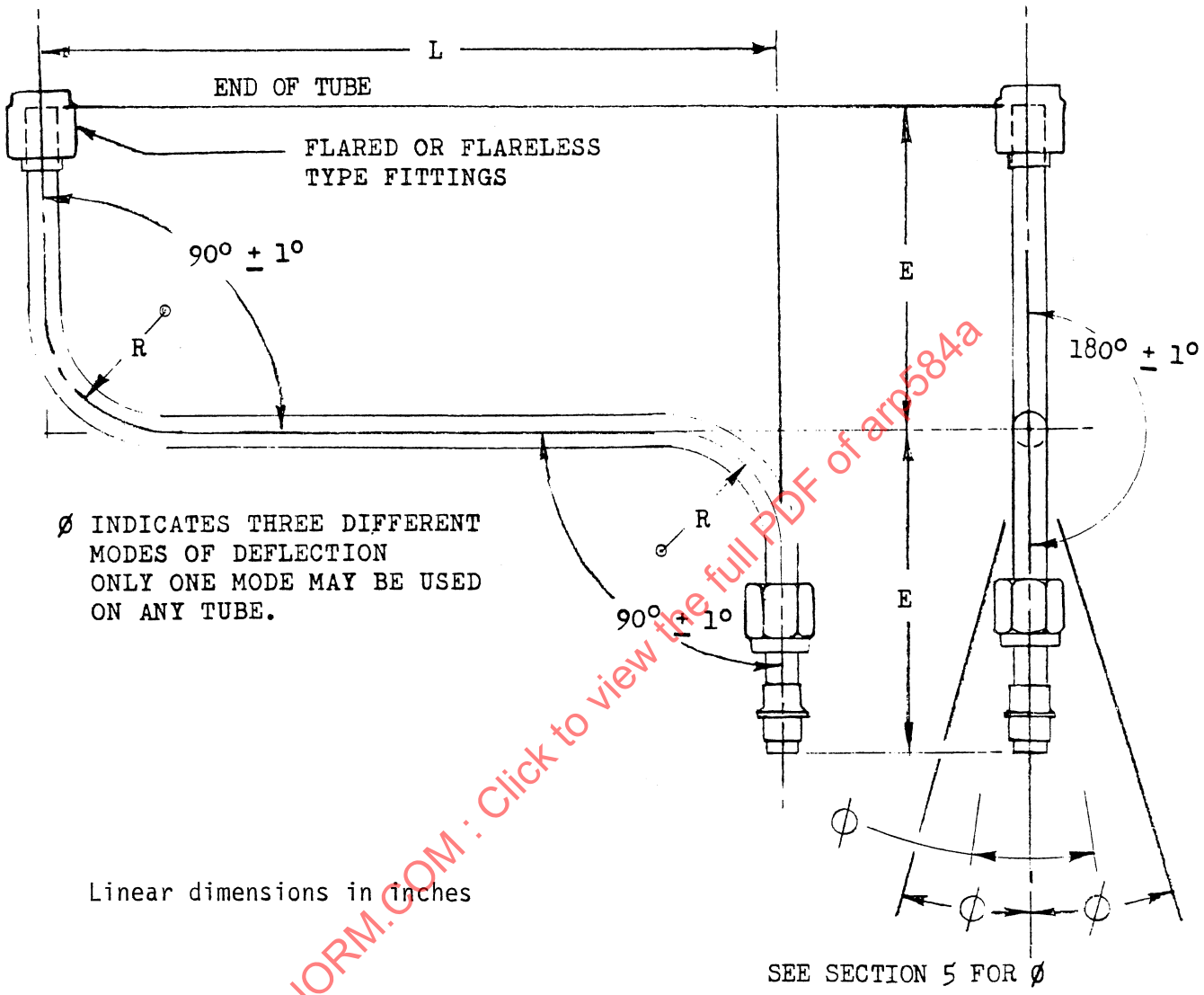
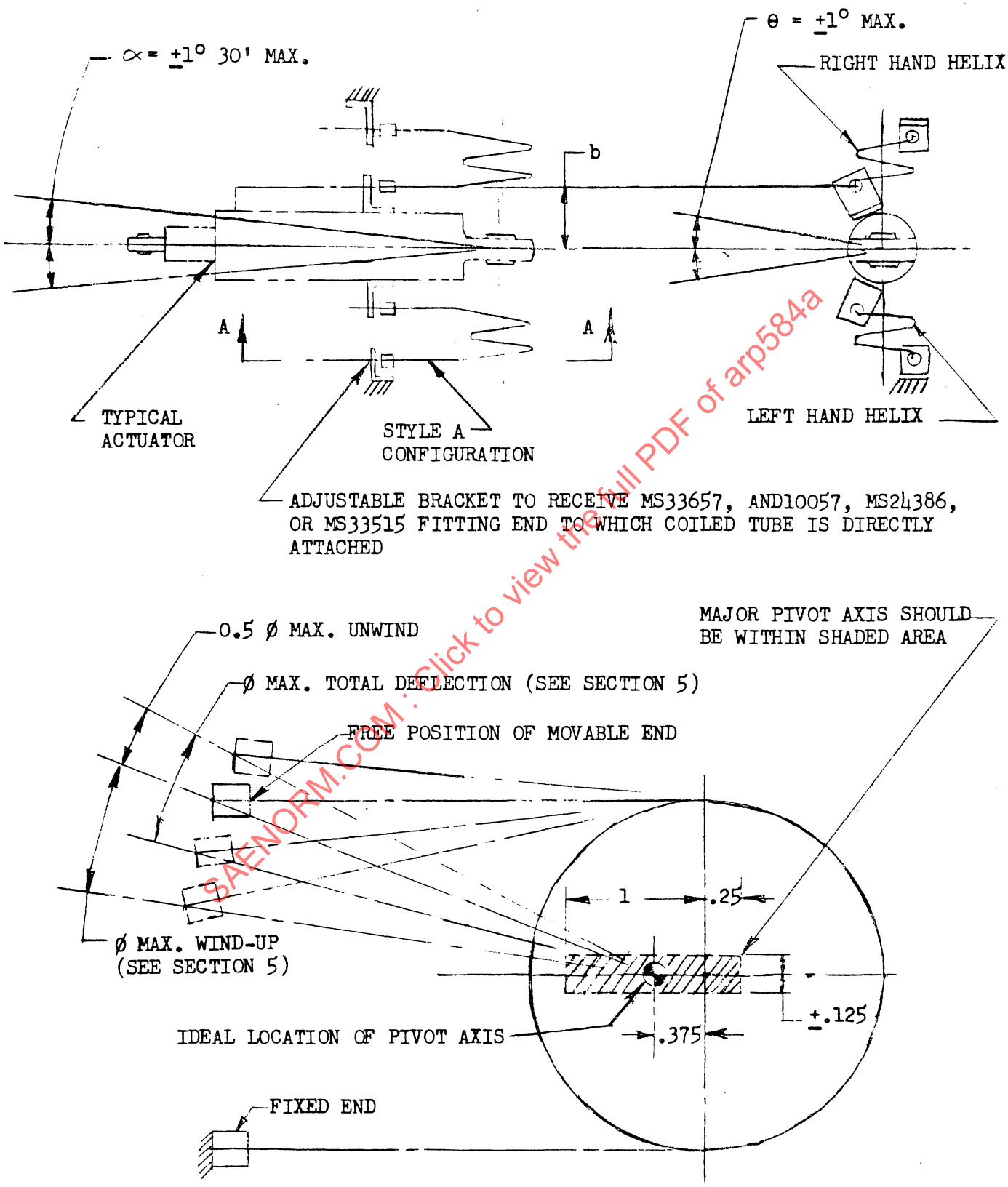


FIGURE 2 - Style B "Torsion Tube"

TUBE OD	WALL THICKNESS NOM	R RAD	L ±0.032	E ±0.032
0.250	0.028	1.000	11.125	4.000
0.313	0.035	1.125	14.000	5.000
0.375	0.042	1.375	16.750	6.000
0.500	0.058	1.750	22.250	8.000
0.625	0.078	2.250	27.875	10.000
0.750	0.083	2.625	33.375	12.000
1.000	0.120	3.500	44.500	16.000



Linear dimensions in inches

FIGURE 3 - Installation of Style A

7. FARRICATION:

Style B may be manufactured with conventional tube bending tools. Style A may be manufactured by conventional tube bending techniques except as follows:

The conventional die block which contains a semi-circular shaped groove around 180 - 270 degrees of its external surface must be replaced by a similar block containing a groove which spirals through 600 degrees (1-2/3 turns). As this spiral die block turns, it must be free to shift along its axis, or the feed block must move relative to the spiral die to accommodate the lead of the spiral.

The feed block (which supports the unbent tube) must be tilted to an angle approximately equal to the helix angle, which can be adjusted to produce the correct pitch (typical spring winding technique).

Use of a mandrel is recommended to ensure minimum flattening of the tubing at the bends. The percent flattening must not exceed 5% defined as:

$$\text{Flatness} = \frac{(\text{MAXIMUM O.D.} - \text{MINIMUM O.D.})}{(\quad \text{NOMINAL O.D.} \quad)} \times 100$$

A careful check along the entire bend should be made, particularly at the midpoint of the bend and at the tangency points (where bend meets straight section) to find minimum O.D. Maximum O.D. is defined as the measurement 90 degrees to the minimum O.D. at the section of this minimum O.D. In production, a check fixture should be used to check configuration tolerances. For tubing sizes below 3/8, a keeper which interconnects the tubing ends should be attached after proof testing to prevent excessive deflection during the handling.

8. INSTALLATION (Styles A & B Only):

A space layout and geometry study will indicate which style configuration can be used most advantageously. In the process, Style A would be located with the ℄ helix close to the major pivot axis or Style B with the ℄ middle straight section along the major pivot axis. However, it is necessary to determine or estimate all other factors which may cause relative motion such as misalignment, structural deflections, thermal expansion, etc. These should be resolved about the three principal axes of motion and compared with the installation tolerances illustrated herein.

During actuator installation or replacement, one must be careful not to deflect the flexible tubing beyond the design limits. The designer may be able to limit the over flexure in the cavity by means of structural stops or provide satisfactory instructions for installation and removal. It is imperative that designer, mechanic and inspector observe installation limits to ensure maximum fatigue life and reliability of flexible plain metal tubing.

8.1 Style A Installation: The recommended deflection for Style A can all be taken in the windup direction or it can be split with 50% maximum deflection on each side of the free position. (See Fig. 3 on page 6)

Style A should be oriented so that the axis of the helix is parallel to the principal axis of motion, which may be offset to any point within the shaded area (illustrated in Fig. 3, page 6).

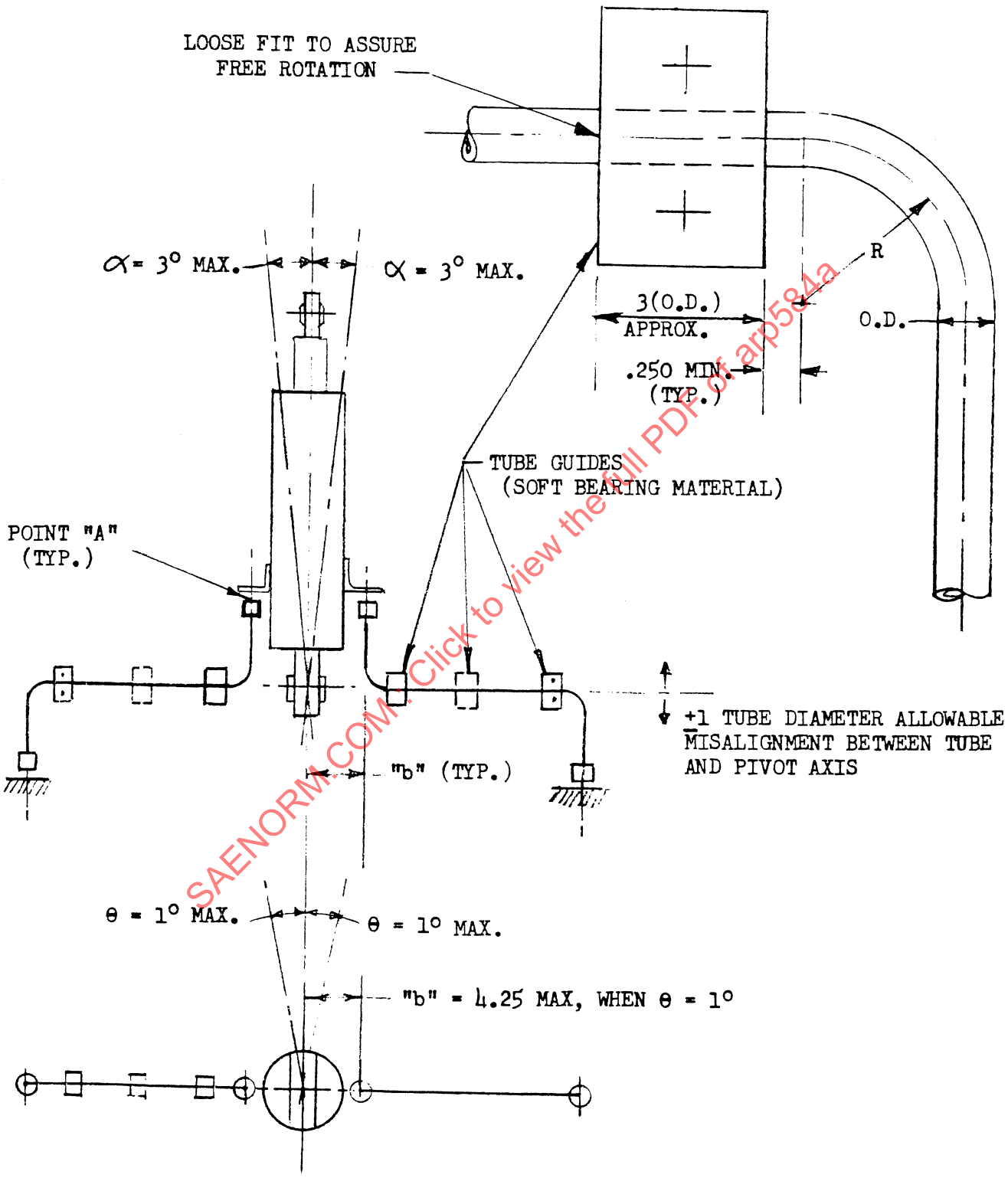
The helix of Style A should be located as close as practical to the actuator (in the type of application illustrated by dimension b in Fig. 3) to minimize the effects of misalignment. Actuator misalignment α should be limited to 1.5 degrees and rotation about actuator centerline, θ should be limited to 1 degree. A symmetrical installation about either side of the actuator using right and left hand pitch in the helixes will result in balance of rotational forces which is desirable. When self aligning bearings are used, restrict actuator rotation torsionally by mechanical means such as special washers or lugs on the bearing strap.

8.2 Style B Installation: The total deflection of the torsion tube is limited to 13 degrees which may be displaced in either direction, such that the combination does not exceed 13 degrees. The torsion tube will require tubing guides which will allow the tube to rotate but not deflect such that bending is imposed during flexure. The guides shall be located within 0.250 inch of the tangency point to radius, and a third guide shall be installed at the midpoint on the larger sizes (0.5 inch O.D. and larger). Satisfactory adjustments shall be incorporated at the guide and tube attachment points to stay within the installation tolerances. It is suggested that the tube be attached to the connecting fittings before guide block is installed. This will readily indicate if any tube deflection occurs.

The axis of the torsion tube shall be placed in line with the pivot centerline of the actuator within the limits as shown on Fig. 4.

The misalignment angle α of the actuator is limited to +3 degrees when combined with an offset b of 4.25 inch, a rotational deflection θ of ± 1 degree and the principal deflection $\emptyset$ established in section 5. Larger angle of misalignment may be tolerated if the inboard clamps can flex in the plane of the tubing, thereby reducing the bending on the tube.

Actuator rotation can be limited with a symmetrical installation and with appropriate lugs on actuator end cap.



Linear dimensions in inches

FIGURE 4. Installation of Style "B" torsion tube