#70

ARROW

UNCLASSIFIED

MAINTENANCE INSTRUCTIONS

THE USE OF PRE-LOAD INDICATING

)P.L.I.) WASHERS

70/MAINT 00/3

AVRO AIRCRAFT

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FORM 1749 A

TABLE OF CONTENTS

1. INTRODUCTION

The information contained in this instruction has been compiled from the Standard Pressed Steel Company catalogue and is published for the guidance of maintenance personnel in the use of Pre-Load Indicating (P.L.I) washers.

2. DESCRIPTION

2.1 The P.L.I. (Preload Indicating) washer offers simple and accurate means of applying a known torque load to bolts without using a torque wrench or other special tools.

2.2 Each P.L.I. washer assembly consists of two concentric steel rings sandwiched between two close-tolerance hardened steel washers. The inner ring is smaller in diameter and thicker than the outer. As the assembly is tightened, the inner ring takes the load and is compressed until the loose outer ring binds between the upper and lower plain washers. The tightened load in the bolt is equal to the load required to compress this inner ring. When the binding of the outer ring occurs, it is a sign that the exact desired load has been reached. (See Figure 1).

2.3 P.L.I. washers are part numbered in relation to the tensile strength group of the bolts being used. Each group is identified by means of a distinctive coloured outer ring. (See Table 1).

2.4 Part numbers are made up of two series of digits. The first series, which directly follows the identifying letters "P.L.I.", indicates the diameter of the bolt in sixteenths of an inch. The second series of digits indicates the mean preload in thousands of pounds.

NOTE

This preload is NOT to be confused with torque-load in inch-pounds or foot-pounds, which is an entirely different figure and is pre-calculated.

EXAMPLE

PLI - 10 - 31.7

10 = BOLT DIAMETER IN 1/16"

31.7 = MEAN PRELOAD IN THOUSANDS OF LBS.

This washer would be fitted to a 5/8" bolt in the 180,000 psi group; the colour identification would be blue. In the 220,000 psi group, the prefix is altered to PLI22, the remainder of the part number being obtained in the same way as the other groups, e.g. PLI22-10-36.4

3. Using the P.L.I. Washer

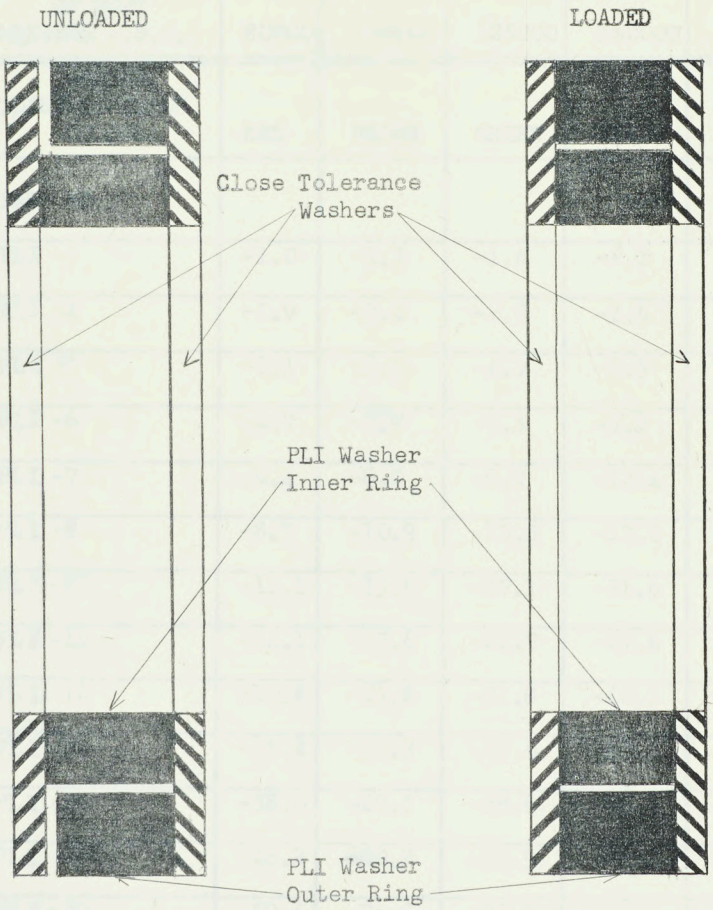
The close-tolerance hardened steel washers are supplied in two forms, PLAIN and COUNTERSUNK, for varying locations. The COUNTERSUNK washer is countersunk at 45° on the inside diameter of the washer on one face only.

3.1 Where a P.L.I. washer is assembled under a nut, two PLAIN washers are required.

3.2 Where a P.L.I. washer is assembled under the head of a bolt, one PLAIN and one COUNTERSUNK washer is required. The COUNTERSUNK washer MUST be fitted immediately under the head of the bolt so that the countersink clears the radius between the head and the shank of the bolt. Failure to observe this point could cause the bolt to shear under a high load.

3.3 Standard tools only are required to tighten nuts and bolts. It will be noticed that there are 3 indents in the outer surface of the outer ring. These indents are incorporated so that the operator can check the outer ring for movement while tightening the bolt or nut. The bolt is considered to be properly torque-loaded when it is just possible to move the outer ring. If the outer ring is tight, an over-torque load is indicated.

FIGURE 1



SECTION THROUGH P.L.I. WASHERS

TABLE 1

	TENSILE STRENGTH OF BOLT MINIMUM P.S.I.	80000	100000	125000	160000	180000	220000
	WASHER IDENTIFICATION COLOUR	RED	BROWN	GREEN	PLAIN	BLUE	OLIVE DRAB
BOLT SIZE	PART NO.						PART NO PLI 22
#10	PLI -3	-1.0	-1.3	-1.6	-2.1	-2.3	
1/4	PLI -4	-1.9	-2.4	-2.9	-3.6	-4.3	-4-5.0
5/16	PLI -5	-3.1	-3.8	-4.7	-5.9	-6.9	-5-8.1
3/8	PLI -6	-4.7	-5.9	-7.3	-9.2	-10.7	-6-12.4
7/16	PLI -7	-6.4	-8.0	-9.9	-12.4	-14.4	-7-16.7
1/2	PLI -8	-8.7	-10.9	-13.5	-17.0	-19.6	-8-22.7
9/16	PLI -9	-11.1	-13.9	-17.1	-21.6	-24.9	-9-28.7
5/8	PLI -10	-14.1	-17.6	-21.7	-27.6	-31.7	-10-36.4
3/4	PLI -12	-20.6	-25.8	-31.8	-40.3	-46.5	-12-53.3
7/8	PLI -14	-28.2	-35.3	-43.5	-55.2	-63.5	-14-72.9
1"	PLI -16	-38.0	-47.5	-58.6	-74.3	-85.5	-16-97.9
1 1/8	PLI -18	-48.2	-60.2	-72.9	-93.4	-108.4	-18-1229
1 1/4	PLI -20	-59.4	-74.2	-92.8	-117.8	-133.6	-20-154.8
1 3/8	PLI -22	-73.1	-91.4	-114.2	-145.1	-164.5	-22-190.3
1 1/2	PLI -24	-88.2	-110.3	-137.9	-175.3	-198.5	-24-229.5

P.L.I. WASHERS - PART NUMBERS AND IDENTIFICATION

TABLE 2

	FOR USE WITH BOLTS UP TO 180000 P.S.I.		FOR USE WITH BOLTS UP TO 220000 P.S.I.	
	COUNTERSUNK WASHER	PLAIN WASHER	COUNTERSUNK WASHER	PLAIN WASHER
BOLT SIZE				
#10	WC-3	WP-3		
1/4	WC-4	WP-4	WC22-4	WP22-4
5/16	WC-5	WP-5	WC22-5	WP22-5
3/8	WC-6	WP-6	WC22-6	WP22-6
7/16	WC-7	WP-7	WC22-7	WP22-7
1/2	WC-8	WP-8	WC22-8	WP22-8
9/16	WC-9	WP-9	WC22-9	WP22-9
5/8	WC-10	WP-10	WC22-10	WP22-10
3/4	WC-12	WP-12	WC22-12	WP22-12
7/8	WC-14	WP-14	WC22-14	WP22-14
1	WC-16	WP-16	WC22-16	WP22-16
1 1/8	WC-18	WP-18	WC22-18	WP22-18
1 1/4	WC-20	WP-20	WC22-20	WP22-20
1 3/8	WC-22	WP-22	WC22-22	WP-22-22
1 1/2	WC-24	WP-24	WC22-24	WP22-24

P.L.I. CLOSE - TOLERANCE WASHERS