D-31-02

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400 COMMONWEALTH DRIVE WARRENDALE PA 15096

AEROSPACE INFORMATION REPORT

AIR 1754

Issued 12-1-81
Revised Editorial Change 3-31-83

WASHER, THERMAL COMPENSATING, METRIC SERIES

1. GENERAL:

1.1 Scope: The purpose of this document is to define:

- compensation washer application requirements
- recommended materials
- washer thickness determination
- dimensioning

1.2 Application: Compensation washers may be used to counteract tightening losses or overloads in fasteners of a bolted assembly that result from the difference in heat expansion factors that exist among the components of the assembly.

2. MATERIAL:

The corrosion resistant material for the washer should be selected by considering the relative heat expansion factors of the bolt and flanges. There are two possible cases:

a) The bolt has a greater heat expansion than the flanges: This condition results in a tightening loss: to counteract this loss, a material having a greater heat expansion factor than that of the bolt should be selected for the washer.

α bolt > α flange: recommended material A286

b) The flanges have a greater heat expansion than the bolt: This condition induces a tightening overload: to prevent this overload, a material having a smaller heat expansion factor than that of the bolt shall be selected for the washer.

α flange > α bolt: recommended material: low expansion alloy (INVAR) cold work

3. SYMBOLS - UNITS:

TABLE 1

CALCULATION DATA	SYMBOL	UNITS
Linear expansion factor		
1. If dissimilar for flanges 1 and 2		
- Flange 1	αb_1	m per m°C
- Flange 2	αb_2	m per m°C
2. If identical for flanges 1 and 2		m per m°C
Flanges 1 and 2	αb	m per m°C
Washer	αr	m per m°C
Bolt	αv	m per m°C
Washer thickness	E	m
Flange thickness		
- Flange 1	L_1	m
- Flange 2	L_2	m
3. Temperature	θ	°C
4. Roughness	xx	μ metre

4. WASHER THICKNESS DETERMINATION:

4.1 General Case: Flanges having dissimilar heat expansion factors:

Formula to be applied:

$$E = \frac{L_1(\alpha b_1 - \alpha v) + L_2 (\alpha b_2 - \alpha v)}{\alpha v - \alpha r}$$

(Refer to paragraph 4.4 - Example 1)

4.2 Specific Case: Flanges having the same heat expansion factor:

Formula to be applied:

$$E = \frac{\alpha b - \alpha v}{\alpha v - \alpha r} \times (L_1 + L_2)$$

(Refer to paragraph 4.4 - Example 2)

4.3 Rounding-Off-Rule: The resulting thickness should be rounded-up or rounded-down contingent on the compensation effect to be obtained. The rounding of calculated values should not contribute to fastener overstress or loss of fastener preload.

4.4 Examples of Calculation

4.4.1 Example 1: Operating Temperature:

$\vartheta = 200°C$

TABLE 2

COMPONENT	MATERIAL	Heat Expansion Factor (m per m°C)	Thickness (mm)
Flange 1	AA 2618	$\alpha b_1 = 23.1 \times 10^{-6}$	$L_1 = 6$
Flange 2	Aluminum Cast Alloy 5Cu 0.3 Mg 0.2 Ti	$\alpha b_2 = 23.8 \times 10^{-6}$	$L_2 = 10$
1 Bolt	A286	$\alpha v = 17.0 \times 10^{-6}$	
1 Washer	Low expansion alloy (INVAR) Cold work	$\alpha r = 3.0 \times 10^{-6}$	

$$E = \frac{6 \times 10^{-3} (23.1 - 17.0) 10^{-6} + 10 \times 10^{-3} (23.8 - 17.0) 10^{-6}}{(17.0 - 3.0) 10^{-6}} = 7.47 \times 10^{-3} m$$

After rounding-off: E = 7.5 mm

4.4.2 Example 2: Operating Temperature:

$\theta = 400°C$

TABLE 3

COMPONENT	MATERIAL	Heat Expansion Factor (m per m°C)	Thickness (mm)
2 Flanges (with same material)	INCONEL 903	$\alpha b = 7.5 \times 10^{-6}$	L = 10
1 Bolt	WASPALOY	$\alpha v = 13.7 \times 10^{-6}$	
1 Washer	A286	$\alpha r = 17.4 \times 10^{-6}$	

$$E = \frac{(7.5 - 13.7)\ 10^{-6}}{(13.7 - 17.4)\ 10^{-6}} \times 10 \times 10^{-3} = 16.8 \times 10^{-3} m$$

After rounding-off: E = 17 mm

5. DIMENSIONING (DIMENSIONS IN MM): (Recommended Values for Washer Definition)

TABLE 4

NOMINAL THREAD SIZE	DRILLED DIAMETER A min	max	COUNTERSINK DIAMETER B min	max	EXTERNAL DIAMETER C min	max	THICKNESS E
4	4.1	4.28	4.7	4.9	7.78	8	see para. 4
5	5.1	5.28	5.7	5.9	9.78	10	
6	6.1	6.31	7.3	7.5	11.73	12	
7	7.1	7.31	8.3	8.5	13.73	14	
8	8.1	8.31	9.3	9.5	15.73	16	
10	10.1	10.37	11.3	11.5	19.67	20	
12	12.1	12.37	14.0	14.2	23.67	24	