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AEROSPACE
INFORMATION
REPORT

AIR 1754

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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.

$\alpha_{\text{bolt}} > \alpha_{\text{flange}}$: 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.

$\alpha_{\text{flange}} > \alpha_{\text{bolt}}$: recommended material: low expansion alloy
(INVAR) cold work

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3. SYMBOLS - UNITS:

TABLE 1

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

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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 Calculation4.4.1 Example 1: Operating Temperature:

$$\theta = 200^{\circ}\text{C}$$

TABLE 2

COMPONENT	MATERIAL	Heat Expansion Factor (m per m°C)	Thickness (mm)
Flange 1	AA 2618	$\alpha_{b1} = 23.1 \times 10^{-6}$	$L_1 = 6$
Flange 2	Aluminum Cast Alloy 5Cu 0.3 Mg 0.2 Ti	$\alpha_{b2} = 23.8 \times 10^{-6}$	$L_2 = 10$
1 Bolt	A286	$\alpha_v = 17.0 \times 10^{-6}$	
1 Washer	Low expansion alloy (INVAR) Cold work	$\alpha_r = 3.0 \times 10^{-6}$	

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

After rounding-off: $E = 7.5 \text{ mm}$

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4.4.2 Example 2: Operating Temperature:

$$\theta = 400^{\circ}\text{C}$$

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	WASPALLOY	$\alpha_v = 13.7 \times 10^{-6}$	
1 Washer	A286	$\alpha_r = 17.4 \times 10^{-6}$	

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

After rounding-off: E = 17 mm

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

TABLE 4

NOMINAL THREAD SIZE	DRILLED DIAMETER A		COUNTERSINK DIAMETER B		EXTERNAL DIAMETER C		THICKNESS E
	min	max	min	max	min	max	
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	