1 Joint overview

This report is a demonstration of what is possible with an automated reporting tool. Place-holder values are used.

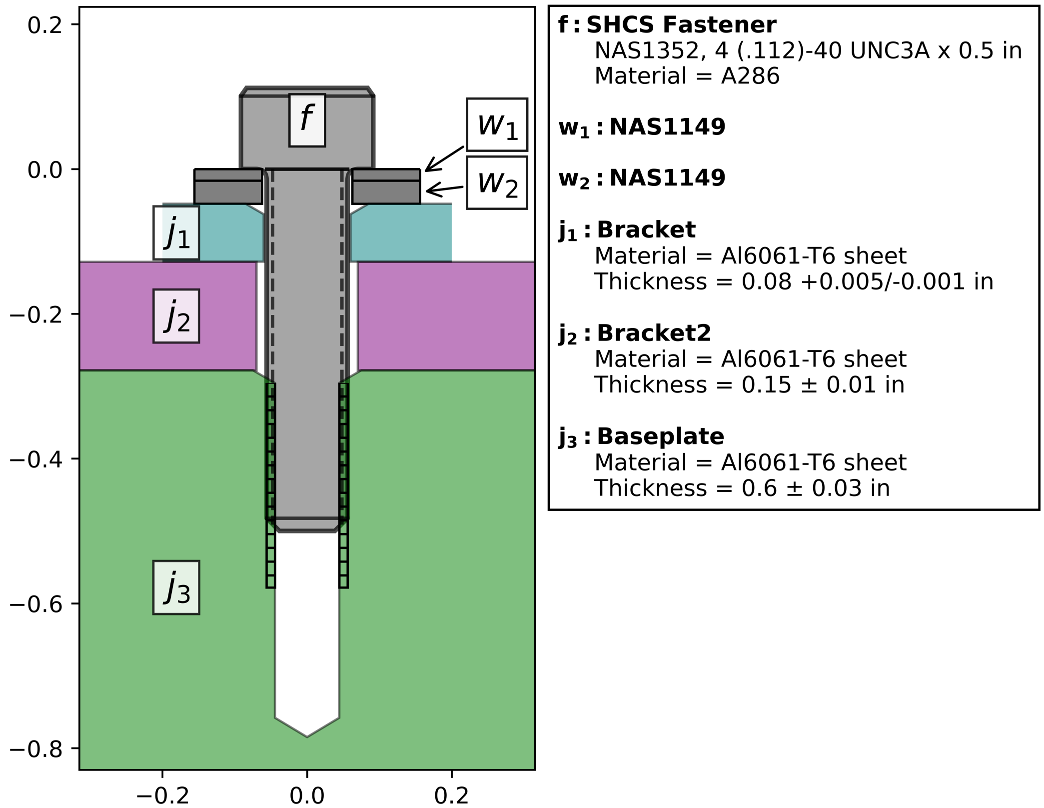

Figure 1: Plot of joint at nominal.

2 Preload

The following parameters were provided:

- Torque (T) = 9.0 +0.5/-0.5 in lbf
- Nut factor (K) = 0.2 (as-received)
- Preload uncertainty (Γ) = 0.35

2.1 Nominal preload

Nominal preload (P_{pi-nom}) is calculated per NASA-STD-5020B Eq. 24 see equation 1

$$
\begin{aligned}
P_{p-nom} &= \frac{T}{K \cdot D} \\
&= \frac{9.0}{0.2 \cdot 0.112} \\
&= 401.8\ lbf
\end{aligned} \tag{1}
$$

2.2 Minimum preload

$$
\begin{aligned}
c_{min} &= \frac{T_{nom} - T_{tol-minus}}{T_{nom}} \\
&= \frac{9.0 - 0.5}{9.0} \\
&= 0.944
\end{aligned} \tag{2}
$$

A single fastener joint is specified. Minimum initial preload (P_{pi-min}) is calculated per NASA-STD-5020B, Eq. 26a , see equation 3

$$
\begin{aligned}
P_{pi-min} &= c_{min}(1 - \Gamma)P_{pi-nom} \\
&= 0.944(1 - 0.35)401.7857142857142 \\
&= 512.277\ lbf
\end{aligned} \tag{3}
$$

3 Margins of safety

Margins of safety are calculated using $FF = 1.15$, $FS_y = 1.4$, $FS_u = 2.0$.External loads and temperatures shown below in table 1

Table 1: Loads used to calculate margins of safety

case	eid	ΔT_{min}	ΔT_{max}	P	V	M
cold	1000	-80.00	0.00	21.39	93.68	57.98
	1001	-80.00	0.00	93.00	63.56	35.83
	1002	-80.00	0.00	27.02	92.37	34.15
	1003	-80.00	0.00	7.90	4.93	24.49
hot	1000	-0.00	100.00	23.42	79.13	2.50
	1001	-0.00	100.00	63.68	65.67	63.06
	1002	-0.00	100.00	26.07	59.82	55.75
	1003	-0.00	100.00	81.18	77.07	91.28

Margins of safety are shown below in table 2

Table 2: Calculated margins of safety

case	eid	P	V	M	MS_{sep}	MS_{tu}	MS_{su}	MS_{ty}	MS_{slip}	MS_{int}
cold	1000	21.39	93.68	57.98	14.83	18.62	3.22	0.80	-0.65	9.34

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Table 2: Calculated margins of safety

case	eid	P	V	M	MS_{sep}	MS_{tu}	MS_{su}	MS_{ty}	MS_{slip}	MS_{int}
	1001	93.00	63.56	35.83	2.64	3.51	5.22	-0.59	-0.54	8.44
	1002	27.02	92.37	34.15	11.53	14.53	3.28	0.42	-0.64	9.31
	1003	7.90	4.93	24.49	41.83	52.10	79.22	3.86	4.92	102.56
hot	1000	23.42	79.13	2.50	13.46	16.92	4.00	0.64	-0.58	10.85
	1001	63.68	65.67	63.06	4.32	5.59	5.03	-0.40	-0.53	10.11
	1002	26.07	59.82	55.75	11.98	15.10	5.62	0.47	-0.46	13.73
	1003	81.18	77.07	91.28	3.17	4.17	4.13	-0.53	-0.60	8.31

3.1 Bolt shear ultimate

The margin of safety for bolt shear ultimate (MS_{su}) is calculated using NASA-STD-5020B, Eq. 14. The equation and the calculation for the minimum margin of safety are shown below in equation 4

$$\begin{aligned} MS_{su} &= \frac{P_{su-allow}}{FF \cdot FS_u \cdot P_{sL}} - 1 \\ &= \frac{910.1}{1.15 \cdot 2.0 \cdot 93.7} - 1 \\ &= 3.224 \end{aligned} \tag{4}$$

3.2 Separation

$$\begin{aligned} &P'_{sep} \leq P'_{tu} \\ &= 637.708 \leq 160.513 \\ &= False \end{aligned} \tag{5}$$

$$\begin{aligned} &P'_{sep} \leq P'_{ty} \\ &= 637.708 \leq 61.879 \\ &= False \end{aligned} \tag{6}$$

3.3 Joint separation

Joint separation margin of safety (MS_{sep}) is calculated using NASA-STD-5020B, eq TODO. The equation and the calculation for the minimum margin of safety are shown below in equation 7

$$\begin{aligned} MS_{sep} &= \frac{P_{p-min}}{FF \cdot FS_{sep} \cdot P_{tL}} - 1 \\ &= \frac{486.663}{1.15 \cdot 1.25 \cdot 21.4} - 1 \\ &= 0.1 \end{aligned} \tag{7}$$

3.4 Bolt tensile ultimate

The margin of safety for bolt tensile ultimate (MS_{tu}) is calculated using NASA-STD-5020B, Eq. 6 . The joint is predicted to separate before rupture, so the allowable is determined by the bolt tensile ultimate strength ($P_{tu-allow}$).The equation and the calculation for the minimum margin of safety are shown below in equation 8

$$\begin{aligned} MS_{tu} &= \frac{P_{tu-allow}}{FF \cdot FS_u \cdot P_{tL}} - 1 \\ &= \frac{965.2}{1.15 \cdot 2.0 \cdot 200.0} - 1 \\ &= -0.1 \end{aligned} \tag{8}$$