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SUBJECT : Evaluation of Interface Loads On CAL/GLAST

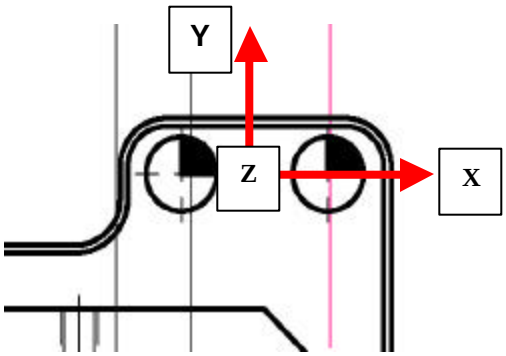
This memo documents the evaluation of interface loads specified in Section 6.5.1.3 of LAT-SS-00238 "CAL –LAT Interface Control Document". The results show positive margin on the base plate and its interface to the LAT. No failure is expected.

- The grid interface loads on the CAL tabs are specified in the Table 2 of ICD and are tabulated as follows. A MUF of at least 15% must be added to the load shown below.

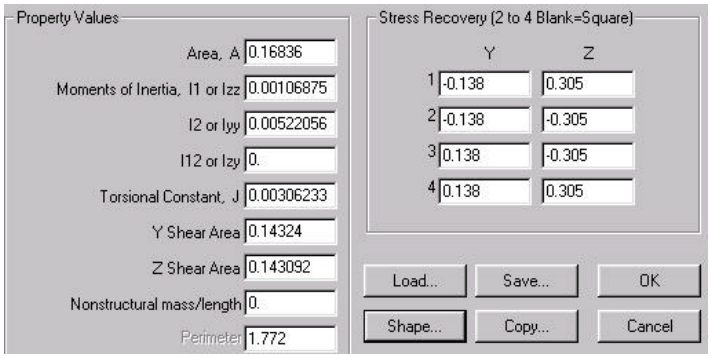
| CAL | Unit in N & m | | | Unit in lbs & in | | | |
|---|---|---|---|---|---|---|---|
| Tabs | LC1 | LC2 | LC3 | LC1 | LC2 | LC3 | Comments |
| F(x) | 4373 | 1140 | -3302 | 983 | 256 | -742 | Across tab in plane of plate |
| F(y) | 206 | 2994 | 1414 | 46 | 673 | 318 | Along tab |
| F(z) | -195 | -11 | 654 | -44 | -3 | 147 | Out of plane of plate |
| M(x) | 1.39 | -0.05 | -6.09 | 12.34 | -0.43 | -53.85 | Around x-axis |
| M(y) | 0.45 | -1.28 | 0.22 | 3.94 | -11.32 | 1.93 | Around y-axis |
| M(z) | 20.98 | 4.58 | -14.86 | 185.65 | 40.56 | -131.49 | Around z-axis |

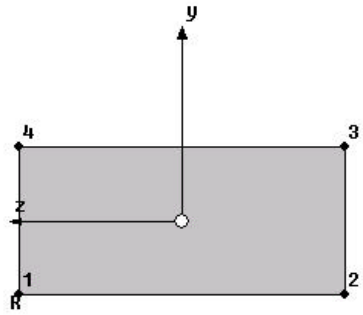
Notes: Interface loads are for CAL tab thickness of 7 mm

The material for the base plate is equivalent to 2618-T71 which has E=10.7 msi, Ftu=55 ksi, Fty=42 ksi, e=4% based on Mil-HDBK-5H.




The thickness of the tabs is 7mm (0.276"). The corner tabs have width of the 18 mm but the root width is only 18-3.5 = 14.5 mm = 0.61". The length from center of screw hole to the root of the tab is 7.5 mm = 0.2953 "




Envelops the interface load from LC1 to LC3,

Fx=983 lbs, Fy=673 lbs, Fz=147 lbs, Mx=53.85 in-lbs, My=11.32 in-lbs, Mz=185.65 in-lbs.

With Mx = 53.85 in-lbs, the bending stress in direction Y is

S_Mx = S1y = 53.85 * 0.138 / 0.0011 = 6.8 ksi

With My = 11.32 in-lbs, the shear stress in YZ plane is

S_My = S2yz = 11.32 * 0.3348 / 0.00306 = 1.2 ksi

With Mz = 185.65 in-lbs, the bending stress in direction Y is

S_Mz = S3y = 185.65 * 0.305 / 0.0052 = 10.9 ksi

With Fx = 983 lbs, the shear load in XY plane is

S_Fx = S4xy = 983 / 0.143 = 6.9 ksi

With Fy = 673 lbs, the tensile stress in Y direction is

S_Fy = S5y = 673 / 0.168 = 4.0 ksi

With Fz = 147 lbs, the shear stress in YZ plane is

S_Fz = S6yz = 147 / 0.143 = 1.0 ksi

Combine all stresses together for Von-Mises stress

Sy = S1y + S3y + S5y = 6.8 + 10.9 + 4.0 = 21.7 ksi

Syz = S2yz + S6yz = 1.2 + 1.0 = 2.2 ksi

Sxy = 6.9 ksi

Svm = sqrt( 21.7^2 + 3*(2.2^2 + 6.9^2) ) = 25.1 ksi

With SF=1.25/1.40 for yield and ultimate, the margin of safety is

MSy = 42 / 1.25 / 25.1 / 1.15 - 1 = **0.16**

MSu= 55 / 1.40 / 25.1 / 1.15 - 1 = **0.36**

Therefore, no failure expected.

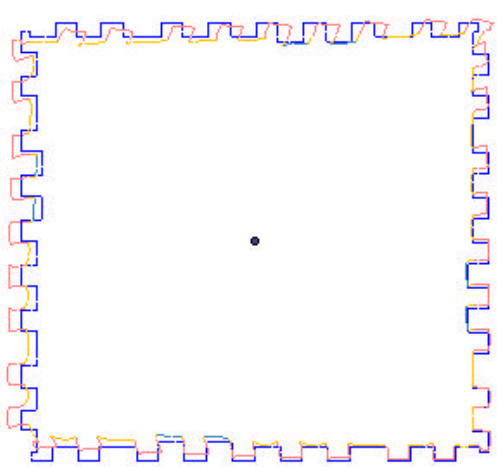
- The CAL/LAT interface is required to be capable of accommodating the out-of-plane distortion as specified in the Table 3 of the ICD. As indicated in the ICD, the interface distortion must be superimposed with the MECO static-equivalent acceleration as specified on Table 1 which is shown as follows.

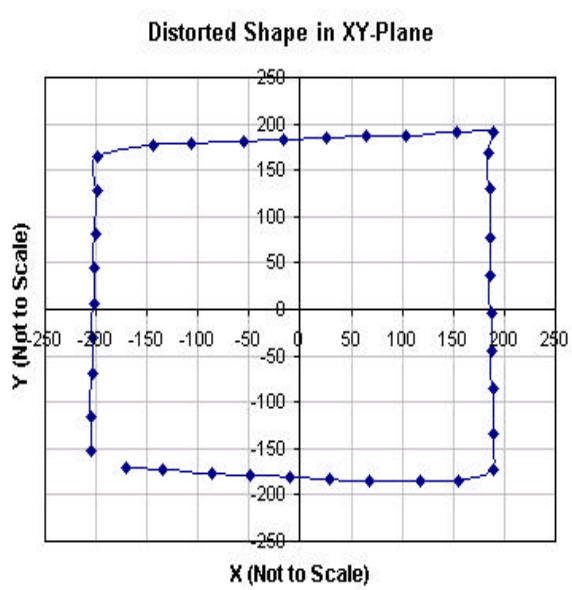
| CAL | Design (+) | | Accept (*) | Qual (*) | Unit |
|---|---|---|---|---|---|
| **Launch Event** | Lift-Off/ Airloads | MECO | | | |
| **Lateral (X)** | +/-2.14 | +/-0.2 | +/-6.0 | +/-7.5 | g |
| **Lateral (Y)** | +/-2.15 | +/-0.2 | +/-6.0 | +/-7.5 | g |
| **Axial (Z)** | +4.43/-1.8 | +6.8 | +6.8/-1.8 | +8.5/-2.25 | g |
| **Rot X** | +/-19.79 | 0 | 0 | 0 | rad/sec$^2$ |
| **Rot Y** | +/-19.27 | 0 | 0 | 0 | rad/sec$^2$ |
| **Rot Z** | +/-20.15 | 0 | 0 | 0 | rad/sec$^2$ |
| **Source** | (2) | (3) | (5) | (5) | |

**Comments:** (*) For analysis, apply design accel's simultaneously
(+) For test, apply test accel's along one axis at a time

The interface distortion as specified in Table 3 is shown on the next page. This interface distortion and MECO design limit loads are applied to CAL FE model. The model used in this analysis is "CAL-h.mod". The results are superimposed together.

The deformed shape of the base plate in the X-Y plane is plotted against the plot on the ICD.

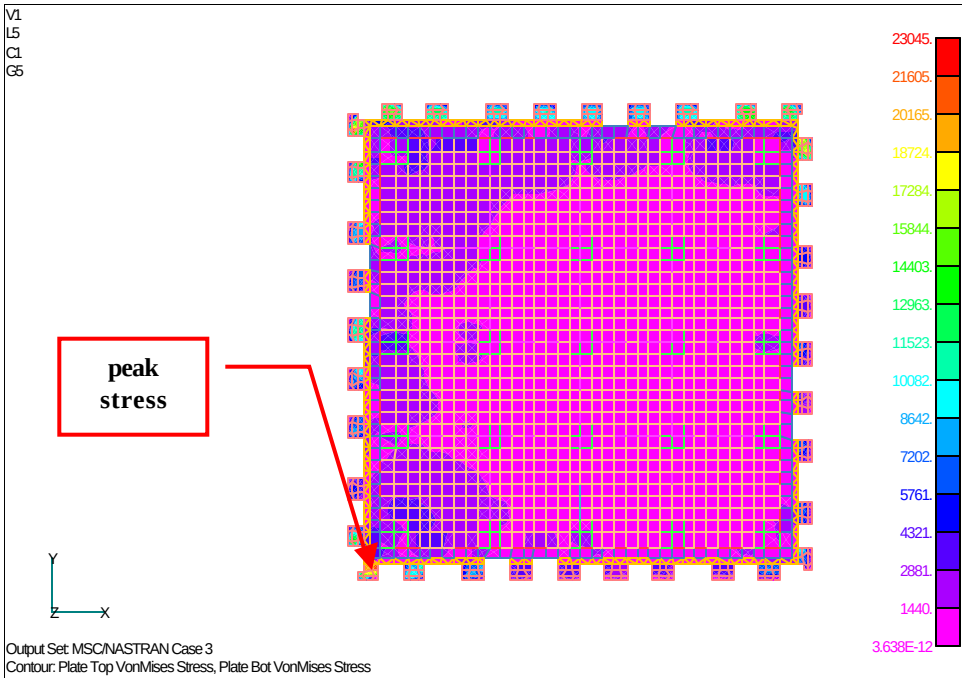




## Enforced Displacement At Tabs

| | Tab Location (mm) | | Tab Motion (mm) | | | Tab Motion (e-3 in) | | |
|---|---|---|---|---|---|---|---|---|
| # | X | Y | Ux | Uy | Uz | Ux | Uy | Uz |
| 1 | -173.675 | -187.25 | 0.005 | 0.027 | 0.000 | 0.20 | 1.06 | 0.00 |
| 2 | -136.675 | -187.25 | 0.003 | 0.024 | -0.001 | 0.12 | 0.94 | -0.04 |
| 3 | -87.75 | -187.25 | 0.002 | 0.018 | -0.002 | 0.08 | 0.71 | -0.08 |
| 4 | -48.75 | -187.25 | 0.001 | 0.014 | -0.002 | 0.04 | 0.55 | -0.08 |
| 5 | -9.75 | -187.25 | 0.000 | 0.010 | -0.001 | 0.00 | 0.39 | -0.04 |
| 6 | 29.25 | -187.25 | -0.001 | 0.007 | 0.000 | -0.04 | 0.28 | 0.00 |
| 7 | 68.25 | -187.25 | -0.001 | 0.005 | 0.001 | -0.04 | 0.20 | 0.04 |
| 8 | 117.675 | -187.25 | -0.001 | 0.003 | 0.003 | -0.04 | 0.12 | 0.12 |
| 9 | 155.175 | -187.25 | -0.002 | 0.003 | 0.005 | -0.08 | 0.12 | 0.20 |
| 10 | 187.25 | -173.675 | 0.002 | 0.002 | 0.016 | 0.08 | 0.08 | 0.63 |
| 11 | 187.25 | -136.675 | 0.002 | 0.003 | 0.039 | 0.08 | 0.12 | 1.54 |
| 12 | 187.25 | -87.75 | 0.002 | 0.005 | 0.071 | 0.08 | 0.20 | 2.80 |
| 13 | 187.25 | -48.75 | 0.001 | 0.006 | 0.097 | 0.04 | 0.24 | 3.82 |
| 14 | 187.25 | -9.75 | 0.000 | 0.009 | 0.122 | 0.00 | 0.35 | 4.80 |
| 15 | 187.25 | 29.25 | -0.001 | 0.011 | 0.149 | -0.04 | 0.43 | 5.87 |
| 16 | 187.25 | 68.25 | -0.002 | 0.015 | 0.176 | -0.08 | 0.59 | 6.93 |
| 17 | 187.25 | 117.675 | -0.003 | 0.020 | 0.211 | -0.12 | 0.79 | 8.31 |
| 18 | 187.25 | 155.175 | -0.005 | 0.024 | 0.238 | -0.20 | 0.94 | 9.37 |
| 19 | 173.675 | 187.25 | 0.026 | 0.006 | 0.252 | 1.02 | 0.24 | 9.92 |
| 20 | 136.675 | 187.25 | 0.027 | 0.005 | 0.224 | 1.06 | 0.20 | 8.82 |
| 21 | 87.75 | 187.25 | 0.026 | 0.001 | 0.189 | 1.02 | 0.04 | 7.44 |
| 22 | 48.75 | 187.25 | 0.026 | -0.001 | 0.162 | 1.02 | -0.04 | 6.38 |
| 23 | 9.75 | 187.25 | 0.025 | -0.003 | 0.137 | 0.98 | -0.12 | 5.39 |
| 24 | -29.25 | 187.25 | 0.023 | -0.006 | 0.112 | 0.91 | -0.24 | 4.41 |
| 25 | -68.25 | 187.25 | 0.022 | -0.009 | 0.089 | 0.87 | -0.35 | 3.50 |
| 26 | -117.675 | 187.25 | 0.019 | -0.014 | 0.062 | 0.75 | -0.55 | 2.44 |
| 27 | -155.175 | 187.25 | 0.018 | -0.016 | 0.043 | 0.71 | -0.63 | 1.69 |
| 28 | -187.25 | 173.675 | -0.018 | -0.016 | 0.025 | -0.71 | -0.63 | 0.98 |
| 29 | -187.25 | 136.675 | -0.019 | -0.014 | 0.017 | -0.75 | -0.55 | 0.67 |
| 30 | -187.25 | 87.75 | -0.021 | -0.010 | 0.008 | -0.83 | -0.39 | 0.31 |
| 31 | -187.25 | 48.75 | -0.023 | -0.007 | 0.003 | -0.91 | -0.28 | 0.12 |
| 32 | -187.25 | 9.75 | -0.024 | -0.005 | 0.000 | -0.94 | -0.20 | 0.00 |
| 33 | -187.25 | -29.25 | -0.026 | -0.002 | -0.002 | -1.02 | -0.08 | -0.08 |
| 34 | -187.25 | -68.25 | -0.027 | 0.000 | -0.003 | -1.06 | 0.00 | -0.12 |
| 35 | -187.25 | -117.675 | -0.028 | 0.004 | -0.003 | -1.10 | 0.16 | -0.12 |
| 36 | -187.25 | -155.175 | -0.028 | 0.005 | -0.001 | -1.10 | 0.20 | -0.04 |

After combine the enforced displacement with MECO design limit load, the stress contour plot of the base plate is shown as follow. The peak stress was found to be 23.0 ksi at the left-lower corner tab.




With SF=1.25/1.40 for yield and ultimate, the margin of safety is

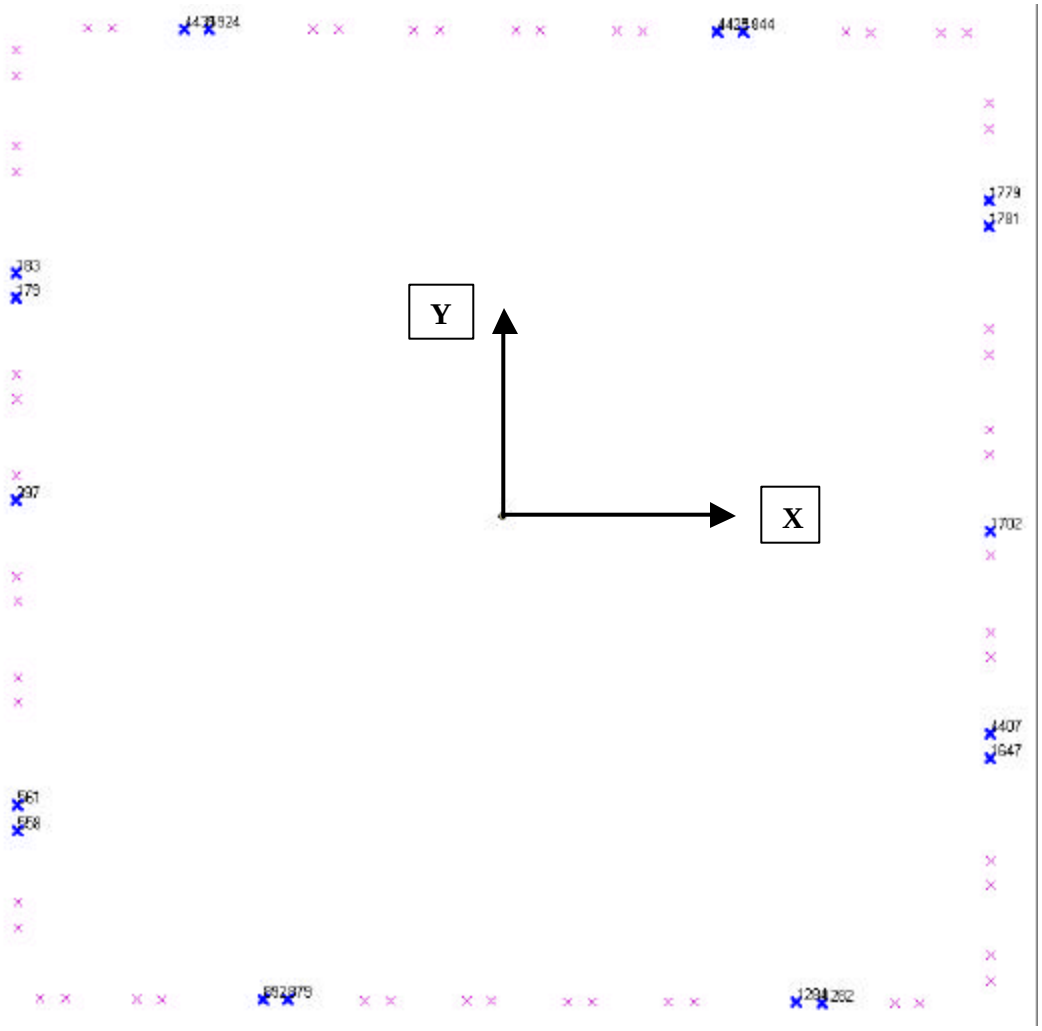
MSy = 42 / 1.25 / 23.0 / 1.15 - 1 = **0.27**

MSu= 55 / 1.40 / 23.0 / 1.15 - 1 = **0.49**

Therefore, no failure expected at the base plate.

## Check fasteners at CAL/LAT interface

There are 18 x 4 mm holes using #6-A286 screws. Those holes are corresponding to the nodes in FE model labeled below.



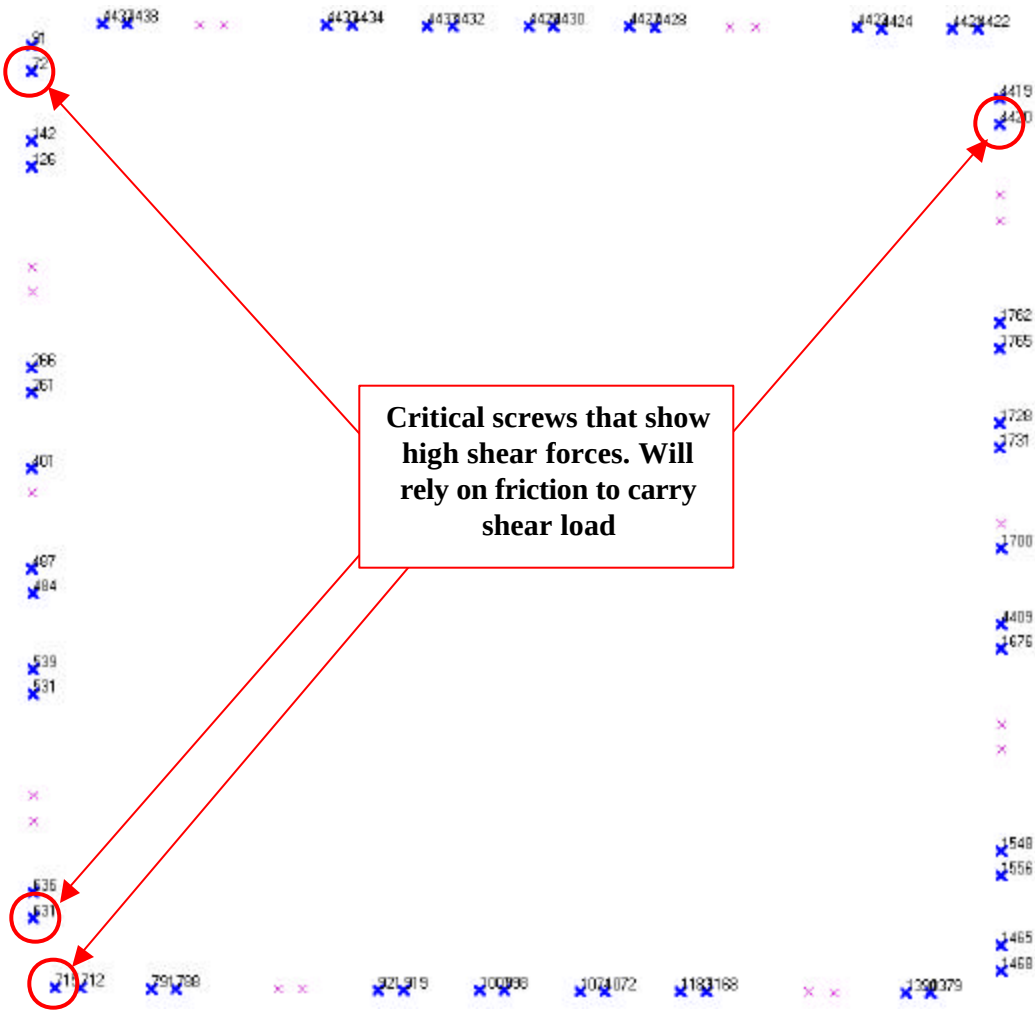
The interface forces at screws were recovered. Shear and tensile forces were combined using interaction equation that is "if Rs^3 + Rt^2 < 1 then no failure expected". The results are tabulated as follows.

As indicated, all margins are positive and no #6 screw failure is expected.

| Interface Fastener Forces For 4 mm Hole w/ #6 screws At Base Plate (lbs) | | | | | | Interaction of Shear/Tension Failue if Rs^3+Rt^2 > 1 | | |
|---|---|---|---|---|---|---|---|---|
| NID | T1 | T2 | T3 | Shear | Tension | Rs | Rt | Rs^3+Rt^2 |
| 179 | -455 | -122 | -55 | 471 | 55 | 0.83 | 0.06 | 0.59 |
| 183 | -298 | -65 | -84 | 305 | 84 | 0.54 | 0.10 | 0.17 |
| 397 | -488 | -92 | -111 | 497 | 111 | 0.88 | 0.13 | 0.70 |
| 558 | -370 | -113 | 17 | 387 | 17 | 0.69 | 0.02 | 0.32 |
| 561 | -251 | -76 | -3 | 262 | 3 | 0.46 | 0.00 | 0.10 |
| 879 | 200 | 71 | 24 | 213 | 24 | 0.38 | 0.03 | 0.05 |
| 892 | 234 | 328 | 42 | 403 | 42 | 0.71 | 0.05 | 0.37 |
| 1282 | 21 | -116 | -58 | 118 | 58 | 0.21 | 0.07 | 0.01 |
| 1284 | 3 | -97 | -29 | 97 | 29 | 0.17 | 0.03 | 0.01 |
| 1647 | 168 | -38 | -6 | 172 | 6 | 0.30 | 0.01 | 0.03 |
| 1702 | 146 | 18 | -124 | 147 | 124 | 0.26 | 0.14 | 0.04 |
| 1779 | -30 | 235 | -45 | 236 | 45 | 0.42 | 0.05 | 0.08 |
| 1781 | -330 | 259 | 81 | 419 | 81 | 0.74 | 0.09 | 0.42 |
| 1844 | 316 | 167 | -65 | 358 | 65 | 0.63 | 0.07 | 0.26 |
| 1924 | 376 | 110 | -80 | 392 | 80 | 0.69 | 0.09 | 0.34 |
| 4407 | 166 | -11 | -121 | 166 | 121 | 0.29 | 0.14 | 0.04 |
| 4425 | 325 | -299 | 56 | 441 | 56 | 0.78 | 0.06 | 0.48 |
| 4435 | 383 | -329 | 25 | 505 | 25 | 0.89 | 0.03 | 0.72 |
| max | 488 | 329 | 124 | 505 | 124 | | | |

| | | | | | |
|---|---|---|---|---|---|
| #6 A286 Screws - | Stu(psi) = | 140000 | Ultimate safety factor | Sfu = | 1.4 |
| | Sty(psi) = | 95000 | Yield safety factor | Sfy= | 1.25 |
| | Ssu(psi) = | 90000 | Joint Factor | JF = | 1.15 |
| Stress Area - | As(in^2) = | 0.0101 | | | |
| Allowable Force (lbs) | Ftu = | 1414 | Allowable Force w/SF& JF (lbs) | Ftu = | 878 |
| | Fty = | 960 | | Fty = | 667 |
| | V = | 909 | | V = | 565 |

There are 54 x 4.7 mm holes that use #8 – A286 screws. Those holes are corresponding to the nodes in FE model labeled below.




The interface forces at screws were recovered. Shear and tensile forces were combined using interaction equation that is " if Rs^3 + Rt^2 < 1 then no failure expected". The results are tabulated on the next page.

| | | | | | |
|---|---|---|---|---|---|
| #8 A286 Screws - | Stu(psi) = | 140000 | Ultimate safety factor | Sfu = | 1.4 |
| | Sty(psi) = | 95000 | Yield safety factor | Sfy= | 1.25 |
| | Ssu(psi) = | 90000 | Joint Factor | JF = | 1.15 |
| Stress Area - | As(in^2) = | 0.0146 | | | |
| | | | | | |
| Allowable Force (lbs) | Ftu = | 2044 | Allowable Force w/SF& JF (lbs) | Ftu = | 1270 |
| | Fty = | 1387 | | Fty = | 965 |
| | V = | 1314 | | V = | 816 |

| Interface Fastener Forces For 4.7 mm Hole w/ #8+B2 screws At Base Plate (lbs) | | | | | | Interaction of Shear/Tension Failue if Rs^3+Rt^2 > 1 | | |
|---|---|---|---|---|---|---|---|---|
| NID | T1 | T2 | T3 | Shear | Tension | Rs | Rt | Rs^3+Rt^2 |
| **72** | **-912** | **-163** | **-71** | **926** | **71** | **1.13** | **0.06** | **1.46** |
| 91 | -362 | 14 | -40 | 363 | 40 | 0.44 | 0.03 | 0.09 |
| 126 | -587 | -245 | -45 | 636 | 45 | 0.78 | 0.04 | 0.47 |
| 142 | -407 | -167 | -88 | 440 | 88 | 0.54 | 0.07 | 0.16 |
| 261 | -372 | -120 | -25 | 391 | 25 | 0.48 | 0.02 | 0.11 |
| 266 | -267 | -71 | -44 | 276 | 44 | 0.34 | 0.03 | 0.04 |
| 401 | -368 | -28 | -120 | 369 | 120 | 0.45 | 0.09 | 0.10 |
| 484 | -379 | -130 | -34 | 401 | 34 | 0.49 | 0.03 | 0.12 |
| 487 | -321 | -84 | -84 | 331 | 84 | 0.41 | 0.07 | 0.07 |
| 531 | -463 | -93 | -14 | 472 | 14 | 0.58 | 0.01 | 0.19 |
| 539 | -346 | -35 | -44 | 348 | 44 | 0.43 | 0.03 | 0.08 |
| **631** | **-879** | **-130** | **46** | **889** | **46** | **1.09** | **0.04** | **1.29** |
| 636 | -565 | -12 | 31 | 565 | 31 | 0.69 | 0.02 | 0.33 |
| 712 | 212 | 640 | 108 | 674 | 108 | 0.83 | 0.09 | 0.57 |
| **715** | **410** | **880** | **57** | **971** | **57** | **1.19** | **0.04** | **1.69** |
| 788 | 211 | 100 | 32 | 234 | 32 | 0.29 | 0.02 | 0.02 |
| 791 | 255 | 453 | 67 | 519 | 67 | 0.64 | 0.05 | 0.26 |
| 919 | 114 | -5 | -11 | 114 | 11 | 0.14 | 0.01 | 0.00 |
| 921 | 126 | 181 | 14 | 221 | 14 | 0.27 | 0.01 | 0.02 |
| 998 | 113 | -2 | -12 | 113 | 12 | 0.14 | 0.01 | 0.00 |
| 1001 | 121 | 126 | 20 | 175 | 20 | 0.21 | 0.02 | 0.01 |
| 1072 | 82 | -52 | -29 | 97 | 29 | 0.12 | 0.02 | 0.00 |
| 1074 | 78 | 10 | -10 | 78 | 10 | 0.10 | 0.01 | 0.00 |
| 1168 | 60 | -74 | -59 | 95 | 59 | 0.12 | 0.05 | 0.00 |
| 1183 | 54 | -13 | -32 | 55 | 32 | 0.07 | 0.03 | 0.00 |
| 1379 | -7 | -95 | -100 | 95 | 100 | 0.12 | 0.08 | 0.01 |
| 1390 | -29 | -143 | -93 | 146 | 93 | 0.18 | 0.07 | 0.01 |
| 1465 | 153 | -36 | -140 | 157 | 140 | 0.19 | 0.11 | 0.02 |
| 1468 | 175 | -82 | 5 | 193 | 5 | 0.24 | 0.00 | 0.01 |
| 1548 | 147 | 3 | -124 | 147 | 124 | 0.18 | 0.10 | 0.02 |
| 1556 | 185 | -27 | -20 | 187 | 20 | 0.23 | 0.02 | 0.01 |
| 1676 | 96 | -3 | 40 | 96 | 40 | 0.12 | 0.03 | 0.00 |
| 1700 | 87 | -4 | 1 | 87 | 1 | 0.11 | 0.00 | 0.00 |
| 1728 | 72 | 76 | -79 | 105 | 79 | 0.13 | 0.06 | 0.01 |
| 1731 | -1 | 70 | 37 | 70 | 37 | 0.12 | 0.04 | 0.00 |
| 1762 | 47 | 124 | -67 | 132 | 67 | 0.16 | 0.05 | 0.01 |
| 1765 | -143 | 130 | 64 | 193 | 64 | 0.24 | 0.05 | 0.02 |
| 4409 | 94 | 13 | -75 | 95 | 75 | 0.12 | 0.06 | 0.01 |
| 4419 | -372 | 339 | -3 | 503 | 3 | 0.62 | 0.00 | 0.23 |
| **4420** | **-807** | **445** | **125** | **921** | **125** | **1.13** | **0.10** | **1.45** |
| 4421 | 293 | -345 | 110 | 452 | 110 | 0.55 | 0.09 | 0.18 |
| 4422 | 286 | 333 | -11 | 439 | 11 | 0.54 | 0.01 | 0.16 |
| 4423 | 434 | -465 | 92 | 636 | 92 | 0.78 | 0.07 | 0.48 |
| 4424 | 398 | 61 | -35 | 403 | 35 | 0.49 | 0.03 | 0.12 |
| 4427 | 263 | -272 | 54 | 379 | 54 | 0.46 | 0.04 | 0.10 |
| 4428 | 251 | 155 | -69 | 295 | 69 | 0.36 | 0.05 | 0.05 |
| 4429 | 278 | -206 | 46 | 346 | 46 | 0.42 | 0.04 | 0.08 |
| 4430 | 272 | 177 | -108 | 324 | 108 | 0.40 | 0.09 | 0.07 |
| 4431 | 310 | -265 | 63 | 408 | 63 | 0.50 | 0.05 | 0.13 |
| 4432 | 300 | 61 | -54 | 306 | 54 | 0.38 | 0.04 | 0.05 |
| 4433 | 321 | -354 | 21 | 478 | 21 | 0.59 | 0.02 | 0.20 |
| 4434 | 305 | 70 | -83 | 313 | 83 | 0.38 | 0.07 | 0.06 |
| 4437 | 433 | -644 | 16 | 776 | 16 | 0.95 | 0.01 | 0.86 |
| 4438 | 391 | 32 | -93 | 393 | 93 | 0.48 | 0.07 | 0.12 |
| **Max** | **912** | **880** | **140** | **971** | **140** | | | |

As indicated, there are four screws that are subjected to high shear forces. Those screws are labeled on previous page. The maximum shear force 971 lbs was found at Node 715 at left-bottom corner. The allowable shear force for #8 screw was found to be 1314 lbs. With safety factor of 1.4 and joint uncertainty factor of 1.15, the allowable shear force is reduced down to 816 lbs (i.e. 1314/1.4/1.15). This is higher than the shear force 971 lbs.

However, for the screw to carry shear force to failure, it must also break the friction force. This friction force adds more shear resistance. The friction force can be estimated by assuming a conservative coefficient of friction of 0.20. Assuming all screws are preloaded to 70% of yield strength, the friction force for each screw can be found to be

Vf_tab = F_preload * coef_of_friction * #_screws_per_tab / SFu

= 0.7 * 1387 * 0.20 * 2 / 1.4 = 277 lbs

The shear force distribution on each screw after breaking friction is assumed to have the same ratio before it breaks friction. Therefore, the shear force at Node 715 can be found as

V_N715 = (971/1645) * (1645-277) = 807 lbs

Using interaction equation to combine shear with tension,

Rs^3 + Rt^2 = (799/807)^3 + (57/1270)^2 = 0.97 < 1

All other critical screws are also evaluated by the same approach. The results are tabulated as follows.

| Interface Fastener Forces For Critical Tabs | | | | | | | Interaction of Shear/Tension | | |
|---|---|---|---|---|---|---|---|---|---|
| NID | T1 | T2 | T3 | Shear | Tension | Shear After break friction | Rs | Rt | Rs^3+Rt^2 |
| 72 | -912 | -163 | -71 | 926 | 71 | 727 | 0.89 | 0.06 | 0.71 |
| 91 | -362 | 14 | -40 | 363 | 40 | 285 | 0.35 | 0.03 | 0.04 |
| **SUM** | | | | **1289** | **111** | | | | |
| 631 | -879 | -130 | 46 | 889 | 46 | 719 | 0.88 | 0.04 | 0.69 |
| 636 | -565 | -12 | 31 | 565 | 31 | 458 | 0.56 | 0.02 | 0.18 |
| **SUM** | | | | **1454** | **77** | | | | |
| 712 | 212 | 640 | 108 | 674 | 108 | 560 | 0.69 | 0.09 | 0.33 |
| 715 | 410 | 880 | 57 | 971 | 57 | 807 | 0.99 | 0.04 | 0.97 |
| **SUM** | | | | **1645** | **165** | | | | |
| 4419 | -372 | 339 | -3 | 503 | 3 | 405 | 0.50 | 0.00 | 0.12 |
| 4420 | -807 | 445 | 125 | 921 | 125 | 742 | 0.91 | 0.10 | 0.76 |
| **SUM** | | | | **1424** | **128** | | | | |

- CAL-TEM interface load is specified in Table 4 that is shown as follows. This load is applied to the plane of interface that is the connection of the standoff to the CAL base plate backside.

| E-Box Stand-Off | Unit N-m | Unit Lb-in |
|---|---|---|
| Tension | 3,750 | 844 |
| Compression | 2,625 | 591 |
| Shear | 1,288 | 290 |
| Bending Moment | 19.3 | 170.9 |

The interface load is applied to CAL FE model at a node 0.59" below the interface. This offset produces 171 in-lbs moments when 290 lbs shear force is applied (i.e. 290 * 0.59 = 171 in-lbs). This node is connected to the four interface nodes with RBE3 element to distribute the force without rigidizing the base plate.

The stress contour plot is shown as follow. The peak stress at base plate was found to be 2.8 ksi. This stress is very low and no failure is expected.

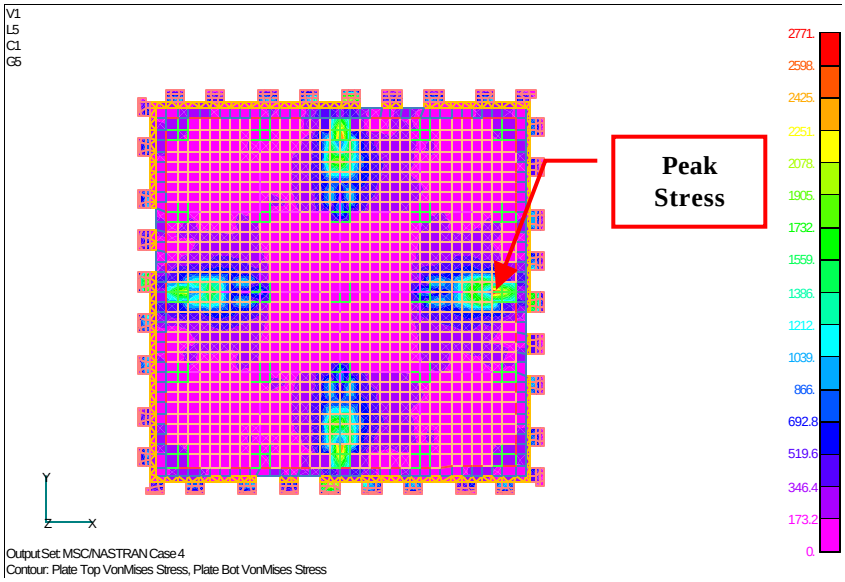


**Table 3.2.10.0(b). Design Mechanical and Physical Properties of 2618 Aluminum Alloy Die Forging**

| | |
|---|---|
| Specification | MIL-A-22771 and QQ-A-367 |
| Form | Die forging |
| Temper | T61 |
| Thickness, in. | ≤ 4.000[a] |
| Basis | S |
| Mechanical Properties: | |
| $F_{tu}$, ksi: | |
| L | 58 |
| T[b] | 55 |
| $F_{ty}$, ksi: | |
| L | 45 |
| T[b] | 42 |
| $F_{cy}$, ksi: | |
| L | ... |
| T[b] | ... |
| $F_{su}$ | ... |
| $F_{bru}$, ksi: | |
| (e/D = 1.5) | ... |
| (e/D = 2.0) | ... |
| $F_{bry}$, ksi: | |
| (e/D = 1.5) | ... |
| (e/D = 2.0) | ... |
| $e$, percent: | |
| L | 4 |
| T[b] | 4 |
| $E$, $10^3$ ksi | 10.7 |
| $E_c$, $10^3$ ksi | 10.9 |
| $G$, $10^3$ ksi | 4.1 |
| $\mu$ | 0.33 |
| Physical Properties: | |
| $\omega$, lb/in.$^3$ | 0.100 |
| $C$, Btu/(lb)(°F) | 0.23 (at 212°F) |
| $K$, Btu/[(hr)(ft$^3$)(°F)/ft] | 90 (at 77°F) |
| $\alpha$, $10^{-6}$ in./in./°F | See Figure 3.2.9.0 |