**WaSP GUIDER CCD FASTENER TORQUE EVALUATION**

Belleville Washers

Mc Master P/N: 9713K11

4 Series of 2 parallel

Detector Mounting Plate

JPL P/N: 10366091

Material: 6061-T6



Guider CCD M3-0.5 Fastener

Caltech P/N: WASP-M00-1011

Material: 17-4PH Stainless Steel

Guider Package Base

JPL P/N: 10371432

Material: Invar 36



**Guider CCD M3-0.5 Fastener Torque Evaluation based on Material Strength:**



**In this assembly, the Stainless Steel screw is 24% stronger than the Invar Nut.**

**The current Belleville washer design provides a Force of 98Lbf when torqued to 0.4 N.m with 1.5 turns.**

**This force should be sufficient and provides a comfortable margin of safety.**

**Force Generated by the Torque:**





**Conclusion:**

Applying a 0.4N.m torque on the fastener will provide 98lbf on the CCD contact pads.

The 98ksi ultimate strength of the Invar CCD is safely well above the recommended 42ksi

**Mechanical Assembly Verification:**

The spring rate of 4 disc spring in series of 2 parallel disc, as specified, should be:

K= F/L = 2x36Lbs / (4 x .13mm) = 72Lbs / 0.52mm = 138Lbs/mm

Deflection for the calculated 98Lbf work load: L=F/K=98/138=0.71mm

Number of turns necessary to reach the load: 0.71/0.5= 1.42 turn

Deflection of each Disc: 0.68/4=0.17mm

Max total Deflection of each disc: .026”-.016”=.01”=0.25mm.

The Belleville will work at 68% of their capacity.



**Belleville Washer experimental spring rate characterization:**

The spring rate of each individual Belleville, as specified, should be: 36Lbs/0.13mm = 277Lbs/mm

The spring rate of 6 disc spring in series, as specified, should be:

K= F/L = 36Lbs / (6 x .13mm) = 36Lbs / 0.78mm = 46Lbs/mm

Max Stack deflection: 6 x 0.254mm = 1.5mm (3 Turns)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| M3-0.5 |  |  | 6 Belleville in Series |  |
| # of turn | Displacement (mm) | Force (Lbs) | Stack Spring Cst (Lbs/mm) | Individual average Spring Cst (Lbs/mm) |
| 0 | 0 | 0 | 0 | 0 |
| 1/4 | 0.125 | 5 | 40 | 240 |
| 1/2 | 0.25 | 10 | 40 | 240 |
| 3/4 | 0.375 | 15 | 40 | 240 |
| 1 | 0.5 | 21 | 42 | 252 |
| 1.25 | 0.625 | 28 | 45 | 269 |
| 1.5 | 0.75 | 35 | 47 | 280 |
| 1.75 | 0.875 | 42 | 48 | 288 |
| 2 | 1 | 48 | 48 | 288 |
| 2.25 | 1.125 | 54 | 48 | 288 |
|  |  |  |  | 238 |

**Experiment Conclusion:** At specified 0.13mm Deflection this Belleville washers shows a spring rate of: 280 Lbs/mm or 36Lbs.

**4 Belleville in series of 2 parallel:**

|  |  |  |  |
| --- | --- | --- | --- |
| M3-0.5 |  |  | 4 Belleville in series of 2 parallel |
| # of turn | Displacement (mm) | Force (Lbs) | Stack Spring Cst (Lbs/mm) |
| 0 | 0 | 0 | 0 |
| 1/4 | 0.125 | 8 | 64 |
| 1/2 | 0.25 | 22 | 88 |
| 3/4 | 0.375 | 38 | 101 |
| 1 | 0.5 | 55 | 110 |
| 1.25 | 0.625 | 73 | 117 |
| 1.5 | 0.75 | 90 | 120 |
| 1.75 | 0.875 | 117 | 134 |
| 2 | 1 | 140 | 140 |
| 2.25 | 1.125 | 174 | 155 |
| 2.5 | 1.25 | 240 | 192 |
| 2.75 | 1.375 | 340 | 247 |
| 3 | 1.5 | 455 | 303 |
|  |  |  | 136 |
|  |  |  |  |

**Verification Conclusion:** The 4 Belleville in series of 2 parallel requires 1.5 turns to achieve the desired 98Lbf.

**Guider CCD M3-0.5 Socket Head Cap Screw Torque Evaluation based on Material Strength:**



**For Un-vented Screws:**



**For Vented Screws:**



The recommended torque on the M3-0.5 Socket Head Cap Screw Item 5 is lower than the recommended torque of the Fastener to the CCD, the M3-0.5 Socket Head Cap Screw Item 5 have to be secured to the fastener with thread lock.