K1DM3 Technical Note 872-LTN1038

Mirror Assy Lateral Adjustment HW Analysis

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The groove lock lateral adjustment hardware are described in Reference 1 and shown in Figures 1 & 2. Their primary function is to move the mirror assembly laterally (in the plane of the mirror) to properly position the mirror during alignment. Originally standard torque specifications were to be applied after final alignment. However, this procedure needed to be applied while dial gauge indicators are attached to the assembly (Reference 1), which does not allow access to all the hardware when using a torque wrench. As a result the proper procedure could not be applied without moving the assembly and compromising alignment.

In reality and upon further inspection torquing this hardware to standard or typical specifications is not necessary. This hardware is not actively securing components and are essentially unnecessary after final alignment. Their function after alignment is stay securely in place and be available if re-alignment of the mirrror is necessary in the future. They also provide a load sharing during worst case earthquake response. The criteria for the M3 location at the top of the tower is 15Gs.

Component strength and safety margins have been calculated for all hardware and is shown in Figure 3. The worksheet calculations show that the (worst case) groove lock bracket can take 435 lbs before yielding. The friction force resistance provided by the Groove Plate lock down bolts is 2115 lbs. Together this is a restraining force of 2550 lbs. Given the weight of the Mirror Assembly at 165 lbs, this is a factor of (2550/165) 15.46. Sufficient for the 15G requirement.

The lateral adjustment screws only need to snugly contact the groove plate and be secured either by safety wire or Loctite. Only positve contact is required so that they can function as a resistive force in the event of earthquake.

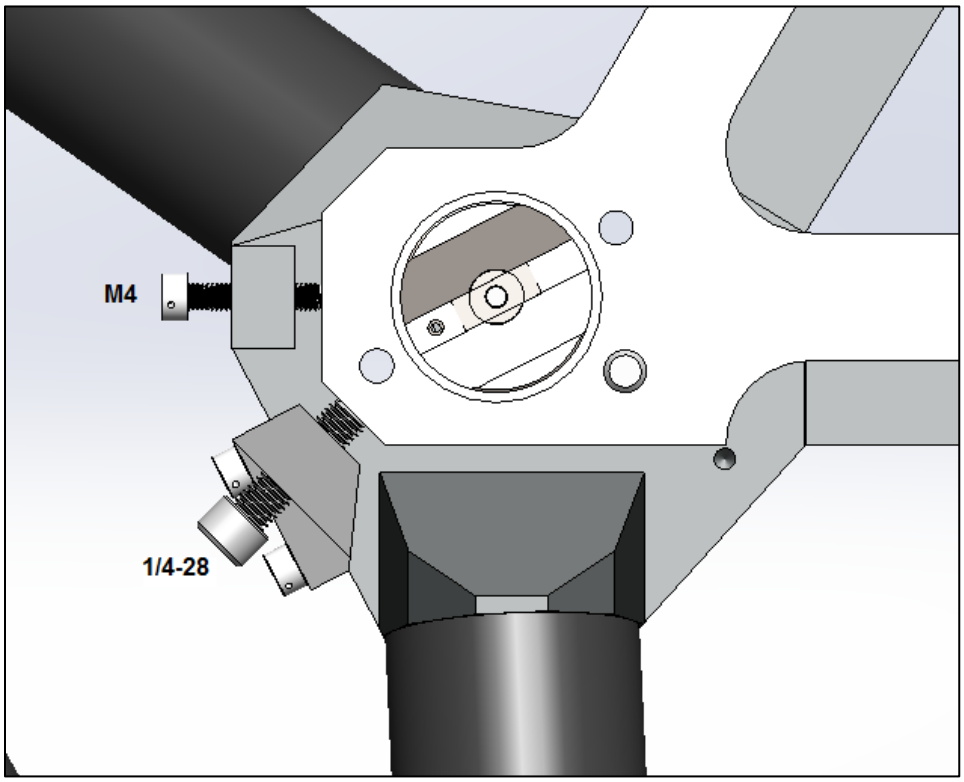

Figure 1 - Groove Lock off axis position components and hardware. Note that Swing-Arm HW is M4 and the Groove Lock component is 1/4-28. Hardware is drilled head for safety wire after final alignment. [Figure from Reference 1]

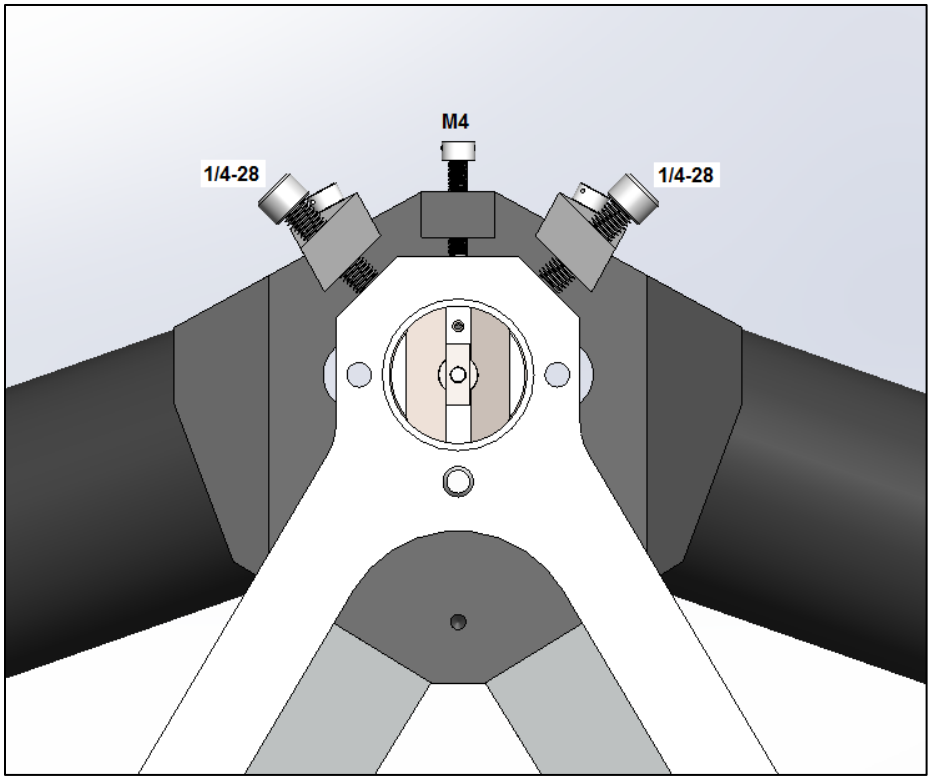

Figure 2 - Groove Lock on axis position components. Note that Swing-Arm is M4 and Groove Lock components are 1/4-28. Hardware is drilled head for safety wire after final alignment. [Figure from Reference 1]

CRITERIA - COMPARE COMPONENT STRENGTH TO STATIC LOAD SCALED TO MAXIMUM EXPECTED G LEVEL AT M3

Item	Description	Qty	Details	Total load or moment	tensile area (in^2) or section modulus (in^3)	load(#) or moment (in-#)	Stress	Strength	SF (1G)	SF (15Gs)	Comments
1	Axial Flex Rod	6	axial stress	113	3.52E-03	18.8	5350	160000	29.90	1.99	
2	Lateral Flex Rod	1	axial stress	84	1.10E-02	80.0	7273	160000	22.00	1.47	max based on worst case gravity
3	Flex Block M4's	6	axial stress	125	1.12E-02	20.8	1858	170000	91.47	6.10	
4	axial puck bond	6	axial stress	113	2.70E-01	18.8	70	3065	43.94	2.93	Keck pull tests on axial puck samples
5	lateral puck bond	1	shear stress	84	5.40E-01	80.0	148	4172	28.16	1.88	Keck segment repair qualification testing
6	lateral puck M4's	2	shear stress	84	5.61E-03	40.0	7136	120000	16.82	1.12	High strengh for FHSHCS M4's
7	flex block flexure	3	axial stress	125	4.30E-02	41.7	969	160000	165.04	11.00	max based on worst case gravity
8	flex block shear pins	3	shear sress	125	2.79E-02	41.7	1492	75000	50.26	3.35	two spring pins and an M4
9	1/4-20's on mirror assy	6	axial stress	165	3.02E-02	30.0	994	170000	170.97	11.40	
10	1/4-20's Groove Plate	3	axial stress	165	3.02E-02	55.0	1823	170000	93.26	6.22	
11	hinge pin	1	bending stress	36	1.23E-02	35.9	2929	160000	54.63	3.64	1/2 load at .2875 moment arm
12	hinge pin	1	shear stress	250	1.96E-01	250.0	1276	160000	125.39	8.36	1/2" dia - load taken by two areas
13	actuator shoulder screws	2	shear stress	250	1.75E-01	125.0	714	160000	224.09	14.94	12 mm dia - load taken by two areas
14	docking pin	1	shear stress	1333	na	1333.0	--	29000	21.76	1.45	breaking strength spec on part 29000 lbs
15	clevis 3/8-24s	4	shear stress	1333	3.70E-02	333.3	9006	170000	18.88	1.26	
16	clevis plate 3/8-24s	4	shear stress	1333	3.70E-02	333.3	9006	170000	18.88	1.26	
17	base plate 5/16-24s	8	shear stress	1333	2.66E-02	166.7	6264	170000	27.14	1.81	clevis assy mount to weldment
18	*Groove Lock M4*		*axial stress*		*1.12E-02*	*58*	*5174*	*170000*	*32.86*	*2.19*	
19	*Groove Lock Shear*		*shear stress*		*1.56E-01*	*78*	*500*	*18000*	*36.00*	*2.40*	*Worst case groove lock scenario*
20	*Groove Lock Moment*		*bending stress*		*6.51E-03*	*73.32*	*11263*	*36000*	*3.20*	*0.21*	

THE GROOVE PLATE IS BOLTED TO THE SWING ARM WITH THREE 1/4-20 FASTNERS TORQUED TO 70 IN-LBS, OR 1410 LBS OF TENSION (EACH), GIVEN A COEFFICIENT OF FRICTION OF .5, THE RESULTING NET RESISTIVE FORCE IS 2115 LBS.
15G X 165 = 2475 LBS ; LESS 2115 LEAVES 360 LBS, OR 360/165 = 2.18G

			Balance after friction	Capacity	
20	Groove Lock Moment	bending stress	**2.18G**	**3.2G**	Given a 15G worst case scenario the combination of the Groove Plate lock down bolts and the Groove Lock hardware will survive the load

Figure 3– Worksheet from the K1DM3 Excel file itemizing load components and calculated safety margins for 15G earthquake.

References

1. Mirror Installation Set-Up and Assembly Plan, K1DM3 Technical Note, 872-LTN2002
2. Mirror and Swing-Arm Assembly, K1DM3 Drawing, 872-LM4700
3. K1DM3 project spreadsheet, Excel file, K1DM3.xlsx (Technical Note 872-LTN1001)

Revisions

A. Initial release, 27 July 2018