

**INGRID**

**Lens Mount Assembly and Alignment Procedure**

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## 1. Introduction

The purpose of this document is to describe the assembly procedure to mount the lenses in INGRID. It assumes the reader has a basic understanding on handling optics. Following assembly, the document will then explain how to align the lens elements.

The only INGRID lenses of interest in this document are the ones that are kept cold.

## 2. Overall Philosophy

The layout of the lens elements within INGRID is detailed in figure 1.

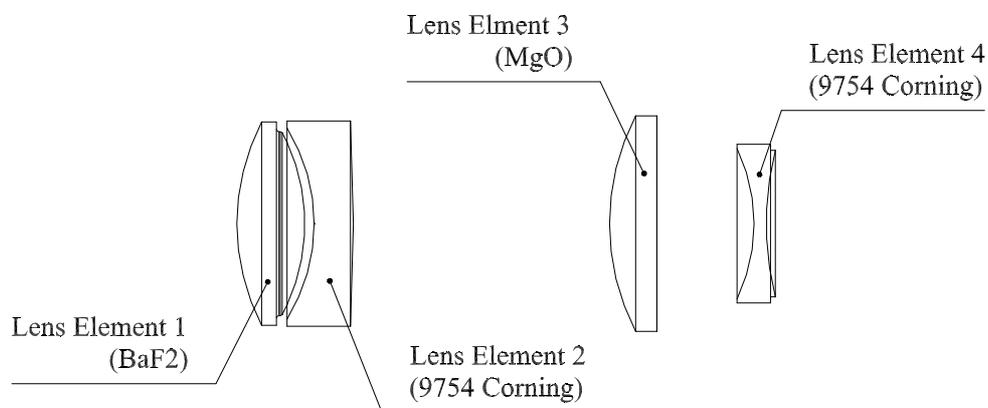


Figure 1 - Lens layout within INGRID

The design has concentrated on three important features

1. Temperature independent lens clamping (athermal)
2. Repeatability during thermal cycling
3. Alignment

### 2.1 Athermal mounting

This is provided by means of a compliant ‘vee block’ arrangement, see figure 2.

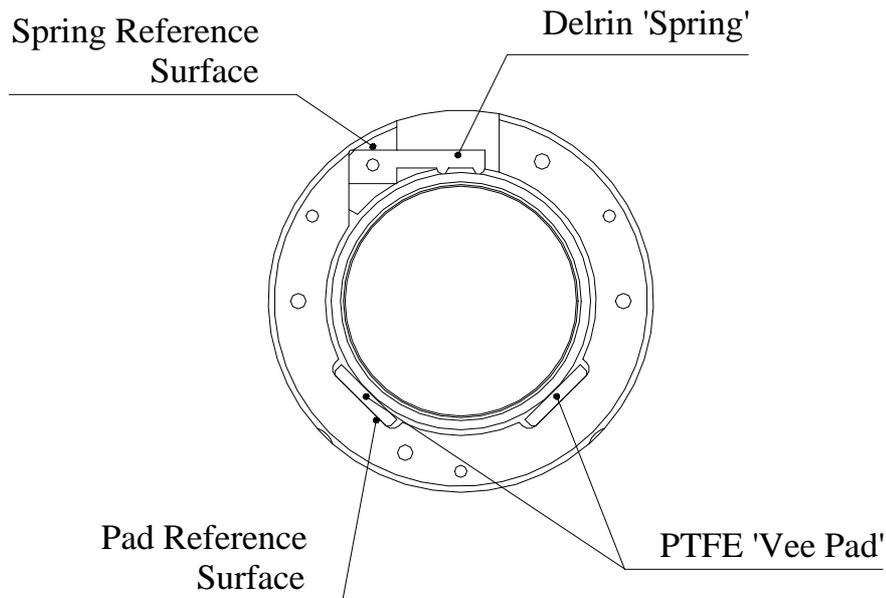


Figure 2: Generic Lens Assembly

The PTFE pads will contract upon cooling, but their reference surface will move towards the lens centre. Additionally, the delrin spring will contract and its reference surface moves inwards. The overall effect of these contractions combined with the lens contraction will not overstress the lens. There will be a residual loading of approximately 2g provided by the delrin spring when cold. Note, when warm there is also a preload from the spring to ease assembly.

## 2.2 Repeatability

Within the assembly, the lenses are restrained from moving radially by the vee block arrangement. By using PTFE and delrin for the contact points we reduce the coefficients of friction between the pads and lens surface. In addition to this, the axial reference surface has been designed to reduce the contact area as much as possible (without inducing excessive stress).

## 2.3 Alignment

As a philosophy, the alignment will be carried out in three phases.

### 2.3.1 Phase 1

Fix the mount containing lens 1 into its holder, this is not to be moved again. Place mount 2 into the holder and adjust using the orthogonal screws. Note the axial position and tilt cannot be adjusted and will be achieved through machining. See section 4.1 for more detailed explanation. This phase will define an optical axis through the first doublet.

### 2.3.2 Phase 2

This is essentially the same as phase 1, but with the remaining pair of lenses, see section 4.2 for more detail. Again, this will define an optical axis through this doublet.

### 2.3.3 Phase 3

Take the first lens doublet in its holder and fix into the lens barrel, note this is not to be moved again. As with phase 1, place the next set in to the lens barrel and adjust into place with the screws. This will position the optical axis of holder 2 (containing lens mount 3 & 4) on axis with lens holder 1. This will define an optical axis through the lens barrel.

## 3. Lens Holder Assembly & Alignment

The lens holders contain one pair of lenses each. Holder 1 contains lens elements 1 & 2 and holder 2 contains elements 3 & 4. The assembly of each holder is essentially the same.

All the parts **MUST** be cleaned and prepared for vacuum use prior to any assembly taking place. All fasteners are to be stainless steel unless otherwise stated. All tools must also be cleaned prior to use.

### 3.1 Lens Holder 1

The full assembly drawings can be found on the mechanical engineering drawing management system (DMS). The general assembly for holder 1 is drawing BO320 (file name bo320.dwg) and can be viewed in appendix A.

During the following assembly procedures the drawing numbers (where appropriate) will appear in parenthesis.

1. Screw the PTFE vee pads (BO322) into mount 1 (BO324) using M2.5 screws and washers.
2. Screw the delrin spring (BO323) into mount 1 using an M2.5 screw and spring washer. Ensure the spring is the correct orientation and is pressed firmly into the recess.
3. Screw mount 1 into lens holder 1 (BO329) using 4-M2.5 screws and spring washers. It should only be possible to insert it in one orientation. Note, do not fully tighten screws yet. Allow the mount to translate but not move axially.
4. Carefully, load in lens element 1 ensuring its reference surface is located on the axial reference tabs in the holder. Check that the lens is sitting in the vee pads and the PTFE spring and is on the axial reference tabs.
5. Put 3 temporary PTFE retaining clips onto mount 1. Secure in place with M2.5 screws and spring/plain washers. Be careful not to damage the lens. These hold lens 1 and allows its edge to be seen for later alignment
6. Tighten all the screws until the spring washer is fully compressed and no more.
7. Check that the lens is in place and does not move.
8. Turn the holder over and place on a clean optical bench. **Ensure that the lens does not touch anything on the bench. Use a foam pad with optical wipes on to support the holder.**
9. Screw the PTFE vee pads (BO326) into mount 2 (BO328) using M2.5 screws and washers.
10. Screw the delrin spring (BO327) into mount 2 using an M2.5 screw and spring washer. Ensure the spring is the correct orientation and is pressed firmly into the recess.

11. Screw mount 2 into lens holder 1 (BO329) using 4-M2.5 screws and spring washers. It should only be possible to insert it in one orientation.
12. Place the holder onto the plattern of the engineers microscope. **Ensure lens one is facing up. Always carry with lens 1 upwards. The temporary clips are NOT designed to hold the lens securely.**
13. Manually centre the lens with respect to the holder by moving the mount. When in position lock in place by tightening the 4-M2.5 screws. **When using screwdrivers near the lens ALWAYS place an optical wipe over the lens AND cover the lens with a clean-gloved hand. This is to prevent damage caused by the screwdriver slipping.**
14. Remove the temporary retaining clips from mount 1. Secure the axial retainer (BO340) into the recesses in mount 1, with the chamfer towards the lens surface. This retainer should press onto the surface of the lens.
15. Put a gentle, even pressure axially down on the lens retaining ring. This is to ensure the lens is sitting square to the reference surface.
16. Place the holder onto a vee block in preparation for laser alignment. Note, the orientation of the holder with respect to the vee block needs to be maintained. This helps the repeatability in taking the holder on and off the vee.
17. Align in tip tilt and translation a laser to ensure return reflections give concentric and evenly illuminated interference rings back at the laser. Check the repeatability of putting the holder onto the vee block.
18. Carefully, load in lens element 2 ensuring its reference surface is located on the axial reference tabs in the holder. Check that the lens is sitting in the vee pads and PTFE spring and is on the axial reference tabs.
19. Place the axial retainer (BO341) onto mount 2. Secure in place with M2.5 screws and spring/plain washers. Be careful not to damage the lens, these clips should press onto the surface of the lens.
20. Check that the lens is in place and does not move.
21. One by one remove the spring washers from under the M2.5 screws holding in mount 2. **When using screwdrivers near the lens ALWAYS place an optical wipe over the lens AND cover the lens with a clean gloved hand. This is to prevent damage caused by the screwdriver slipping.**
22. Screw in the 2-M2 adjusting screws into the side of the holder until they touch the flats on the lens mount.
23. Screw in the spring and spring housing to give pre-load onto these adjusting screws.
24. Release the four M2.5 screws holding mount 2 into the holder sufficient to allow it to translate.
25. Place the holder into the aligned laser beam.
26. Carefully, use the adjusting screws to translate lens 2 in order to centre the large interference fringes. The lens needs to move in the opposite direction to the fringes.
27. Calibrate the translations for when cold alignment is carried out.
28. Remove the holder from the beam and place on a secure bench.
29. Tighten the four M2.5 retaining screws and remove all adjusting screws and springs. Note, in tightening the screws the lens can become stressed and/or moved slightly. This will upset the interference fringes, care needs to be taken.
30. Check alignment of lens as per step 25/26/27. Repeat these steps until fringes are concentric.

31. Place 2-M2.5 screws into mount 2 and tighten all four of these screws. Replace the spring and spring housing with a clean M6 screw. Ensure this screw is in contact with the mount. One by one replace the other M2.5 screws with M2.5 screws and spring washers.
32. Remove the two M6 screws and the adjusting screws.
33. Check alignment by placing the holder back into the laser beam. Repeat the whole alignment procedure (from step 21) if necessary.
34. This completes the assembly.

### 3.2 Lens Holder 2

As stated previously, the assembly of lenses 3 & 4 into holder 2 will essentially be the same as holder 1.

The full assembly drawings can be found on the mechanical engineering drawing management system (DMS). The general assembly for holder 1 is drawing BO330 (file name bo330.dwg) and can be viewed in appendix B.

During the following assembly procedures the drawing numbers (where appropriate) will appear in parenthesis.

1. Screw the PTFE vee pads (BO336) into mount 4 (BO338) using M2.5 screws and washers.
2. Screw the delrin spring (BO337) into mount 4 using an M2.5 screw and spring washer. Ensure the spring is the correct orientation and is pressed firmly into the recess.
3. Screw mount 4 into lens holder 2 (BO339) using 4-M2.5 screws and spring washers. It should only be possible to insert it in one orientation. Note, do not fully tighten screws yet. Allow the mount to translate but not move axially.
4. Carefully, load in lens element 4 ensuring its reference surface is located on the axial reference tabs in the holder. Check that the lens is sitting in the vee pads and the PTFE spring and is on the axial reference tabs.
5. Put 3 temporary PTFE retaining clips onto mount 4. Secure in place with M2.5 screws and spring/plain washers. Be careful not to damage the lens. These hold lens 4 and allows its edge to be seen for later alignment
6. Tighten all the screws until the spring washer is fully compressed and no more.
7. Check that the lens is in place and does not move.
8. Turn the holder over and place on a clean optical bench. **Ensure that the lens does not touch anything on the bench. Use a foam pad with optical wipes on to support the holder.**
9. Screw the PTFE vee pads (BO332) into mount 3 (BO334) using M2.5 screws and washers.
10. Screw the delrin spring (BO333) into mount 3 using an M2.5 screw and spring washer. Ensure the spring is the correct orientation and is pressed firmly into the recess.
11. Screw mount 3 into lens holder 2 (BO339) using 4-M2.5 screws and spring washers. It should only be possible to insert it in one orientation.
12. Place the holder onto the plattern of the engineers microscope. **Ensure lens four is facing up. Always carry with lens 4 upwards. The temporary clips are NOT designed to hold the lens securely.**

13. Manually centre the lens with respect to the holder by moving the mount. When in position lock in place by tightening the 4-M2.5 screws. **When using screwdrivers near the lens ALWAYS place an optical wipe over the lens AND cover the lens with a clean-gloved hand. This is to prevent damage caused by the screwdriver slipping.**
14. Remove the temporary retaining clips from mount 4. Secure the axial retainer (BO343) into the recesses in mount 4. This retainer should press onto the surface of the lens.
15. Put a gentle, even pressure axially down on the lens retaining ring. This is to ensure the lens is sitting square to the reference surface.
16. Place the holder onto a vee block in preparation for laser alignment. Note, the orientation of the holder with respect to the vee block needs to be maintained. This helps the repeatability in taking the holder on and off the vee.
17. Align in tip tilt and translation a laser to ensure return reflections give concentric and evenly illuminated interference rings back at the laser. Check the repeatability of putting the holder onto the vee block.
18. Carefully, load in lens element 3 ensuring its reference surface is located on the axial reference tabs in the holder. Check that the lens is sitting in the vee pads and PTFE spring and is on the axial reference tabs.
19. Place the axial retainer (BO342) onto mount 3. Secure in place with M2.5 screws and spring/plain washers. Be careful not to damage the lens, these clips should press onto the surface of the lens.
20. Check that the lens is in place and does not move.
21. One by one remove the spring washers from under the M2.5 screws holding in mount 3. **When using screwdrivers near the lens ALWAYS place an optical wipe over the lens AND cover the lens with a clean gloved hand. This is to prevent damage caused by the screwdriver slipping.**
22. Screw in the 2-M2 adjusting screws into the side of the holder until they touch the flats on the lens mount.
23. Screw in the spring and spring housing to give pre-load onto these adjusting screws.
24. Release the four M2.5 screws holding mount 3 into the holder sufficient to allow it to translate.
25. Place the holder into the aligned laser beam.
26. Carefully, use the adjusting screws to translate lens 3 in order to centre the interference fringes.
27. Calibrate the translations for when cold alignment is carried out.
28. Remove the holder from the beam and place on a secure bench.
29. Tighten the four M2.5 retaining screws and remove all adjusting screws and springs. Note, in tightening the screws the lens can become stressed and/or moved slightly. This will upset the interference fringes, care needs to be taken.
30. Check alignment of lens as per step 25/26/27. Repeat these steps until fringes are concentric.
31. Place 2-M2.5 screws into mount 3 and tighten all four of these screws. Replace the spring and spring housing with a clean M6 screw. Ensure this screw is in contact with the mount. One by one replace the other M2.5 screws with M2.5 screws and spring washers.
32. Remove the two M6 screws and the adjusting screws.

33. Check alignment by placing the holder back into the laser beam. Repeat the whole alignment procedure (from step 21) if necessary.
34. This completes the assembly.

## 4 Alignment

As mentioned in section 2.3, the alignment is essentially a three phased approach.

### 4.1 Phase 1: Holder 1

This is the most critical to align within INGRID and as such has the tightest positional tolerances. The current specification is  $\pm 10 \mu\text{m}$  decentre,  $\pm 10 \mu\text{m}$  axial and  $\pm 10 \mu\text{m}$  tilt to each other.

Lens 2 is to be aligned with lens 1 within the holder while at the operating temperature of 77K. This is not a procedure that can be done without expensive test equipment. Consequently we intend to align these lenses at room temperature, cool them down to 77K, measure any translations and adjust the position of lens 2 accordingly when warm again.

#### 4.1.1 Warm Set-up

The warm set-up is defined in the assembly procedure 3.1 above.

#### 4.1.2 Check Cold Alignment

Secure the holder into the test cryostat. Prior to cooling get a laser aligned with the two lenses in the holder. During cool down there will be a bulk movement of the holder. If this is not already known from measurements of a cool down cycle with empty holders the laser will have to be translated to bring it on axis.

Once cold, project the return reflections on to a screen. Measure the decentre of fringes. Use the calibration determined in section 3.1 step 27 to estimate the required warm offsets. Warm up the cryostat. To introduce a warm offset, repeat the assembly procedures from step 21. Cool down again in the test cryostat and repeat these steps until the lenses are centred.

#### 4.1.3 Check Repeatability

Maintain the test set-up from before. Take the lens holder through 4/5 thermal cycles. Each time the arrangement is cold, check that the lenses are centred to each other.

The optical axis should now be defined through the lens elements 1 & 2.

### 4.2 Phase 2: Holder 2

The procedure for mounting lenses 3 & 4 within holder 2 is very similar to that employed for holder 1 in section 4.1. The tolerances required for this phase are  $\pm 50 \mu\text{m}$  in decentre  $\pm 100 \mu\text{m}$  axial and  $\pm 50 \mu\text{m}$  in tilt. Although these positional tolerances are greater it should still be possible to achieve similar levels as before.

The procedure to align the lenses in this holder (3 & 4) is the same as holder 1, except that lens 4 is fixed in place first and is not moved. Lens 3 will be the one that is translated in order to centre the lens.

### **4.3 Phase 3: Lens Barrel**

This is the final alignment procedure for the lens elements in INGRID. The technique employed is similar that used for the individual lens mounts. The tolerances required are the same as those in phase 2.

#### *4.3.1 Align Holders*

Mount holder 1 (containing lenses 1 & 2) in the main lens barrel. Secure in place with the 7-M2.5 screws. It is not to be moved again and defines the optical axis of the barrel. Place holder 2 into the other end of the barrel and secure in place. This should position the holders to a tolerance of approximately  $\pm 200 \mu\text{m}$ .

#### *4.3.2 Check Warm Alignment*

Do an initial alignment at room temperature. Ensure all the lens assemblies have the same alignment of PTFE pads and springs with respect to the support plate and gravity vector.

#### *4.3.3 Check Cold Alignment*

Place the lens barrel in to the test cryostat and secure in place. Follow the same alignment test approach as used for the individual lens holders. Cool down the lens barrel to 77K.

If the holders are not aligned to the required accuracy, warm up the cryostat and remove the barrel. Use the adjusting screws acting on holder 2 to translate the holder to account for any translation. Re-perform the cold alignment test above.

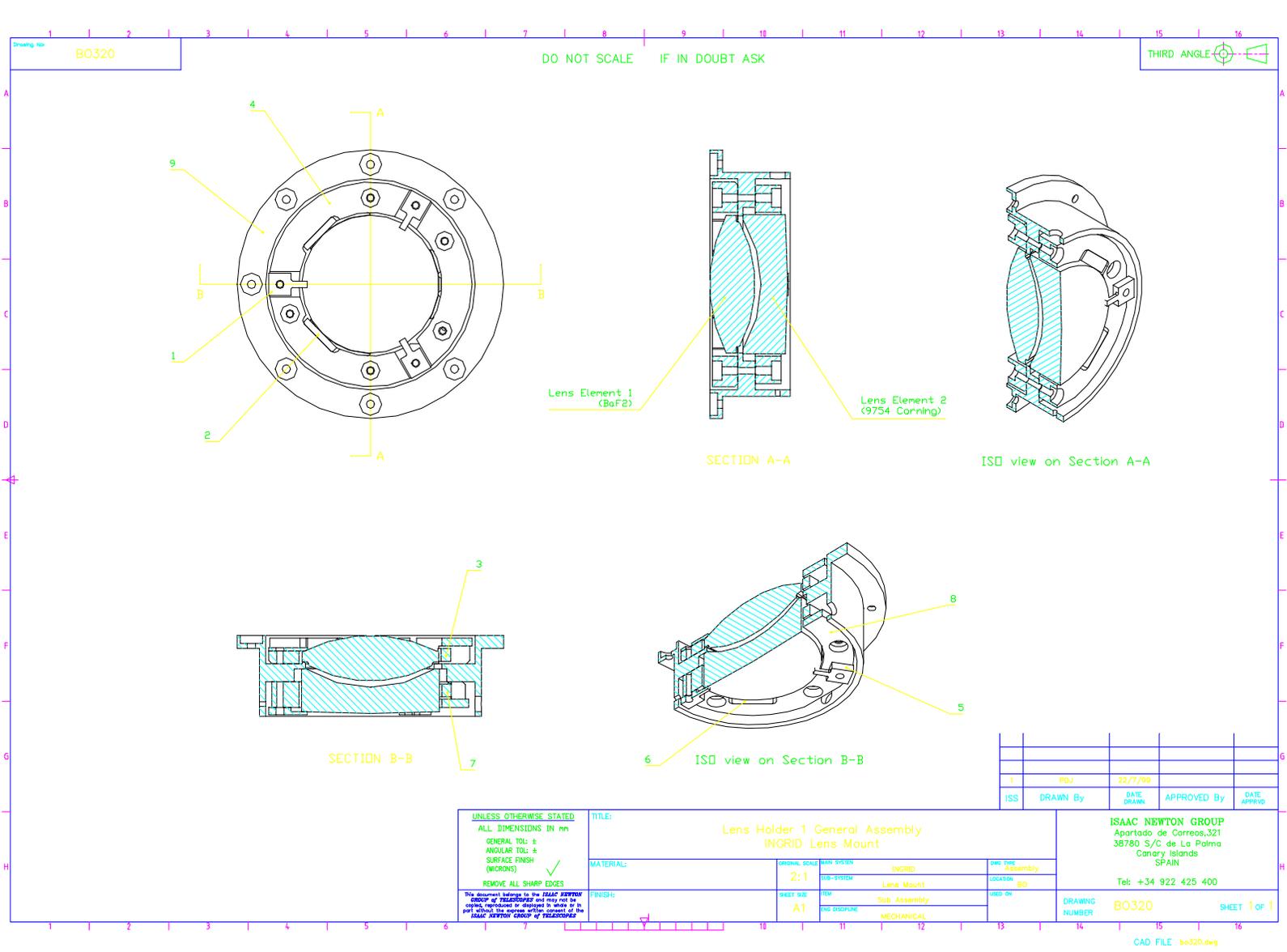
#### *4.3.4 Check Repeatability*

Maintain the test set-up from before. Take the lens barrel through 4/5 thermal cycles. Each time the arrangement is cold, check that the holders are centred to each other.

The optical axis should now be defined through the barrel.

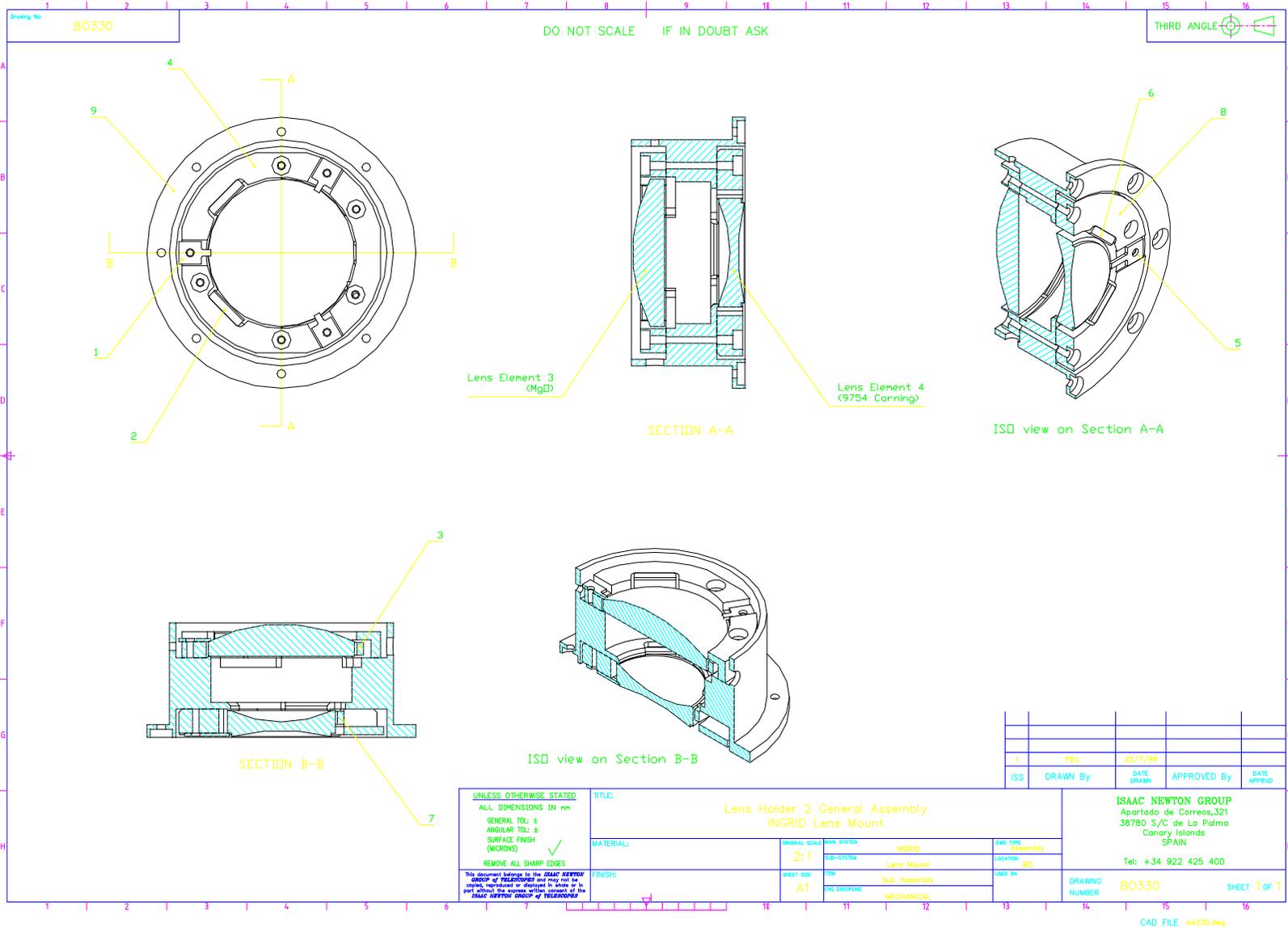
**Appendix A**

 <p><b>ISAAC NEWTON GROUP OF TELESCOPES</b> <i>Apartado de Correos 321, 38780 S/C de La Palma, Canary Islands, SPAIN</i></p>	<b>TITLE:</b>	Lens Holder 1 General Assembly INGRID Lens Mounts		<b>NAME</b>	<b>DATE</b>	<b>REVISION</b>
	<b>DWG No:</b>	BO320		<b>DRAWN:</b>	PDJ	22/07/99
				<b>CHECKED:</b>		
				<b>APPROVED:</b>		
<b>GA ITEM No.</b>	<b>DRAWING NUMBER</b>	<b>REV</b>	<b>DRAWING TITLE OR COMPONENT NAME</b>	<b>No. Per ASSEMBLY</b>	<b>REMARKS</b>	<b>MATERIAL</b>
	BO320	1	General Assembly	1		
1	BO321	1	Mount 1 Axial Clip	3		PTFE
2	BO322	1	Vee Pad For Mount 1	2		PTFE
3	BO323	1	Preload Spring For Mount 1	1		Delrin
4	BO324	1	Lens Mount 1	1		Aluminium Alloy 6082 TF
5	BO325	1	Mount 2 Axial Clip	3		PTFE
6	BO326	1	Vee Pad For Mount 2	2		PTFE
7	BO327	1	Preload Spring For Mount 2	1		Delrin
8	BO328	1	Lens Mount 2	1		Aluminium Alloy 6082 TF
9	BO329	1	Lens Holder 1	1		Aluminium Alloy 6082 TF



**Appendix B**

	<b>ISAAC NEWTON GROUP OF TELESCOPES</b> Apartado de Correos 321, 38780 S/C de La Palma, Canary Islands, SPAIN	<b>TITLE:</b>	Lens Holder 2 General Assembly INGRID Lens Mounts		<b>NAME</b>	<b>DATE</b>	<b>REVISION</b>
		<b>DWG No:</b>	BO330	<b>DRAWN:</b>	PDJ	22/07/99	1
				<b>CHECKED:</b>			
				<b>APPROVED:</b>			
GA ITEM No.	DRAWING NUMBER	REV	DRAWING TITLE OR COMPONENT NAME	No. Per ASSEMBLY	REMARKS	MATERIAL	
	BO330	1	General Assembly	1			
1	BO331	1	Mount 3 Axial Clip	3		PTFE	
2	BO332	1	Vee Pad For Mount 3	2		PTFE	
3	BO333	1	Preload Spring For Mount 3	1		Delrin	
4	BO334	1	Lens Mount 3	1		Aluminium Alloy 6082 TF	
5	BO335	1	Mount 4 Axial Clip	3		PTFE	
6	BO336	1	Vee Pad For Mount 4	2		PTFE	
7	BO337	1	Preload Spring For Mount 4	1		Delrin	
8	BO338	1	Lens Mount 4	1		Aluminium Alloy 6082 TF	
9	BO339	1	Lens Holder 2	1		Aluminium Alloy 6082 TF	



UNLESS OTHERWISE STATED  
 ALL DIMENSIONS IN mm  
 GENERAL TOL: ±  
 ANGULAR TOL: ±  
 SURFACE FINISH (MICRONS) ✓  
 REMOVE ALL SHARP EDGES

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TITLE: <b>Lens Holder 2 General Assembly INGRID Lens Mount</b>			
MATERIAL:	ORIGINAL SCALE: <b>2:1</b>	MAIN SYSTEM: INGRID	DWG TYPE: Assembly
FINISH:	SHEET SIZE: A1	SUB-SYSTEM: Lens Mount	LOCATION: BO
		SUB-ASSEMBLY: MECHANICAL	USED ON:

1	PDU	22/7/99		
ISS	DRAWN By	DATE DRAWN	APPROVED By	DATE APPROVD
ISAAC NEWTON GROUP Apartado de Correos,321 38780 S/C de La Palma Canary Islands SPAIN Tel: +34 922 425 400				
DRAWING NUMBER <b>BO330</b>			SHEET <b>1</b> of <b>1</b>	