

## POLARIS-N4 - Sept. 22, 2016

Item # POLARIS-N4 was discontinued on Sept. 22, 2016. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

- ▶ Flexure Arm Provides Highly Stable Mirror Retention
- ▶ Matched Actuator Threading Minimizes Drift and Backlash
- ▶ Heat Treating Minimizes Temperature-Dependent Hysteresis
- ▶ Sapphire Seats Ensure Long-Term Stability



**POLARIS-K2S2**  
 Ø2" Mirror Mount with  
 Two Hex Adjusters



**POLARIS-K05**  
 Ø1/2" Mirror Mount  
 (Mirror and Post Not  
 Included)



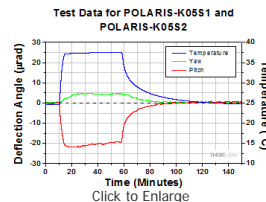
### OVERVIEW

#### Options

- Kinematic Mounts Designed for Ø1/2", Ø1", Ø19 mm (3/4"), or Ø2" Optics
- Monolithic or Flexure Spring Optic Retention
- Versions with 2 or 3 Adjusters
- Knob- or Hex-Driven Designs
- Lock Nuts Available for Certain Models
- See the *Polaris Family* Tab for List of Complete Options
- Custom Mount Configurations are Available by Contacting Tech Support

#### Quick Links

Ø1/2" Polaris Mounts
Ø19 mm Polaris Mounts
Ø1" Polaris Mounts
Ø2" Polaris Mounts
Adjuster Accessories
Lock Nuts



Each Polaris mount undergoes extensive thermal testing to ensure high-quality performance. Please see the *Test Data* tab for additional test results.

#### Features

- Heat-Treated Stainless Steel with Matched Coefficients of Thermal Expansion (CTE)
- Hardened Stainless Steel Ball Contacts with Sapphire Seats for Durability and Smooth Movement
- Matched Actuator/Body or Actuator/Bushing Pairs Provide Smooth Kinematic Adjustment
  - POLARIS-K1 and POLARIS-K1-H Have Bronze Bushing Inserts
  - All Other Polaris Mounts Sold Here Have an Integrated Tapped Steel Body Design
- Select Mounts Equipped with a Patent-Pending Monolithic Flexure Arm for Minimal Optic Distortion (See *Test Data* Tab for Details)
- Extensive Testing Guarantees Less than 2 µrad Deviation after 12.5 °C Temperature Cycling (See *Test Data* Tab for Details)

Polaris™ Low-Drift Kinematic Mirror Mounts are the ultimate solution for applications requiring stringent long-term alignment stability. A flexure spring and setscrew combination provides temperature-independent retention of the optic, unlike nylon-tipped setscrews that are sensitive to temperature fluctuations. As a result, the optic does not need to be glued into the Polaris mount to achieve maximum stability. To further improve stability, our Ø19 mm and Ø2" Polaris mirror mounts, as well as select Ø1" mounts, feature a monolithic retention arm that provides high holding force with minimal optic distortion on the mirror and improved pointing stability; for full details, please see the *Test Data* tab.

Fabricated from heat-treated stainless steel, Polaris mounts utilize precision-matched adjusters and incorporate ball contacts and sapphire seats at all contact points. As shown on the *Test Data* tab, these mounts have undergone extensive testing to ensure high-quality performance. During the design phases of these Polaris kinematic mirror mounts, extensive modeling and testing were used to determine the materials, components, and dimensional specifications that would result in optimum performance. The Polaris design addresses all of the common causes of beam misalignment, including temperature-induced hysteresis of the mirror position, drift, and backlash. Please refer to the *Design Features* tab for detailed information.

The Polaris mirror mounts are equipped with #8 (M4) counterbores for post mounting. We recommend using a stainless steel post and clamping fork, such as our Ø1" Posts for Polaris Mirror Mounts and Polaris Clamping Arm, for maximum stability. Select mounts also include Ø2 mm alignment pin holes around the mounting counterbore, allowing for precision alignments when paired with our posts for Polaris mirror mounts. We also recommend using a torque driver to accurately install the optic and prevent optical surface distortion. Please see the *Usage Tips* tab for more information and other usage recommendations.

#### Cleanroom and Vacuum Compatibility

All our Polaris mounts except the POLARIS-K1 and POLARIS-K1-H are designed to be compatible with cleanroom and vacuum applications. They are chemically cleaned using the Carpenter AAA passivation method to remove sulfur, iron, and contaminants from the surface. After passivation, they are assembled in a clean environment and double vacuum bagged to eliminate contamination when transported into a cleanroom. The POLARIS-K1 and POLARIS-K1-H are also available in vacuum-compatible versions as a custom order. Please contact techsupport@thorlabs.com for details.

All Polaris mounts sold on this page have sapphire contacts bonded into place using a NASA-approved low outgassing procedure. In addition, DuPont Krytox® LVP High-Vacuum Grease, an ultra-high-vacuum-compatible, low outgassing PTFE grease, is applied to the adjusters. Please note that the 8-32 and M4 cap screws included with the Polaris mounts are not rated for pressures below 10<sup>-5</sup> Torr.

**Polaris™**

**Guaranteed Performance**

Our Polaris product line and supporting products bearing its logo are designed to provide the best commercial optomechanical solutions in the photonics industry. If you find another commercially available mount that performs better in your test application,\* let us know, and we will accept the return of the Polaris mounts and refund 100% of the purchase price.

\*Test applications utilizing up to 100 mounts are eligible for the refund. Please contact us to discuss a larger trial quantity.

SPECS

Item # Suffix <sup>a</sup>	-K05	-K05S1	-K05S2	-K19S4	-K1-2AH	-K1S4	-K1	-K1-H	-K2	-K2S3	-K2S1	-K2S2
Optic Size	Ø1/2"			Ø19 mm (3/4")	Ø1"			Ø2"				
Optic Thickness (Min)	0.08" (2 mm)				0.14" (3.5 mm)		0.08" (2 mm)		0.14" (3.5 mm)			
Number of Adjusters	Three	Two		Two	Two		Three		Three		Two	
Adjuster Drive	Low-Profile 5/64" Hex		5/64" Hex	5/64" Hex, Ø0.07" Side Adjustment Holes	Low-Profile 5/64" Hex	5/64" Hex, Ø0.07" Side Adjustment Holes	Removable Knobs	Low-Profile 5/64" Hex	Removable Knobs	5/64" Hex	Removable Knobs	5/64" Hex
Adjuster Pitch	130 TPI				100 TPI				100 TPI			
Actuator Matching	Matched Actuator/Body Pairs						Matched Actuator/Bushing Pairs		Matched Actuator/Body Pairs			
Measured Point-to-Point Mechanical Resolution per Adjuster (Bidirectional Repeatability)	5 µrad (Typical); 2 µrad (Achievable)											
Resolution <sup>b</sup>	~11 mrad/rev			~7 mrad/rev		~7.7 mrad/rev		~7 mrad/rev		~5 mrad/rev		
Front Plate Translation (Max)	5 mm	N/A		N/A	N/A		6 mm		6 mm	N/A		
Mechanical Angular Range (Nominal)	±5°			±4°					±3.4°			
Front Plate Separation at Pivot Adjuster	1.5 mm (Nominal)	1.5 mm	2.0 mm	3.175 mm			3.175 mm (Nominal)		3.175 mm (Nominal)		3.175 mm	
Beam Deviation <sup>c</sup> After Thermal Cycling	<2 µrad				<1 µrad			<2 µrad				
Recommended Optic Mounting Torque <sup>d</sup>	6 - 10 oz-in for 6 mm Thick Optics			3 - 4 oz-in for 6 mm Thick Optics	6 - 10 oz-in for 6 mm Thick Optics	5 - 7 oz-in for 6 mm Thick Optics	6 - 10 oz-in for 6 mm Thick Optics		4 - 6 oz-in for 12 mm Thick Optics			
Mounting <sup>e</sup>	Two #8 (M4) Counterbores								Four #8 (M4) Counterbores			
Alignment Pin Holes	Two at Each Counterbore <sup>f</sup>			None	Two at Each Counterbore <sup>f</sup>		None		Two at Each Mounting Face <sup>f</sup>			
Vacuum Compatibility <sup>g</sup>	10 <sup>-9</sup> Torr at 25 °C with Proper Bake Out 10 <sup>-5</sup> Torr at 25 °C without Bake Out Grease Vapor Pressure: 10 <sup>-13</sup> Torr at 20 °C; 10 <sup>-5</sup> Torr at 200 °C Epoxy Meets Low Outgassing Standards NASA ASTM E595, Telcordia GR-1221						No <sup>h</sup>		10 <sup>-9</sup> Torr at 25 °C with Proper Bake Out 10 <sup>-5</sup> Torr at 25 °C without Bake Out Grease Vapor Pressure: 10 <sup>-13</sup> Torr at 20 °C; 10 <sup>-5</sup> Torr at 200 °C Epoxy Meets Low Outgassing Standards NASA ASTM E595, Telcordia GR-1221			
Operating Temperature Range	-30 to 200 °C											

- All item numbers in the Polaris line start with POLARIS.
- When the front plate is parallel to the back plate.
- After 12.5 °C temperature cycle, the beam returns to within 2 µrad, or 1 µrad for the POLARIS-K1S4, of its original position for a Polaris mounted on a Ø1" post with a 2" beam height. Please see the *Test Data* tab for more details.
- The optimal optic mounting torque can vary by ±1 oz-in due to variations in optic diameter and tolerance buildup.
- The Ø1/2" Mounts come with 8-32 and M4 low-profile cap screws for mounting without obstructing the transmissive beam path. The Ø19 mm, Ø1", and Ø2" Mounts come with standard 8-32 and M4 cap screws.
- Standard DIN 7-m6 ground dowel pins are recommended. The recommended tolerance for the location of the mating dowel pin holes and threaded mounting hole is ±0.003".
- Vacuum-compatible Polaris mounts are assembled in a clean environment, chemically cleaned using the Carpenter AAA passivation method to remove sulfur, iron, and contaminants from the surface, and double vacuum bagged. The 8-32 and M4 cap screws included with the Polaris mounts are not rated for pressures below 10<sup>-5</sup> Torr. Prior to placing any components in a sensitive vacuum system, a thorough pre-baking in a bake-out oven should be performed to remove all moisture and surface volatiles. Contact techsupport@thorlabs.com for details.
- While these mounts use the same grease and epoxy as our other Polaris mounts, they include components unsuitable for use in vacuum environments. Mounts that are not vacuum compatible from stock can be requested with vacuum compatibility as a custom order. Contact techsupport@thorlabs.com for details.



Click to Enlarge  
Polaris Mounts are Shipped Inside Two Vacuum Bag Layers

**Vacuum Compatible and Low Outgassing**

Each vacuum-compatible Polaris™ mount is packaged within two vacuum bag layers after assembly in a clean environment, as seen in the image to the right. These vacuum bags do not contain any desiccant materials and tightly wrap the mount, preventing friction against the mount during shipping. This packing method protects the mount from corrosion, gas or liquid contamination, and particulates during transport. The first vacuum bag should be opened in a clean environment while the second vacuum bag should only be opened just prior to installation. When operating at pressures below 10<sup>-5</sup> Torr, we highly recommend using an appropriate bake out procedure prior to installing the mount in order to minimize contamination caused by outgassing.

TEST DATA & NBSP;

**Polaris™ Mirror Mounts Test Data**

All of the Polaris Low-Drift Kinematic Mirror Mounts have undergone extensive testing to ensure high-quality performance. Thermal Shock testing confirms the exceptional stability of the mounts and demonstrates that they reliably return to their initial position after a transient temperature shift. Interferometric

wavefront distortion testing demonstrates the ability of Polaris mounts to secure an optic without significantly distorting the optical surface.

### Vibration Testing

**Purpose:** This testing was done to determine how reliably Polaris mirror mounts behave when subjected to intense physical vibrations.

**Procedure:** A pair of identical mirror mounts (either POLARIS-K19S4 or POLARIS-K1S4) were mounted on Ø1" Posts for Polaris Mirror Mounts and secured to a stainless steel breadboard with POLARIS-CA1 clamping arms. Laser beams were reflected from the mirrors onto two position sensing detectors, located on the same breadboard. The entire platform was vibrated with a variable frequency and amplitude and the displacement of the beam on the detector was recorded. The two beam paths were oriented at right angles so that the vibrational motion was in a direction parallel to the face of one mount and perpendicular to the face of the other. Please see the video to the right for a demonstration of our POLARIS-K19S4 Ø19 mm Polaris vibration test.

**Results:** When subjected to vibrational frequencies as high as 100 Hz and accelerations as high as 6 g, the POLARIS-K19S4 and POLARIS-K1S4 mounts remained mechanically sound. The angular position of the mounts remained stable within about 10 µrad for both parallel and perpendicular vibrations.

**Conclusions:** Our POLARIS-K19S4 Ø19 mm and POLARIS-K1S4 Ø1" Polaris mirror mounts provide exceptional performance, even under rugged operating conditions. As a result, these mounts are ideal for use in systems that require the greatest degree of stability when vibrational noise is expected.

### Positional Repeatability After Thermal Shock

**Purpose:** This testing was done to determine how reliably the mount returns the mirror, without hysteresis, to its initial position. These measurements show that the alignment of the optical system is unaffected by the temperature shock.

**Procedure:** After mounting the Polaris to a Ø1" Post, the mirror and post assembly was secured to a stainless steel optical table in a temperature-controlled environment. The mirror was held using the flexure mechanism; see the *Usage Tips* tab for additional mounting recommendations. A beam from an independently temperature-stabilized laser diode was reflected by the mirror onto a position sensing detector. The temperature of each mirror mount tested was raised to 37 °C. The elevated temperature was maintained in order to soak the mount at a constant temperature. Then the temperature of the mirror mount was returned to the starting temperature. The results of these tests are shown below.

**Results:** As can be seen in the plots below, when the Polaris mounts were returned to their initial temperature, the angular position (both pitch and yaw) of the mirrors returned to within 2 µrad (1 µrad for the POLARIS-K1S4 Ø1" mount) of its initial position. The best result achieved with a competitor's mount was significantly worse than the Polaris mounts. The performance of the Polaris was tested further by subjecting the mount to repeated temperature change cycles. After each cycle, the mirror's position reliably returned to within 2 µrad of its initial position.

**For Comparison:** To get a 1 µrad change in the mount's position, the 100 TPI adjuster on the POLARIS-K1 Ø1" Polaris mount needs to be rotated by only 0.05° (1/7200 of a turn). A highly skilled operator might be able to make an adjustment as small as 0.3° (1/1200 of a turn), which corresponds to 6 µrad.

**Conclusions:** The Polaris Mirror Mounts are high-quality, ultra-stable mounts that will reliably return a mirror to its original position after cycling through a temperature change. As a result, the Polaris mounts are ideal for use in applications that require long-term alignment stability.

#### Ø1/2" Polaris Mirror Mounts Thermal Shock Data

#### Ø19 mm (Ø3/4") Polaris Mirror Mounts Thermal Shock Data

#### Ø1" Polaris Mirror Mounts Thermal Shock Data

#### Ø2" Polaris Mirror Mounts Thermal Shock Data

### Optical Distortion Testing Using a ZYGO Phase-Shifting Interferometer

Mounting stresses are responsible for the strain that results in optical surface distortion. Minimizing distortion effects is crucial; any distortion to the optic affects the reflected wavefront. Our Ø19 mm and Ø2" Polaris mounts, as well as select Ø1" Polaris mounts, feature a monolithic flexure arm that is designed to provide maximum stability while minimizing optic distortion.

To determine the amount of optic distortion exerted on the mirror by the flexure arm, a ZYGO Phase-Shifting Interferometer was used to measure the wavefront distortion at different torque values (see the images below to the left). Based on results of the tests seen below, we recommend a torque of 3 - 4 oz-in for our Ø19 mm Polaris mount, 5 - 7 oz-in for our Ø1" Polaris mount, and 4 - 6 oz-in for our Ø2" Polaris mounts, at which the optic wavefront distortion is ≤0.1λ.

Please note that the optimal optic mounting torque can vary by ±1 oz-in due to variations in optic diameter and tolerance buildup.

**Procedure:**

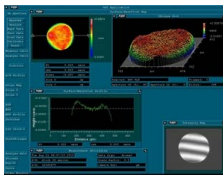
A broadband dielectric mirror was installed into a Polaris mount using the setscrew to clamp down the flexure arm. Measurements of the optic distortion were then recorded using the ZYGO interferometer. Once each measurement was complete, the amount of force needed to push the optic out of the mount was measured to check optic retention. The wavefront distortion values shown here give peak-to-valley distortion across the entire optic, representing the worst-case scenario; the center of the optic exhibits significantly less distortion than the edge.

**Results:**

As seen in the tables below, the peak-to-valley wavefront distortion was found to be ≤0.1λ when 3 - 4 oz-in of torque was applied to the setscrew of the Ø19 mm mount, when 5 - 7 oz-in of torque was applied to the setscrew of our POLARIS-K1S4 Ø1" mount, and when 4 - 6 oz-in of torque was applied to the setscrew of the Ø2" mount.

### Ø19 mm (3/4") Mount

Torque (oz-in) <sup>a</sup>	Push-Out Force (lbf) <sup>b</sup>	Wavefront Distortion (Peak to Valley) <sup>c</sup> (Click for Example Zygo Screenshot)
3		0.044λ to 0.079λ
3.5		0.025λ to 0.112λ
4		0.065λ to 0.110λ

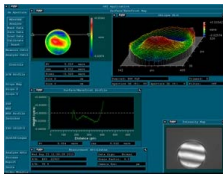


Click to Enlarge  
POLARIS-K19S4 Wavefront Distortion for  
Setscrew Torque of 3.5 oz-in (See Table to the  
Right for Other Setscrew Torques)

4.5	>12	0.028λ to 0.131λ
5		0.170λ to 0.173λ
5.5		0.132λ to 0.187λ
6		0.193λ to 0.243λ

- The recommended optic mounting torque range is indicated by the green highlighted rows.
- Push-out force is the force required to move the mounted optic at the given torque value. The Push-out force was only tested at 3 oz-in of torque.
- Wavefront distortion measurements were performed at  $\lambda = 633$  nm. The Zygo interferometer aperture outer diameter was set to 85% for these measurements. These values represent the minimum and maximum values over multiple independent tests.

### Ø1" Mount

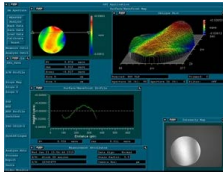


Click to Enlarge  
POLARIS-K1S4 Wavefront Distortion for  
Setscrew Torque of  
7 oz-in (See Table to the Right for Other  
Setscrew Torques)

Torque (oz-in) <sup>a</sup>	Push-Out Force (lbf) <sup>b</sup>	Wavefront Distortion (Peak to Valley) <sup>c</sup> (Click for Example Zygo Screenshot)
4.5	>12	0.072λ to 0.093λ
5		0.047λ to 0.090λ
5.5		0.057λ to 0.097λ
6		0.085λ to 0.103λ
6.5		0.057λ to 0.073λ
7		0.059λ to 0.067λ
7.5		0.083λ to 0.092λ
8		0.128λ to 0.145λ
8.5		0.102λ to 0.117λ
9		0.141λ to 0.162λ
10	0.188λ to 0.224λ	

- The recommended optic mounting torque range is indicated by the green highlighted rows.
- Push-out force is the force required to move the mounted optic at the given torque value.
- Wavefront distortion measurements were performed at  $\lambda = 633$  nm. The Zygo interferometer aperture outer diameter was set to 80% for these measurements. These values represent the minimum and maximum values over multiple independent tests.

### Ø2" Mounts



Click to Enlarge  
POLARIS-K2 Wavefront Distortion for Setscrew  
Torque of  
5 oz-in (See Table to the Right for Other  
Setscrew Torques)

Torque (oz-in) <sup>a</sup>	Push-Out Force (lbf) <sup>b</sup>	Wavefront Distortion (Peak to Valley) <sup>c</sup> (Click for Example Zygo Screenshot)
4	>12	0.075λ to 0.090λ
5		0.076λ to 0.091λ
6		0.089λ to 0.100λ
7		0.115λ to 0.121λ
8		0.128λ to 0.139λ
9		0.172λ to 0.180λ
10	0.171λ to 0.182λ	

- The recommended optic mounting torque range is indicated by the green highlighted rows.
- Push-out force is the force required to move the mounted optic at the given torque value.
- Wavefront distortion measurements were performed at  $\lambda = 633$  nm. The Zygo interferometer aperture outer diameter was set to 90% for these measurements. These values represent the minimum and maximum values over multiple independent tests.

## DESIGN FEATURES

Several common factors typically lead to beam misalignment in an optical setup. These include temperature-induced hysteresis of the mirror's position, crosstalk, drift, and backlash. Polaris™ mirror mounts are designed specifically to minimize these misalignment factors and thus provide extremely stable performance. Hours of extensive research, multiple design efforts using sophisticated design tools, and months of rigorous testing went into choosing the best components to provide an ideal solution for experiments requiring ultra-stable performance from a kinematic mirror mount.

### Thermal Hysteresis

The temperature in most labs is not constant due to factors such as air conditioning, the number of people in the room, and the operating states of equipment. Thus, it is necessary that all mounts used in an alignment-sensitive optical setup be designed to minimize any thermally induced alignment effects. Thermal effects can be minimized by choosing materials with a low coefficient of thermal expansion (CTE), like stainless steel. However, even mounts made from a material with a low CTE do not typically return the mirror to its initial position when the initial temperature is restored. All the critical components of the Polaris mirror mounts are heat treated prior to assembly since this process removes internal stresses that can cause a temperature-dependent hysteresis. As a result, the alignment of the optical system will be restored when the temperature of the mirror mount is returned to the initial temperature.

The method by which the mirror is secured in the mount is another important design factor for the Polaris; these Polaris mounts offer excellent performance without the use of adhesives. Instead, they use a flexure spring that is pressed onto the edge of the mirror using a setscrew. Setscrews, when used by themselves to hold an optic, tend to move as the temperature changes. In contrast, the holding force provided by the stainless steel flat spring is sufficient to keep the mirror locked into place regardless of the ambient temperature.

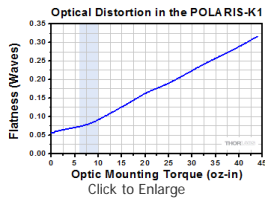
### Crosstalk

Crosstalk is minimized by carefully controlling the dimensional tolerances of the front and back plates of the mount so that the pitch and yaw actuators are orthogonal. In addition, sapphire seats are used at all three contact points. Standard metal-to-metal actuator contact points will wear down over time. The polished sapphire seats of the Polaris mounts, in conjunction with the hardened stainless steel actuator tips, maintain the integrity of the contact surfaces over time.

### Drift and Backlash

In order to minimize the positional drift of the mirror mount and backlash, it is necessary to limit the amount of play in the adjuster as well as the amount of lubricant used. When an adjustment is made to the actuator, the lubricant will be squeezed out of some spaces and built up in others. This non-equilibrium distribution of lubricant will slowly relax back into an equilibrium state. However, in doing so, this may cause the position of the front plate of the mount to move. The Polaris™ mounts use adjusters matched to the body or bushings that exceed all industry standards so very little adjuster lubricant is needed. As a result, alignment of the Polaris mounts is extremely stable even after being adjusted (see the *Test Data* tab for more information). In addition, these adjusters have a smooth feel that allows the user to make small, repeatable adjustments.

## USAGE TIPS



Click to Enlarge  
At zero torque, the sample mirror's flatness was  $\lambda/20$  over the clear aperture ( $\lambda = 633$  nm). The shaded region in this plot denotes the recommended optic mounting torque for a 6 mm thick optic in the POLARIS-K1. At higher mounting torque values, the optic distortion increases dramatically.

The Polaris' performance is optimized for use with our  $\varnothing 1"$  Posts and our POLARIS-CA1 clamping arm. These posts are made of stainless steel and provide two lines of contact with the mount, which help confine the bottom of the mount during variations in the surrounding temperature, thereby minimizing potential alignment issues.

### Optic Mounting

Since an optic is prone to movement within its mounting bore, all optics should be mounted with the Polaris out of the setup to ensure accurate mounting that will minimize misalignment effects. We recommend using a torque wrench when installing an optic in the Polaris mounts. Over torquing the flexure-spring optic retainer can result in dramatic surface distortions (see the graph to the left).

### Front Plate's Position

Polaris mounts are designed to allow adjustments of up to  $10^\circ$  for  $\varnothing 1/2"$  mounts, up to  $8^\circ$  for  $\varnothing 19$  mm and  $\varnothing 1"$  mounts, and up to  $6.8^\circ$  for  $\varnothing 2"$  mounts. To achieve the best performance, it is recommended that the front plate be kept as parallel as possible to the back plate. This ensures the highest stability of the adjustments.

### Mount as Close to the Table's Surface as Possible

To minimize the impact of vibrations and temperature changes, it is recommended that your setup has as low of a profile as possible. Using short posts will reduce the Y-axis translation caused by temperature variations and will minimize any movements caused by vibrations. Mount the Polaris directly onto a flat surface such as a breadboard using a  $1/4"-20$  to  $8-32$  thread adapter (AE8E25E) or M6 x 1.0 to M4 x 0.7 adapter (AE4M6M). For direct mounting, the POLARIS-K1 must have the bottom two knobs removed, as in the photo to the right. By doing so, the instability introduced by a post will be eliminated.

### Polish and Clean the Points of Contact

We highly recommend that the points of contact between the mount and the post, as well as the post and the table, are clean and free of scratches or defects. For best results, we recommend using a polishing stone to clean the table's surface and a LFG1P polishing pad for the top and bottom of the post as well as the bottom of the mount.

### Not Recommended

We do not recommend taking the adjusters out of the bushings, as it can contaminate the threading. This can reduce the fine adjustment performance significantly. Also, do not pull the front plate away as it might stretch the springs beyond their operating range or crack the sapphire seats. Finally, do not over tighten the retaining screws that secure the flat spring that holds the optic in place; only slight force is required to secure the optic in place.

Through thermal changes and vibrations, the Polaris™ kinematic mirror mounts are designed to provide years of use. Below are some usage tips to ensure that the mount provides optimal performance.

### Match Materials

Due to its relatively low coefficient of thermal expansion, stainless steel was chosen as the material from which to fabricate the front and back plates of the Polaris mounts. When mounting, we recommend using components fabricated from the same material, such as our  $\varnothing 1"$  Posts for Polaris Mirror Mounts and Polaris Clamping Arm.

### Use a Wide Post



Click to Enlarge  
A POLARIS-K05 mount can be mounted to a surface using a  $\varnothing 1"$  Post for Polaris Mirror Mounts and a Polaris Clamping Arm. Using a 1.50" long post, the optical axis is 2.0" above the table surface.



Click to Enlarge

## POLARIS FAMILY

Thorlabs offers several different general varieties of Polaris mounts, including standard low drift, SM threaded, low optic distortion, kinematic glue-in optic, piezo actuated, fixed monolithic, and fixed glue in optic. The tables below compare the features of all of our Polaris mirror mounts. We also offer a line of accessories that have been specifically designed for use with our Polaris mounts; these are listed in the table to the right.

### Accessories for Polaris Mounts

$\varnothing 1"$ Posts for Polaris Mirror Mounts
Polaris Clamping Arm
Polaris 45° Adapter

Polaris Mounts for  $\varnothing 1/2"$  Optics

Polaris Mounts for  $\varnothing 19$  mm ( $3/4"$ ) Optics

Polaris Mounts for  $\varnothing 1"$  Optics

Polaris Mounts for  $\varnothing 2"$  Optics

Polaris Kinematic Platform Mount

### Polaris $\varnothing 1/2"$ Kinematic Mirror Mount, 3 Adjusters, Flexure Spring Optic Retention

- ▶ 3-Adjuster Hex-Driven Design
- ▶ Designed for use with  $\varnothing 1/2"$  Optics
- ▶ 130 TPI Matched Actuator/Body Pairs

- ▶ ±5° Mechanical Angular Range
- ▶ ~11 mrad/rev Resolution
- ▶ Less than 2 μrad Deviation after Temperature Cycling (See the *Test Data* Tab for Details)
- ▶ 1" Wide Compact Footprint



Click to Enlarge  
A POLARIS-K05 mount, shown here with a Fixed Fiber Collimator, can be mounted to a surface using a Ø1" post and a POLARIS-CA1 clamping arm.

This Ø1/2" 3-Adjuster Standard Polaris Kinematic Mirror Mount is designed to provide easy high-resolution adjustment and long-term alignment stability. The Polaris integrated matched adjuster/body design results in greater durability and thermal performance compared to non-Polaris mirror mounts. Kinematic adjustment is provided by three 130 TPI adjusters that are compatible with 5/64" (2 mm) hex keys; they may be adjusted with our HKTS-5/64 Hex Key Thumbscrew (sold below) or any other 5/64" (2 mm) hex wrench. The three-adjuster design provides tip and tilt plus Z-axis (optical axis) adjustment. A two-adjuster version is also available below.

Post mounting is provided by two #8 (M4) counterbores. For custom mounting configurations, Ø2 mm alignment pin holes are located on both sides of each counterbore for setting a precise location and mounting angle. Standard DIN 7-m6 ground dowel pins are recommended (see the red documents icon below for details). We recommend using this mount with a stainless steel post that also has Ø2 mm alignment pin holes, such as our Ø1" Posts for Polaris Mirror Mounts. Due to the shallow design of the counterbores, low-profile 8-32 and M4 cap screws are included for mounting without obstructing the transmissive beam path. The 8-32 cap screw accepts a 5/64" (2 mm) hex wrench, while the M4 cap screw accepts a 2.5 mm hex wrench.

Part Number	Description	Price	Availability
POLARIS-K05	Polaris™ Low Drift Ø1/2" Mirror Mount, 3 Low-Profile Hex Adjusters	\$133.00	Today

### Polaris Ø1/2" Kinematic Mirror Mounts, 2 Adjusters, Flexure Spring Optic Retention

- ▶ 2-Adjuster Hex-Driven Design
- ▶ Designed for use with Ø1/2" Optics
- ▶ 130 TPI Matched Actuator/Body Pairs
- ▶ Low-Profile or Standard-Profile Adjusters
- ▶ ±5° Mechanical Angular Range
- ▶ ~11 mrad/rev Resolution
- ▶ Less than 2 μrad Deviation after Temperature Cycling (See the *Test Data* Tab for Details)
- ▶ 1" Wide Compact Footprint



Click for Details  
POLARIS-K05S2 Mount with Mirror Installed

These 2-adjuster Ø1/2" Standard Polaris Kinematic Mirror Mounts are similar to the standard hex-driven 3-adjuster version sold above but feature a hardened steel ball in place of the third adjuster. The 2-adjuster design improves mount stability by limiting the available degrees of freedom for movement. An integrated matched adjuster/body design results in greater durability and thermal performance compared to non-Polaris mirror mounts.

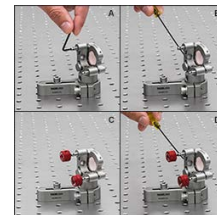
The POLARIS-K05S1 mount has standard-profile hex adjusters and includes two adjuster lock nuts. For fitting into tight spaces, the POLARIS-K05S1 mount is equipped with low-profile hex adjusters that are 0.15" (3.8 mm) shorter than the adjusters on the POLARIS-K05S2; due to the shorter adjusters, the POLARIS-K05S1 does not include lock nuts. The hex actuators are compatible with 5/64" (2 mm) hex keys and may be adjusted with our HKTS-5/64 Hex Key Thumbscrew (sold below) or any other 5/64" (2 mm) hex wrench.

Post mounting is provided by two #8 (M4) counterbores. For custom mounting configurations, Ø2 mm alignment pin holes are located on both sides of each counterbore for setting a precise location and mounting angle. Standard DIN 7-m6 ground dowel pins are recommended (see the red documents icon below for details). We recommend using this mount with a stainless steel post that also has Ø2 mm alignment pin holes, such as our Ø1" Posts for Polaris Mirror Mounts. Due to the shallow design of the counterbores, low-profile 8-32 and M4 cap screws are included for mounting without obstructing the transmissive beam path. The 8-32 cap screw accepts a 5/64" (2 mm) hex wrench, while the M4 cap screw accepts a 2.5 mm hex wrench.

Part Number	Description	Price	Availability
POLARIS-K05S1	Polaris™ Low Drift Ø1/2" Mirror Mount, 2 Low-Profile Hex Adjusters	\$126.00	Today
POLARIS-K05S2	Polaris™ Low Drift Ø1/2" Mirror Mount, 2 Hex Adjusters with Lock Nuts	\$141.00	Today

### Polaris Ø19 mm (3/4") Kinematic Mirror Mount, 2 Adjusters, Monolithic Optic Retention

- ▶ 2-Adjuster Hex-Driven Design
- ▶ Easily Accessible Ø0.07" Adjuster Side Through Holes for Fine Adjustments
- ▶ Designed for use with Ø19 mm (3/4") Optics
- ▶ 130 TPI Matched Actuator/Body Pairs
- ▶ ±4° Mechanical Angular Range
- ▶ ~7 mrad/rev Resolution
- ▶ Less than 2 μrad Deviation after Temperature Cycling (See the *Test Data* Tab for Details)
- ▶ Monolithic Flexure Arm for Minimal Optic Distortion and Improved Optic Holding Stability (See the *Test Data* Tab for Details)



Click to Enlarge  
Methods of Adjusting the Ø19 mm (3/4") Polaris Mount:  
A: 5/64" or 2.0 mm Hex Key in the End of the Adjuster  
B: 1/16" or 1.5 mm Balldriver Through Adjuster Side Holes  
C: HKTS-5/64 Hex Knobs in the Adjuster  
D: Hex Knobs with Side Hole Fine Adjustment

This 2-adjuster Ø19 mm (3/4") Polaris Kinematic Mirror Mount is designed to provide easy high-resolution adjustment and long-term alignment stability. The mount features a monolithic flexure arm design that keeps wavefront distortion on the mounted optic to a minimum while providing an optic retention force that is much stronger than the force provided by a typical setscrew design, as shown in the *Test Data* tab. The 2-adjuster design improves mount stability by limiting the available degrees of freedom for movement. The monolithic front plate and stiffer springs used in the construction of this mount provide enhanced stability and make it an ideal solution for OEM applications that require reliable operation in rugged environments.

The 130 TPI adjusters on this mount are compatible with 5/64" (2 mm) hex keys and may be adjusted with our HKTS-5/64 Hex Key Thumbscrew (sold below) or any other 5/64" (2 mm) hex wrench. In addition, the adjusters feature two Ø0.07" through holes for a 1/16" (1.5 mm) balldriver or hex key that allow for actuation from the side, as shown in the picture to the right. The adjusters on this mount can be locked using the POLARIS-LN05 lock nuts (sold separately below).

Post mounting is provided by two #8 (M4) counterbores. For custom mounting configurations, two Ø2 mm alignment pin holes are located on each mounting face for setting a precise location and mounting angle. Standard DIN 7-m6 ground dowel pins are recommended (click on the red documents icon below for details).

For more information about Thorlabs' selection of Ø19 mm mirrors, please expand the table below.

#### Ø19 mm Mirrors

- Transmission Plot at 0° AOI and 45° AOI
- Transmission Plot at 0° AOI and 45° AOI

- Transmission Plot at 0° AOI and 45° AOI

Part Number	Description	Price	Availability
POLARIS-K19S4	Polaris™ Low Drift Ø19 mm (3/4") Mirror Mount, 2 Hex Adjusters with Side Holes	\$145.00	Today

### Polaris Ø1" Kinematic Mirror Mounts, 3 Adjusters, Flexure Spring Optic Retention

- ▶ 3-Adjuster Knob- or Hex-Driven Design
- ▶ Designed for use with Ø1" Optics
- ▶ 100 TPI Matched Actuator/Bushing Pairs
- ▶ ±4° Mechanical Angular Range
- ▶ ~7 mrad/rev Resolution
- ▶ Less than 2 µrad Deviation after Temperature Cycling (See the *Test Data* Tab for Details)



Click for Details  
The POLARIS-K1-H  
Features Low-Profile  
Hex Adjusters Instead  
of Knobs

These Ø1" Standard Polaris Kinematic Mirror Mounts are designed to provide easy high-resolution adjustment and long-term alignment stability. We offer standard Ø1" Polaris Mirror Mounts with three adjustment screws. The POLARIS-K1 features removable knob adjusters while the POLARIS-K1-H mount is equipped with low-profile hex adjusters. POLARIS-LN1 Lock nuts for the POLARIS-K1 adjusters are sold separately below. The adjusters are compatible with 5/64" (2 mm) hex keys and may be adjusted with our HKTS-5/64 Hex Key Thumbscrew (sold below) or any other 5/64" (2 mm) hex wrench. The three-adjuster design provides tip and tilt plus Z-axis (optical axis) adjustment. A two-adjuster version is also available below.

Post mounting is provided by two #8 (M4) counterbores. We recommend using this mount with a stainless steel post, such as our Ø1" Posts for Polaris Mirror Mounts. We also recommend using a torque driver to accurately install the optic and prevent optical surface distortion. Please see the *Usage Tips* tab for more information and other usage recommendations.

Part Number	Description	Price	Availability
POLARIS-K1	Polaris™ Low Drift Ø1" Mirror Mount, 3 Adjusters	\$133.00	Today
POLARIS-K1-H	Customer Inspired! Polaris™ Low Drift Ø1" Mirror Mount, 3 Low-Profile Hex Adjusters	\$130.00	Today

### Polaris Ø1" Kinematic Mirror Mount, 2 Adjusters, Flexure Spring Optic Retention

- ▶ 2-Adjuster Hex-Driven Design
- ▶ Designed for use with Ø1" Optics
- ▶ 100 TPI Matched Actuator/Body Pairs
- ▶ ±4° Mechanical Angular Range
- ▶ ~7 mrad/rev Resolution
- ▶ Less than 2 µrad Deviation after Temperature Cycling (See the *Test Data* Tab for Details)



Click for Details  
POLARIS-K1-2AH  
Features an Integrated  
Tapped Steel Body  
Design for Durability  
and Stability

This 2-adjuster Ø1" Standard Polaris Kinematic Mirror Mount is similar to the standard hex-driven 3-adjuster version sold above but features a hardened steel ball in place of the third adjuster. The 2-adjuster design improves mount stability by limiting the available degrees of freedom for movement. The Polaris integrated matched adjuster/body design results in greater durability and thermal performance compared to non-Polaris mirror mounts. For fitting into tight spaces, the POLARIS-K1-2AH mount is equipped with low-profile hex adjusters and therefore is not compatible with our lock nuts. The 5/64" (2 mm) hex actuators may be adjusted with our HKTS-5/64 Hex Key Thumbscrew (sold below) or any other 5/64" (2 mm) hex wrench.

Post mounting is provided by two #8 (M4) counterbores. We recommend using this mount with a stainless steel post, such as our Ø1" Posts for Polaris Mirror Mounts. We also recommend using a torque driver to accurately install the optic and prevent optical surface distortion. Please see the *Usage Tips* tab for more information and other usage recommendations.

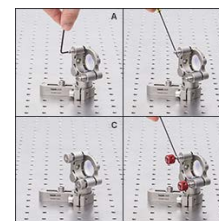
Part Number	Description	Price	Availability
POLARIS-K1-2AH	Customer Inspired! Polaris™ Low Drift Ø1" Mirror Mount, 2 Low-Profile Hex Adjusters	\$123.00	Today

### Polaris Ø1" Kinematic Mirror Mount, 2 Adjusters, Monolithic Optic Retention

- ▶ 2-Adjuster Hex-Driven Design
  - ▶ POLARIS-N4 Removable Knobs Available Separately
- ▶ Easily Accessible Ø0.07" Adjuster Side Through Holes for Fine Adjustments
- ▶ Designed for use with Ø1" Optics
- ▶ 100 TPI Matched Actuator/Body Pairs
- ▶ ±4° Mechanical Angular Range
- ▶ ~7.7 mrad/rev Resolution
- ▶ Less than 1 µrad Deviation after Temperature Cycling (See the *Test Data* Tab for Details)
- ▶ Monolithic Flexure Arm for Minimal Optic Distortion and Improved Optic Holding Stability (See the *Test Data* Tab for Details)



Click to Enlarge  
Mount Shown with  
Optional POLARIS-N4  
Removable Knobs



Click to Enlarge  
Methods of Adjusting the POLARIS-K1S4 Ø1"  
Polaris Mount:  
A: 5/64" or 2.0 mm Hex Key in the End of the Adjuster  
B: 1/16" or 1.5 mm Balldriver Through Adjuster Side Holes  
C: POLARIS-N4 Removable Knobs on the Adjuster  
D: HKTS-5/64 Hex Knobs with Side Hole Fine Adjustment

This 2-adjuster Ø1" Polaris Kinematic Mirror Mount is designed to provide easy high-resolution adjustment and long-term alignment stability. The mount features a monolithic flexure arm design that keeps wavefront distortion on the mounted optic to a minimum while providing an optic retention force that is much stronger than the force provided by our other Ø1" Polaris mounts that use a setscrew and flexure spring design, as shown in the *Test Data* tab. The 2-adjuster design improves mount stability by limiting the available degrees of freedom for movement. The monolithic front plate and stiffer springs used in the construction of this mount provide enhanced stability and reduced optic distortion, making it an ideal solution for OEM applications that require reliable operation in rugged environments.

The 100 TPI adjusters on this mount are compatible with 5/64" (2 mm) hex keys and may be adjusted with our HKTS-5/64 Hex Key Thumbscrew (sold below) or any other 5/64" (2 mm) hex wrench. The POLARIS-N4 Removable Knob is also available, which provides improved feel for fine-resolution adjustments and a lower profile than our hex key thumbscrews. In addition, the adjusters feature three Ø0.07" through holes for a 1/16" (1.5 mm) balldriver or hex key that allow for actuation from the side, as shown in the picture to the right. Note that the POLARIS-N4 removable knobs will block the adjuster side holes. The adjusters on this mount can be locked using the POLARIS-LN1 lock nuts (sold separately below).

Post mounting is provided by two #8 (M4) counterbores. For custom mounting configurations, two Ø2 mm alignment pin holes are located on each mounting



face for setting a precise location and mounting angle. Standard DIN 7-m6 ground dowel pins are recommended (click on the red documents icon below for details). We recommend using this mount with a stainless steel post that also has Ø2 mm alignment pin holes, such as our Ø1" Posts for Polaris Mirror Mounts.

Part Number	Description	Price	Availability
POLARIS-K1S4	Polaris™ Low Drift Ø1" Mirror Mount, 2 Hex Adjusters with Side Holes, Monolithic Optic Retention	\$150.00	Today
POLARIS-N4	Polaris™ Removable Knob for 1/4"-100 Adjusters with Side Holes, Qty. 1	\$7.60	Lead Time

### Polaris Ø2" Kinematic Mirror Mount, 3 Adjusters, Monolithic Optic Retention

- ▶ 3-Adjuster Knob- or Hex-Driven Design
- ▶ Designed for use with Ø2" Optics<sup>a</sup>
- ▶ 100 TPI Matched Actuator/Body Pairs
- ▶ ±3.4° Mechanical Angular Range
- ▶ ~5 mrad/rev Resolution
- ▶ Less than 2 µrad Deviation after Temperature Cycling (See the *Test Data* Tab for Details)
- ▶ Monolithic Flexure Arm for Minimal Optic Distortion and Improved Optic Holding Stability (See the *Test Data* Tab for Details)



These Ø2" 3-Adjuster Standard Polaris Kinematic Mirror Mounts are designed to provide easy high-resolution adjustment and long-term alignment stability. These mounts feature a monolithic flexure arm design that keeps wavefront distortion on the mounted optic to a minimum, as shown in the *Test Data* tab. The three-adjuster design provides tip and tilt plus Z-axis (optical axis) adjustment. A two-adjuster version is also available below.

Kinematic adjustment is provided by three 100 TPI adjusters that are compatible with 5/64" (2 mm) hex keys; they may be adjusted with our HKTS-5/64 Hex Key Thumbscrew (sold below) or any other 5/64" (2 mm) hex wrench. The POLARIS-K2 is equipped with removable knob adjusters while the POLARIS-K2S3 has hex adjusters; adjusters on both mounts can be locked using the POLARIS-LN1 lock nuts (sold separately below).

Post mounting is provided by four #8 (M4) counterbores. For custom mounting configurations, two Ø2 mm alignment pin holes are located on each mounting face for setting a precise location and mounting angle. Standard DIN 7-m6 ground dowel pins are recommended (see the red documents icon below for details). We recommend using this mount with a stainless steel post that also has Ø2 mm alignment pin holes, such as our Ø1" Posts for Polaris Mirror Mounts.

a. Please note that these mounts are designed for Ø2" Optics and are not intended for use with the Ø50 mm metric mirror size. To order a mount designed for metric optics, please contact Tech Support.

Part Number	Description	Price	Availability
POLARIS-K2	Polaris™ Low Drift Ø2" Mirror Mount, 3 Adjusters	\$265.00	Today
POLARIS-K2S3	Polaris™ Low Drift Ø2" Mirror Mount, 3 Hex Adjusters	\$250.00	Today

### Polaris Ø2" Kinematic Mirror Mount, 2 Adjusters, Monolithic Optic Retention

- ▶ 2-Adjuster Knob- or Hex-Driven Design
- ▶ Designed for use with Ø2" Optics<sup>a</sup>
- ▶ 100 TPI Matched Actuator/Body Pairs
- ▶ ±3.4° Mechanical Angular Range
- ▶ ~5 mrad/rev Resolution
- ▶ Less than 2 µrad Deviation after Temperature Cycling (See the *Test Data* Tab for Details)
- ▶ Monolithic Flexure Arm for Minimal Optic Distortion and Improved Optic Holding Stability (See the *Test Data* Tab for Details)



These 2-adjuster Ø2" Standard Polaris Kinematic Mirror Mounts are similar to the standard 3-adjuster versions sold above but feature a hardened steel ball in place of the third adjuster. The 2-adjuster design improves mount stability by limiting the available degrees of freedom for movement. These mounts feature a monolithic flexure arm design that keeps wavefront distortion on the mounted optic to a minimum, as shown in the *Test Data* tab.

The 100 TPI adjusters on these mounts are compatible with 5/64" (2 mm) hex keys and may be adjusted with our HKTS-5/64 Hex Key Thumbscrew (sold below) or any other 5/64" (2 mm) hex wrench. The POLARIS-K2S1 is equipped with removable knob adjusters while the POLARIS-K2S2 has hex adjusters; adjusters on both mounts can be locked using the POLARIS-LN1 lock nuts (sold separately below).

Post mounting is provided by four #8 (M4) counterbores. For custom mounting configurations, two Ø2 mm alignment pin holes are located on each mounting face for setting a precise location and mounting angle. Standard DIN 7-m6 ground dowel pins are recommended (see the red documents icon below for details). We recommend using this mount with a stainless steel post that also has Ø2 mm alignment pin holes, such as our Ø1" Posts for Polaris Mirror Mounts.

a. Please note that these mounts are designed for Ø2" Optics and are not intended for use with the Ø50 mm metric mirror size. To order a mount designed for metric optics, please contact Tech Support.

Part Number	Description	Price	Availability
POLARIS-K2S1	Polaris™ Low Drift Ø2" Mirror Mount, 2 Adjusters	\$250.00	Today
POLARIS-K2S2	Polaris™ Low Drift Ø2" Mirror Mount, 2 Hex Adjusters	\$240.00	Today

### 1/4"-100 Large Adjustment Knob

- ▶ Ø0.925" Knob for Additional Angular Resolution
- ▶ Clearance Hole Allows Access to Hex Socket of the Adjuster

This removable adjustment knob is compatible with our 1/4"-100 adjusters, including those used in the Ø1" and Ø2" Polaris Kinematic Mounts and our Polaris Kinematic Platform Mount. The larger Ø0.925" size provides additional angular resolution over the standard Polaris knobs.



Click to Enlarge  
The F25USK2 Knob is  
Compatible with our  
Polaris Mounts

Part Number	Description	Price	Availability
F25USK2	Ø0.925" 1/4"-100 Removable Adjuster Knob	\$8.20	Today



### 5/64" Hex Key Adjusters

- ▶ For Convenient Adjustment of 5/64" and 2 mm Hex-Driven Actuators
- ▶ Red Anodized Adjustment Knob with Engraved Hex Size
- ▶ Replaceable Hex Tip
- ▶ Sold in Packages of 4



Click for Details  
POLARIS-K1-2AH with HKTS-5/64 Adjuster

These 5/64" Hex Key Adjuster Thumbscrews allow for quick adjustment of many 5/64" and 2 mm hex-driven actuators (or standard actuators with the knobs removed). These temporary knobs can be left in the screw's hex socket between adjustments for convenience (see photo to the right). An 8-32 setscrew (5/64" hex) secures the replaceable hex bit, which can be reversed if the tip is stripped. Contact Tech Support to order replacement hex key bits.

We offer hex key thumbscrews in sizes from 0.050" to 3/16" and 2 mm to 5 mm.

Part Number	Description	Price	Availability
HKTS-5/64	Customer Inspired!5/64" (2 mm) Hex Key Thumbscrew (4 Pack)	\$22.50	Today

### Adjuster Lock Nuts for Polaris Mounts

- ▶ Lock Nuts for Long-Term Adjuster Stability
- ▶ Compatible with Select Polaris Mounts



Click to Enlarge  
POLARIS-LN05 Lock Nuts on a POLARIS-K1954 Mount

These lock nuts are designed for use with any Polaris kinematic mount that does not contain low-profile adjusters.

Designed for long-term adjuster stability or applications that are exposed to shock and vibration, these lock nuts are pre-greased with the same ultra-high-vacuum-compatible, low-outgassing PTFE grease as the Polaris mounts and have been tested for adjuster fit.

To install a lock nut without cross threading, gently place the lock nut against the end of the adjuster. "Unscrew" the nut until the threads of the nut and the adjuster align before threading the nut onto the adjuster. This animation shows the installation of a POLARIS-LN1 lock nut on a POLARIS-K1F1 low distortion mount.

To secure the lock nut on an adjuster, lightly tighten to a torque of approximately 4 to 8 oz-in (0.03 to 0.06 N-m). The beam can be held on target with the adjuster thumbscrew or hex key while lightly tightening the lock nut by hand or with a thin-head wrench or cone wrench; POLARIS-LN05 lock nuts require a 6 mm hex tool for tightening, while POLARIS-LN1 lock nuts require a 13 mm hex tool. To avoid cross threading the lock nut, place it against the adjuster and "unscrew" the lock nut until you feel a slight drop; then thread the lock nut onto the adjuster.

Part Number	Description	Price	Availability
POLARIS-LN05	3/16"-130 Lock Nut, 6 mm Hex, Stainless Steel	\$12.00	Today
POLARIS-LN1	1/4"-100 Lock Nut, 13 mm Hex, Stainless Steel	\$8.00	Today