2/25/02 (revised 9/13/2011 to fix several typos and errors, HDT)

NIRC2 Normal Maintenance Procedures

General Procedures

Introduction

NIRC2 is a imaging spectrograph fed by the AO on the Keck II Nasmyth platform. It is a complicated system that has as its main subsystem, D82, the evacuated cryogenic instrument adjacent to the AO optical bench. It has several subsystems external to it that combine with it to form the full system. This document addressees only the maintenance of D82. Other subsystems are only mentioned incidentally.

Servicing a large complicated vacuum cryogenic instrument with a large number of mechanisms presents special concerns that are often much less important in general observatory instruments:

1. The service personnel probably have not seen the insides for a long time, if ever. That is under the assumption that the instrument is reliable.

2. The instrument is cryogenic and under vacuum. Which means that there are many physical changes on cooling. Mechanisms that work warm might not work cold unless properly assembled, because of shrinkage. Clearances were determined for cryogenic operation. Wiring shrinks on cooling. Poor thermal contact will not show up until the instrument is cold. Also, no liquid lubricants can be used, and the solid ones have a limited life which can be greatly shortened by operation in air.

3. The insides of the instrument cannot be observed when it is in its operational state. For this reason, diagnosing mechanical and electrical problems is tricky.

4. The turnaround time from an operating instrument, to internal access, and then back to an operating instrument again is long: about ten days in the case of D82.

5. In order to obtain high optical throughput and low scattered light, the optics were built under class 100 clean room conditions and the instrument under conditions approaching class 10000. Also, great care was taken to clean all internal parts of oil contamination by ultrasonic cleaning or other appropriate methods. All of the painted surfaces were baked and vacuum degassed. Because it is a vacuum cryogenic instrument, contamination will only be introduced when the instrument is opened, so it will remain clean unless improperly serviced.

6. The instrument, because of its size, uses an electrically powered hoist to lift its lid and radiation shields. Improper use of the hoist can cause catastrophic damage to the instrument and possibly cause injury to personnel.

For these reasons, certain general preparations and procedures should be used. Many of them are appropriate for work on any instrument, but they are especially important for NIRC2. Work on D82 has a little of the feel of astronauts servicing HST. The detail given below is not meant as an insult to ones intelligence but as a reminder that a small slipup can be unusually costly.

General Preparations.

1. A plan and schedule should be worked out.

2. The proper personnel should be available.

3. All pertinent drawings and documents should have been studied and should be readily available.

4. Appropriate clean room conditions should have been obtained before work is started.

5. The room and the outside of D82 should be cleaned before D82 is opened.

6. Clean room accessories should be in place.

7. Necessary tool should have been cleaned and should be at hand.

8. Any parts, jigs and fixtures to be used, should be checked and be ready to use.

9. A check list should be made up.

10. The work space should be organized and free of clutter.

11. The work space should be very well lit.

12. A plain cloth or plastic sheet should be placed under the work so that any parts that are dropped can be retrieved. White or black are good colors for this.

General Procedures

1. A check list should be followed and be in the hands of a person distinct from one of the ones doing the work, so that the check list person can confirm the operation.

2. The work should be done slowly and deliberately, and if multiple people are working, careful coordination is important.

3. If anything arises that is unexpected, all work should stop until the anomaly is fully understood.

4. All work should be rechecked, and everything accessible should be checked again as the instrument is being closed up for the final time.

5. When using the electric hoist, extreme care must be taken that ALL fasteners are properly undone and that nothing is hanging up. Lift and lower at the slowest speed and in small steps until the lid and shields are know to be clear.

6. No tools or parts should ever be placed to rest inside of the instrument, and tools and parts that are used should be inventoried.

7. All parts that are removed should inventoried to the extent that it is known exactly where they came from and they should placed in clean labeled containers. Transparent ones are best.

8. As far as is practicable, measurements should be make of the position of adjustable items before any fasteners are loosened, so they can be reinstalled at the same setting.

9. All screws and all washers on them should be inventoried and placed in clean labeled containers. Transparent ones that seal such as zip lock bags or screw top plastic jars are good. They should not be mixed up. IT IS ABSOLUTELY IMPORTANT that the same length screws with the same washers that are removed from a place be reinstalled in that same place.

10. Any parts that are dropped or are otherwise missing must be found, or it must be otherwise assured that they are not in the instrument.

11. Screws should not be over tightened. If a torque is indicated, a torque wrench should be used.

12. Any screw or item that binds or starts to gall should not be forced. Work should stop until the appropriate action is determined.

13. When D82 is open, full clean room apparel, including gloves head covering and face mask should be worn.

14. If D82 is opened for major work, sheets of stiff clean plastic should be placed over the optical beam holes in the collimator and the cameras. The optics are hard to clean, and this prevents dust from entering.

15. All temporary item placed inside the instrument for servicing it should be inventoried and their removal checked before the instrument is closed.

16. The insides of the instrument should be vacuumed before it is closed. If dust has to be blown off it should only be done with small amounts of clean dry nitrogen. Try not to blow dust into the camera or collimator.

17. Do not run the mechanisms in air any more than necessary to position them because of the effect of humidity on life of the dry film lubricant.

18. If, because of a rising dew point, there is any chance of condensation in D82 when it is open, the lid should be lowered and dry nitrogen introduced through the backfill port to lower the dew point. The lid does not have to be fastened.

Warming D82

Introduction

The normal method of warming D82 is by the controlled electrical heating of the insides using the normal temperature control apparatus while the dewar is being pumped. In this way, the detector is protected from contamination and the optics are not thermally shocked. The back filling of the vacuum with gas before the insides are near ambient is discouraged. Though this will speed up warming, it poses several risks: these are thermal shock, depositing condensed matter on the optics and detector, condensing water on the outside of the window, and loading the getter.

A minimum of 4 days should be scheduled for warming at full current. The suggested reduced current will take a day or so more.

Special Preparations

None

Procedure

Put the preslits (PSI and PSO), the slits and slit mask (SLS and SLM) in the down position.

Make sure that the pumping system is on auto or turned on (See Evacuating D82 instructions).

Turn off the cold heads, either manually or by computer (See cryogenic operations).

Turn the current control on the Kepco power supply 1 turn CCW from full CW for less violent heating. fully CW for fastest heating.

Set the temperature controller to ramp at 0.1 K/min, record the set points, and then set the set points to a target of 295 K.

Check that the outputs on loops 1 and 2 increase as the set points rise above the controlled temperatures.

Check that the controller alarms when the temperature goes past the alarm point and also that the pumps turn on if on automatic (the normal vacuum controller setting).

Wait until the camera temperature reaches 3 degrees above ambient before setting the set points on the temperature controller back to their original setting. They will now ramp down.

Make sure that D82 is setup for back filling (See "Back filling D82").

The pump can now be turned off. After the solenoid valve is closed the dewar should be back filled with dry N2 starting as soon as possible but certainly within the hour. (See "Back filling D82")

Wait for at least 8 hours before opening (See "Back filling D82").

Backfilling D82

Introduction

The normal method of bringing the internal volume of D82 to atmospheric pressure is to introduce dry, clean nitrogen or argon into the vacuum space by using the back fill plumbing under the left back of the bottom plate of the vacuum shell. The gas should be introduced slowly at no more than 5 psi on the regulator on the gas supply cylinder. The reason for the slow introduction of the gas is to not stir up particulates. The backfill can take up to an hour. The hoses should be vacuum and pressure tight. Unless the gas is being used to warm the insides, which is not recommended (see Warming D82), the whole instrument should be at ambient temperature or above before back filling starts. The gas is introduced slowly from a clean rubber hose to the barbed fitting.

There are two plug valves: The first valve controls the flow to the back fill tank, and the second valve controls the gas flow into the vacuum shell. There is a 4 micrometer pore filter in series with this valve so that particulates are not introduced. The back fill tank has a 5 psi pressure relief valve on one of its ends as a safety relief and for purging the tank and line before back filling. A pressure/vacuum gage is provided to monitor the pressure between the valves.

Special Preparations

Have on hand a high-pressure cylinder of dry, clean nitrogen or argon.

Put a two stage pressure regulator that has gages on the cylinder that can regulate below 5 psi on the cylinder.

Put a clean 1/4 inch ID flexible (rubber or a material that is flexible at observatory temperatures) on the regulator. It should go on barbed fitting of the back fill tank easily.

Have a hose clamps ready for the hose where it goes on the barbed fittings.

Procedure

Check that dewar is at ambient temperature or above.

The pump controller switch should be set to off.

Check that the solenoid valve between the turbo pump and the vacuum shell of D82 is closed; the black bar in the center of the yellow cap of the solenoid valve will be flush with the cap.

Record the pressure on the gage between the valves. It should read a vacuum. If is does not, the tank might not have been pumped, or there might be a leak.

Check that both valves on the backfill line are close. The handles should be perpendicular to the line. DO NOT open them in checking!

Purge the flexible hose from the pressure regulator with gas from the cylinder.

Connect the hose to the barbed fitting on the first back fill valve. Do not pull on the fitting; the pipe connections will not take a lot of torque.

Set the regulator to read 5 psi.

Open the valve from the hose to the back fill tank.

Check that the pressure gage between the valves now reads about 5 psi.

Up the pressure on the regulator until gas comes out of the relief valve on the back fill tank.

Let enough gas escape to purge the tank.

Lower the regulator pressure until the gas stops flowing out of the relief valve.

Slowly open the valve between the back fill tank and the vacuum shell of D82 until the pressure drops to 1 psi on the gage between the valves. Note that this gage has about a 1/2 psi zero error.

As the pressure builds up in D82, the pressure on the gage between the valves will rise. The valve to the vacuum shell can be slowly opened to lower the pressure to 1 psi.

When the valve to the vacuum shell is fully opened wait till the pressure on gage reaches 3 psi and lower the regulator pressure to 3 psi. Note that there is a pressure relief valve on the bottom of D82 that will not let the pressure in D82 get much above 4 to 5 psi.

To check progress, close the valve between the flex hose to the gas cylinder and the back fill tank and check the pressure gage between the valves. If it reads more than 1-1/2 psi, D82 is above atmospheric pressure.

To make sure that D82 is slightly above atmospheric, close both plug valves and carefully disconnect the flex hose from the barbed fitting. Record the pressure on the gage between the valves. Open the valve between the back fill tank and the barbed fitting. Record the pressure on the gage which is now at atmospheric. This is zero gage pressure. If the first reading was higher D82 is above atmospheric pressure as it is supposed to be.

If D82 is not above atmospheric start the procedure again.

When D82 is at atmospheric, open both valves and let the pressure bleed to atmospheric so there is no pressure differential when the lid is unbolted.

Opening and Closing D82

Introduction

For most procedures that need access to the interior of D82, the instrument will remain fixed to its mounting pads and only the lid and radiation shields will be lifted by the hoist located above the AO room ceiling. In this procedure, the lid is lifted in stages guided by posts attached to the bottom of the vacuum shell. At each stage successive shields are unclamped and fasten to the lid with special fixtures. The lid and the three shields now nested in it remain suspended above the instrument by the hoist and are pined for safety to the posts.

Special Preparations

D82 must be at ambient temperature and pressure.

The environment should be at applicable clean room conditions.

Have at hand the proper four upright posts (normally the long square ended posts are used) and their four guide tubes.

The three sets of four shield lifting fixtures.

A straight ball end 3/16 inch hex driver for the 1/4 - 20 lid and guide bolts.

A straight standard end 9/64 hex driver for loosening the 10-24 shield screws.

A straight torque screw driver set to 20 inch-lbs. with a 9/64 hex driver bit for tightening the 10-24 shield bolts.

Procedure - Opening

Remove the acoustic skirt completely from the D82 vacuum shell bottom.

Install the four guide tubes with four posts installed in them to the sides of the D82 lid. Bolts should only be tightened lightly. Use the 3/16 inch straight ball end hex driver.

Fasten the posts to the bottom of the D82 vacuum shell.

Loosen each of the four captive lid bolts in the holes at the bottom of the guide posts completely. Use the 3/16 inch straight ball end hex driver. Do not remove them. They should move up and down freely when pushed with a finger. It is important to do this as these bolts can easily be overlooked and be ripped off when the lid is lifted.

Turn on master switch to the hoist.

Lower hoist hook to just above lid of D82 and remove spring loaded cover from hook.

Attach hoist hook to swivel eye in the center of the D82 lid and take up all but a slight bit of slack.

Turn off hoist master switch

Check that D82 is at ambient temperature or above.

Check that both plug valves at back fill apparatus are open and that dewar is at ambient pressure.

Loosen all of the captive 1/4 - 20 socket head bolts holding the lid of D82 to the bottom of the vacuum shell. Use the 3/16 straight ball end hex driver. Do not remove them. They should move up and down freely when pushed with a finger. Sight along them to make sure that they are all hanging do at the same level, including the ones in the holes in the upright posts.

Remove the snout that goes between the AO bench cover to the front of the D82 lid at the window.

Turn on the hoist master switch.

Check the lid bolts again to see that they are all hanging free.

With the hoist on low speed, lift the lid in small steps until it breaks free. If it hangs or tilts, check the bolts.

Close the plug valve on the back fill apparatus between the barbed hose fitting to air and the back fill tank.

Lift the lid so that the 10 - 24 socket head cap screws clamping the outer high temperature shield are easily accessible.

Loosen all of the outer shield screws 1 to 1-1/2 turns. Use the straight 9/64 hex head driver.

Inspect all of the screws to see that they were loosened. The Belleville washers under their heads will be cone shape.

With the hoist, adjust D82 lid so that lower ring on guide posts just clears bottom of guide tubes.

Install the four short length rod lifting fixtures on the lid. The lifting rod of each should be in the hole in the outer shield. Use the 1/4 inch ball end straight driver. Tighten the screws just snug.

With the hoist in low speed, lift the shield in small steps to see that it is free and does not cock. If it hangs or tilts, check the screws.

Lift the lid so that the 10 - 24 socket head cap screws clamping the next shield in, the inner high temperature shield, are easily accessible.

Loosen all of the inner high temperature shield screws 1 to 1-1/2 turns. Use the straight 9/64 hex head driver.

Inspect all of the screws to see that they were loosened.

With hoist, adjust D82 lid so that middle ring on guide posts just clears bottom of guide tubes.

Install the four medium length rod lifting fixtures on the lid. The lifting rod of each should be in the hole in the inner shield. Use the 3/16 inch ball end straight driver. Tighten the screws just snug.

With the hoist in low speed, lift the shield in small steps to see that it is free and does not cock. If it hangs or tilts, check the screws.

Lift the lid so that the 10 - 24 socket head cap screws clamping the next shield in, the optical bench box shield, are easily accessible.

Loosen all of the optical bench shield screws 1 to 1-1/2 turns. Use the straight 9/64 hex head driver.

Inspect all of the screws to see that they were loosened.

With hoist, adjust D82 lid so that upper ring on guide posts just clears bottom of guide tubes.

Install the four longest rod lifting fixtures on the lid. The lifting rod of each should be in the hole in the optical bench shield. Use the 3/16inch ball end straight driver. Tighten the screws just snug.

With the hoist in low speed, lift the optical bench shield in small steps to see that it is free and does not cock. If it hangs or tilts, check the screws.

Lift the lid until the 1/2 inch diameter holes on the sides of the guide tubes near their bottoms align with the slots near the top of the guide posts, so that there in no obstruction.

Shut off the hoist master switch.

Insert the four 1/2 inch diameter ball pins attached to the guide tubes all the way through the 1/2 inch holes in the tubes. The tubes are now pined to the posts as a safety in case the hoist fails to hold the lid.

Procedure - Closing

Check that the inside of D82 is in condition to close: That no cables are hanging where they can be cut, that no loose parts are left inside, and that the inside is clean.

Remove the four 1/2 inch diameter ball pins from the holes in the guide tubes and tuck them in the o-rings on the tubes.

Turn on the hoist master switch.

Check to see that all four of the ball pins were removed from the holes in the guide tubes.

With the hoist, lower the lid until the optical bench shield is just above the bench.

Using low hoist speed, lower the lid until the lower edge of the optical bench shield engages with the shield clamps around the edge of the bench.

Lower further until the slides with the pins of the four lifting fixtures holding the optical bench shield to the lid are loose and can be moved up and down by hand a little. The lines on the guide posts will be just below the guide tubes.

With the 3/16 ball end straight hex driver, remove the four lifting fixtures for the optical bench shield. Each fixture is held with four captive 1/4 - 20 socked head screws to the lid. Make sure that the correct fixtures are being removed.

Lift the lid until the 10 - 24 socked head shield clamp screws for the optical bench box shield are easy to tighten.

Using the 20 inch pound torque wrench with the 9/64 hex bit, tighten the optical bench box shield clamp screws to 20 inch pounds torque.

Check that all of the optical bench box shield clamp screws were tightened. The Belleville washers will be flat.

With the hoist, lower the lid until the inner high temperature shield is just above the inner shield bottom.

Using low hoist speed, lower the lid until the lower edge of the inner shield engages with the shield clamps around the edge of the shield bottom.

Lower further until the slides with the pins of the four lifting fixtures holding the inner shield to the lid are loose and can be moved up and down by hand a little. The lines on the guide posts will be just below the guide tubes.

With the 3/16 ball end straight hex driver, remove the four lifting fixtures for the inner shield. Each fixture is held with four captive 1/4 - 20 socked head screws to the lid. Make that the correct fixtures are being removed.

Lift the lid until the 10 - 24 socked head shield clamp screws for the inner shield are easy to tighten.

Using the 20 inch pound torque wrench with the 9/64 hex bit, tighten the inner shield clamp screws to 20 inch pounds torque.

Check that all of the inner shield clamp screws were tightened.

With the hoist, lower the lid until the outer, high temperature shield is just above the outer shield bottom.

Using low hoist speed, lower the lid until the lower edge of the outer shield engages with the shield clamps around the edge of the shield bottom.

Lower further until the slides with the pins of the four lifting fixtures holding the outer shield to the lid are loose and can be moved up and down by hand a little. The lines on the guide posts will be just below the guide tubes.

With the 3/16 ball end straight hex driver, remove the four lifting fixtures for the outer shield. Each fixture is held with four captive 1/4 - 20 socked head screws to the lid.

Lift the lid until the 10 - 24 socked head shield clamp screws for the outer shield are easy to tighten.

Using the 20 inch pound torque wrench with the 9/64 hex bit, tighten the outer shield clamp screws to 20 inch pounds torque.

Check that all of the outer shield clamp screws were tightened.

Check the o-ring that seals the lid to the bottom. It should not be greased. Make sure that there is no contamination in the groove or on the o-ring.

Lower the lid until it is one inch above the bottom of the vacuum shell.

Check that the temperature and heater cables are dressed away from the seat for the lid.

Using low speed, lower the lid until it seats and the hoist hook is loose.

Turn off the hoist master switch.

Using the 3/16 ball end straight hex driver tighten the lid screws lightly.

Go around and tighten them until they are snug and the lid is flush with the bottom. DO NOT tighten them hard.

Check to see that the lid bolts in the holes in the bottom of the guide posts are also tight.

Turn on the hoist master switch.

Remove the hoist hook from the lid.

Attach the hoist hook to the spring-loaded cover for the hole in the roof.

Raise the cover until the spring pulls the cover against the roof.

Turn off the hoist master switch.

Replace the snout that goes between the AO bench cover to the front of the D82 lid at the window.

Remove the guide tubes and posts from D82.

Return the four guide tubes, four guide posts (there should be four unused) and 16 lifting fixtures to their boxes.

Replace the acoustic skirt around the bottom of the vacuum shell of D82.

Evacuating D82

Introduction

D82 has its own vacuum system complete with automatic controller. The system consists of an electrically operated solenoid valve on which a turbo pump is mounted. The solenoid valve is mounted to the bottom of the D82 vacuum shell along with two full range vacuum gages. The turbo pump is connected to a oil-less roughing pump on the floor under D82 by a short length of vacuum line. The turbo pump controller is in a chassis also under D82 along with the automatic controller. The turbo pump controller also reads out one of two full range vacuum gages; it can swapped with the other gage in case of malfunction.

The auto controller is on generator power so it will operate in case of main power failure. It controls and powers all of the D82 vacuum equipment. Pumping is normally done in automatic mode after closing the plug valve to atmosphere from the back fill tank. Since the inside of D82 is at ambient the temperature, the temperature controller will give a high temperature alarm which will activate the vacuum pump automatic controller when it is in automatic mode. In fact, any time the temperature exceeds the high temperature set point of the temperature controller the pumps will automatically come on and only go off after the alarm is reset. IF AND ONLY IF D82 is at ambient pressure, the switch under the red protective cover on the automatic controller chassis should be pushed and held while the controller is switched to auto or on. This opens the solenoid valve and delays the start of the turbo pump. The solenoid valve is opened so that there is not a burst of air into the pump from D82 that could stir up any particles. The start of the turbo pump is held off for three hours so that the turbo does not over heat during the time that the pressure is well above the pressure at which the turbo can get to full speed. In all cases, if the turbo is not up to speed in five hours, or if it falls below speed, or if there is a failure, then the solenoid valve will close and the turbo will shut down. This is a safety feature to prevent air flowing back into the vacuum space. This is especially important when the instrument is at cryogenic temperatures.

The vacuum should be pumped for at least 1/2 day and the pressure should be below 1E-2 mbar before turning on the cold heads. Pumping for 24 hours or more is desirable. After cooling , the getter should bring the pressure to about 1E-7 mbar or below. There is no need to heat or change the getter.

When the dewar is being warmed, the controller should be left on auto (it can be turned to on, but that is unnecessary) so that the vacuum is maintained. This protects the detector and optical elements from contamination in case of an unanticipated warm up.

Special Preparations

None.

Procedure

If D82 is at atmospheric pressure and has been worked on, check that all the lid bolts are firmly tightened, that the window, vacuum gages, pumps, etc. are properly in place.

Check to see that the generator light is lit on the vacuum controller.

The DCU can be set to auto or on; the pumping will start in either case after the following steps.

IF AND ONLY IF D82 is at atmospheric pressure, close the valve (handle perpendicular to the line) from the back fill tank to the outside atmosphere (the barbed hose fitting), and open the valve (handle parallel to the line) from the back fill tank to the vacuum shell. This allows the back fill tank to be evacuated.

IF AND ONLY IF D82 is at atmospheric pressure, push and hold the momentary switch under the red safety shield while turning the controller switch from off to automatic (it can be turn to on, but this is not necessary if the temperature controller alarm is activated). When the DCU initializes if it is on auto, or immediately if it is on, the solenoid valve should open (there will be a bang and the black bar on the yellow end of the valve should stick out) and the fore pump will start.

IF AND ONLY IF D82 is below atmospheric pressure and at cryogenic temperatures, DO NOT push the switch under the red safety shield. Doing so can allow air back into the dewar. Heating the dewar above the alarm temperature will automatically start the pumps if the controller is on auto; turning the controller to on will also start the pumps. The solenoid valve should open within ten minutes. There is a five minute delay after the turbo pump gets up to speed before the solenoid valve opens.

By pushing the select arrows (Do not push both at the same time as this can cause an unwanted change in the parameters!) on the DCU, parameter 340, the pressure read out, can be accessed.

If D82 started out at atmospheric pressure and ambient temperature, the pressure should be below 1E-1 mbar 5 hours after pumping has started, and below 1E-2 mbar after 24 hours. Suspect a leak or defective pumping system if these pressures are not close to being achieved.

Anytime after the pressure is below 1E-2 mbar and before turning on the cold-heads, check the valve between the back fill tank and the vacuum shell and close (handle perpendicular to the line) it. Also check that the valve between the backfill tank and outside atmosphere is also closed (handle perpendicular to the line)

The cold heads can be turned on (See "Cooling D82") when the vacuum has reached the desired state. Note that the pressure will never fall much below 1E-3 mbar at ambient temperature.

The pump controller should be set to automatic for normal operation and the generator light should be on.

When the temperature is below the high temperature alarm set point, the alarm can be reset. This should cause the solenoid valve to shut (the bar on the yellow end of valve should retract to be flush) and the pumps turn off. If the DCU is set to auto, it will turn off and only turn on when the alarm triggers the controller; if set to on, it will remain on and the vacuum gage can be read. There is normally no reason to leave it on.

The DCU can be switched to on and parameter 340 selected with the DCU arrow keys at any time that the pressure is to be read.

Cooling D82

Introduction

D82 is cooled by two CTI cold heads, a single stage head (cold head 1) which is used to cool the outer shields to about 120 to 150 K, and a two stage head (cold head 2) the first stage of which cools the optical bench and the assemblies on it to about 50 K while the second stage cools the detector to about 29 K.

Both heads are speed controlled so that they can be run at high speed for fast cool down and then set to slower speeds that are adequate for maintaining operating temperatures. The advantage of low head speed is reduced vibration, prolonged cold head life and reduced gas flow from the compressor through the oil separator. The speed of each heads can be adjusted either by computer or by manually setting its dial on the cold head controller.

The nominal cool down from ambient is done by setting both heads to 72 RPM and running them for about two days, at which time, the shield temperature should be about 120 K and the optical bench temperature about 180 K. The speed of the single stage head can now be lowered to 30 RPM. After a total of about 4 1/2 days, the first stage of the two stage cold head should have reached at temperature of 50 K and loop 2 of the temperature controller should indicate that it is putting out some voltage to control its temperature. At this point, speed of the two stage head can be lowered to 24 RPM and that of the single stage head to a speed that will keep the shield below 150 K (27 RPM in Jan 2001). The optical bench will be below 60 K at this point. From this point on, the shield temperature (tshield) and the heater voltage for the first stage of the two stage cold head (htrhead2hi) should be monitored for degradation in coldhead performance.

If faster cooling is needed, the heads can be run at a maximum speed of 84 RPM. In general, this should not be done since it decreases lifetime and does not speed up cool down very much, maybe 15%,

Special Preparations

Make sure that D82 is under vacuum.

Make sure that the back fill tank is evacuated.

Make sure that both valves to the back fill tank are shut (handles turned perpendicular to the valve)

Procedure

Start logging temperatures.

If the compressor and NIRC2 chassis in the mechanical room are running, and the head were turned off by computer, skip to "Set the speed for both cold heads …"

Turn on cooling water to CTI 9600 compressor in mechanical room.

Check that the 2 CTI frequency converters are properly connected.

Check that the NIRC2 Coldhead Control chassis is properly connected.

Check that the NIRC2 Filter / Computer Interface chassis is properly connected.

The heads should have been turned off previously, either manually or by computer.

Set the speed for both cold heads, either manually or by computer, to 72 RPM.

Turn on compressor if it is not already on.

Turn on the cold heads, either manually or by computer.

After two days, set the single stage cold head (head 1) speed to 30 RPM; the shield temperature (tshield, channel 8 on the Lake Shore Model 218) should be about 120 K.

After 4 1/2 days, set the two stage cold head (head 2) speed to 24 RPM; The cold head first stage (thead2hi, A on the Lake Shore Model 240) should read 50 K the loop 2 set point and loop 2 should be above 0% output. At this point, the speed of the single stage head can be further lowered to a speed that will keep the shield below 150 K (27 RPM in Jan 2001). The optical bench should be below 60 K and normal mechanism operation can commence.

Installing and Removing Grism or Pupil Imaging Lens Holder

Introduction

Each grism or pupil lens holder mounts to the interface plate on the grism stage table with three captive 6-32 socket head cap screws with two Belleville washers under each of their heads. The screws go through 3 pads on the holder which form the mating plane with the interface plate, while the in plane position and rotation are defined with one round pin and one diamond pin (both in the interface plate) that mate with holes in the holder. Some holders have two posts on top that act as handles. These handle must be short enough to clear the detector head mount when the table of the grism stage is translated.

The position on the left of the table (when looking out of front of D82) is special, in that the screw spacing is narrower than for the others, and that a modified 7/64 angle hex key might be needed to turn it. The other screws need a long shank 7/64 hex driver; a long ball end is ideal. At delivery, the pupil reimaging lens holder was in the position on the left with the narrow screw spacing.

Special Preparations

Position the grism stage so that a holder's position that has to be accessed is clear of the detector head mount. It is better if this is done under vacuum, cold or warm, before lid is opened, using the drawings as a guide. The dry lubricant on the roller screws has a significantly shorter lifetime in air.

A long shank 7/64 hex driver should be at hand; a long ball end is ideal.

If the left most position is to be worked on, a 7/64 angle hex key with the short end shortened as much as practicable might be needed.

Full clean room dress including hat, mask. and gloves should be used.

Procedure - removing

Loosen the three captive screws part way with the 7/64 hex wrench.

Back them off till the holder is detached from the plate. Do not remove them from the holder.

Pick up the holder using the posts or two 1/4 -20 screws in the case of the lens holder.

Procedure - installing

Make sure that the captive screws with the two Belleville washers are in the feet and free.

Put the holder on the plate making sure the pins engage and screw in all three captive screws till they engage a bit.

Go around and tighten them till the Belleville washers are flat.

If loose screws were used for handles, as in the pupil re-imaging lens holder, remove them.

Check that the handles on the holder will not hit by sighting along the bottom of the detector head mount.

Installing and Removing Filter Holders from the D82 Filter Wheels

Introduction

Both the inner (FWI) and outer (FWO) filter wheels in D82 have 18 positions (one of which has a clear through baffle) which are designed to take special filter holders. There are square cover plates on both the front and back of the filter wheel assembly near the left side of D82 that allow access to the fill hole for the filter positions in the filter wheels. Each plate is held with four 2 - 56 x 3/16 socket head cap screw with a Belleville washer under each of their heads. A straight hex driver should be used to remove these screw and great care taken not to drop them or the washers.

The filter positions are numbered from 0 to 17 CCW looking into the fill hole of either wheel. These numbers are marked in pencil on the wheel. For FWO, when position N is in the fill hole position (N + 7) modulo 18 is in the beam at the optical axis, while for FWI, when position N is in the fill hole position (N - 7) modulo 18 is in the beam. Remember this is for the 0 to 17 numbering system of the physical wheels. The computer numbering was 1 to 18 at delivery.

Often, the filters will be tilted in their holders to eliminate ghosts. When in the beam on the optical axis, they should be tilted about the vertical axis so the filter is tilted into the filter wheel at its outside edge. The axis of rotation of the tilt is 20 degrees to the tangent to the circle on which the filter centers lie in the FW. For FWO, the angle is 20 degrees CCW, while for FWI the angle is 20 degrees CW. This is because a filter is 20 degrees above horizontal from the center of the filter wheel when it is in the beam on the optical axis. Each loading hole has a mark outside of it indicating the position of where a tilted filter's lowest point should be positioned in the wheel when its holder is installed. This mark is 40 degrees above the horizontal toward the left of the optical bench. Because of the crazy way the screw holes were laid out, they are not at the same orientation with respect to a radius to the center of each position, but an orientation that repeats every three positions, so that a tilted filter has to be loaded in its holder for a specific set of six filter holder positions in each wheel (18 positions / 3 types = 6 positions per type).

There is an installation fixture to which the filter holders are screwed with two 0-80 x 1/2 socket head cap screws. Six 0-80 x 1/4 Long-Lok flat head screws are put in the holder holes through the holes in the installation fixture so that they do not have to be handled over the D82 optical bench. The holder is inserted into the fill hole in the filter wheel assembly using the installation fixture as a handle. If the orientation of the holder is important, the mark on the holder should be oriented properly with respect to the mark near the fill hole for the filter wheel. The orientation should be determined form the filter installation documentation. The six flat head Long-Lok screws are then tightened to attach the filter holder to the filter wheel. The two socket head screws fastening the installation fixture to the filter holder are then unscrewed from the filter holder and the installation fixture removed. Care must be taken that the installation fixture plate is kept in the position that keeps the screws captive to prevent the screws from being accidentally dropped in D82.

The cover plate for the fill hole is reinstalled in the reverse of its removal. It is very important that the screws be tightened only enough to compress the Belleville washers. Their engagement is very small, and the threads can easily be stripped.

Special Preparations

Have at hand the filter installation fixture with its two 0-80 x 1/2 socket head screws. The fixture should be clean; dust and oil free.

Filter holders to be installed should be on hand, ready to go in the filter wheel.

A straight .050 hex driver for fastening the installation fixture to a filter holder with the 0-80 x 1/2 socket head screws.

A straight 5/64 hex driver for removing and reinstalling the four 2-56 x 3/16 socket head cap screws on each fill hole cover plate on the filter wheel assembly.

A straight screwdriver with a .090 to .100 wide blade for tightening the six 0-80 Long-Lok screws that hold each filter holder in a filter wheel. The shank must be narrow and long enough to fit the installation fixture: 0.100 diameter maximum and 1.1 long.

Six 0-80 x 1/4 flat head Long-Lok screws for each filter holder that will be installed. These screws should be checked for burrs by starting the in a nut or threaded hole. Often times this type of screw has burrs sufficient to damage the thread in an aluminum filter wheel.

Optical wipes

Clean dry nitrogen for dusting off the filters.

Full clean room dress including hat, mask. and gloves should be used.

Procedure - Removing

Position the filter wheel to be accessed so that the filter holder is aligned with the fill hole. The can be done by using computer commands to position the wheel, or by using engineering commands to release the motor brake and set the error term to zero, if it is not already at zero, and then moving the wheel by turning the shaft by hand and reading the motor counts.

Using the straight 5/64 hex driver, remove the cover plate over the fill hole. Be careful not to drop the Belleville washers.

Check that the filter holder is accurately centered in the fill hole.

Insert the installation fixture so that the two 0-80 socket head fastening screws line up with the two clearance holes in the cover of the filter holder.

Using the straight .050 hex driver, screw the installation fixture to the filter holder. Tighten till it is just touching but not tight.

Using the straight .090 to .100 blade screwdriver, undo the six 0-80 flat head screws that hold the filter holder to the filter wheel. Do not try to remove the screws from the installation fixture, but let them stay in it.

After all six of the screws are loose, pull the filter holder out using the installation fixture as a handle.

Move the installation fixture with the filter holder to a clean bench before separating them by unscrewing the two 0-80 socket head fastening screws with the .050 hex driver.

Make sure to remove all of the six 0-80 flat head screws used for holding the filter holder to the filter wheel from the installation fixture.

After removal and insertion of filter holders is done. Replace the cover using the straight 5/64 hex driver to reinstalling the four 2-56 x 3/16 socket head cap screws with one Belleville washer under each head in each fill hole cover plate on the filter wheel assembly. Tighten ONLY enough to flatten the Belleville washers.

Check that the filter wheel turns freely. This is best done by hand turning the shaft by hand with the motor brake off and the error term set to zero.

Procedure - Installing

In a laminar flow bench. Check that the two 0-80 x 1/2 socked head cap screws are in the installation fixture.

Align the installation fixture so that the two 0-80 socket head fastening screws line up with the two clearance holes in the cover of the filter holder. If the filter holder has an alignment mark (needed if the filter is tilted), align it with the mark on the installation fixture.

Using the straight .050 hex driver, screw the installation fixture to the filter holder. Tighten till it is just touching but not tight. Check that these screws are the correct length and not protruding.

Insert six 0-80 x 1/4 (the length is critical) flat head Long-Lok screws in the six holes of the installation fixture, and rotate the cover plate to captivate these six screws as well as the two 0-80 socket head cap screws.

Position the filter wheel to be accessed so that the filter holder is aligned with the proper filter wheel hole. This can be done by using computer commands to position the wheel, or by using engineering commands to release the motor brake, and set the error term to zero if it is not already at zero, and then moving the wheel by turning the shaft by hand and reading the motor counts.

Using the straight 5/64 hex driver, remove the cover plate over the fill hole. Be careful not to drop the Belleville washers.

Check that the hole in the filter wheel is accurately aligned with the fill hole in the filter wheel assembly.

Insert the filter holder it the filter wheel hole using the installation fixture, making sure that the first screw hole clockwise of the alignment marks on the installation fixture and filter holder is aligned closest to the mark on the outside of the fill hole in the following manner.

For the inner filter wheel (FWI)

Filter positions 0, 3, 6, 9, 12, 15, ; screw hole 20 degrees counterclockwise from the mark.
Filter positions 1, 4, 7, 10, 13, 16, ; screw hole 0 degrees from the mark.
Filter positions 2, 5, 8, 11, 14, 17, ; screw 20 degrees clockwise from the mark.

For the outer filter wheel (FWO)

Filter positions 0, 3, 6, 9, 12, 15, ; screw hole 20 degrees clockwise from the mark.
Filter positions 1, 4, 7, 10, 13, 16, ; screw hole 20 degrees counter clockwise from the mark.
Filter positions 2, 5, 8, 11, 14, 17, ; screw hole 0 degrees from the mark.

Using the straight .090 to .100 blade screwdriver inserted into the holes in the installation fixture, start the six 0-80 flat head screws that hold the filter holder to the filter wheel. Do not force them if they do not engage easily. Rotate the holder slightly back and forth and check the centering of the insertion fixture.

Only after all six screws are started, screw them in until they are just snug.

Tighten the six screws firmly.

Go around the six screws again to check that all are tight.

Using the straight .050 hex driver, unscrew the installation fixture from the filter holder very slightly.

Vacuum the holes of the fixture

Unscrew the screws all the way and remove the installation fixture from the fill hole.

Vacuum the hole to remove and remaining debris, and check that nothing is on the surface of the filter.

Check by eye that all of the 0-80 flat head screws are flush, so the filter wheel will turn freely. Check that the filter number is correct.

After removal and insertion of filter holders is done. Replace the cover using the straight 5/64 hex driver to reinstalling the four 2-56 x 3/16 socket head cap screws with one Belleville washer under each head in each fill hole cover plate on the filter wheel assembly. Tighten ONLY enough to flatten the Belleville washers.

Check that the filter wheel turns freely. This is best done by hand turning the shaft by hand with the motor brake off and the error term set to zero.

Installing and Removing Filters from the Filter Holders

Introduction

Both the inner (FWI) and outer (FWO) filter wheels in D82 have 18 positions (one of which has a clear through baffle) which are designed to take special filter holders.

The filter positions are number from 0 through 17 CCW looking into the fill hole of either wheel. These numbers are marked in pencil on the wheel. For FWO, when position N is in the fill hole position (N + 6) modulo 18 is in the beam at the optical axis, while for FWI, when position N is in the fill hole position (N - 6) modulo 18 is in the beam. Remember this is for the 0 to 17 numbering system of the physical wheels. The computer numbering was 1 to 18 at delivery.

The filter holders are mechanically identical on the outside. Some of them have slightly different inside diameters. They have a cover ring to hold the filters in the well of the holder. The excess space the well is filled with spacing rings, one of which might be wedged to tilt the filter and a curved spring spacer to take up any looseness. The ring is held with six 0-80 x 1/8 flat head Long-Lok screws. It also has an alignment spot and two clearance hole for screws that will hold the body of the filter holder to the installation fixture.

Often, the filters will be tilted in their holders to eliminate ghosts. When in the beam on the optical axis, they should be tilted about the vertical axis so the filter is tilted into the filter wheel at its outside edge. The axis of rotation of the tilt is 20 degrees to the tangent to the circle on which the filter centers lie in the FW. For FWO, the angle is 20 degrees CCW, while for FWI the angle is 20 degrees CW. This is because a filter is 20 degrees above horizontal from the center of the filter wheel when it is in the beam on the optical axis. Because of the crazy way the screw holes were laid out, the pattern on which they are laid out is not at the same orientation for each filter holder position in the filter wheel, but one that repeats every three positions, so that a tilted filter has to be loaded in its holder for a specific set of six positions.

There is an installation fixture to which the filter holders are screwed with two 0-80 x 1/2 socket head cap screws. Six 0-80 x 1/4 Long-Lok flat head screws are put in the holder holes through the holes in the installation fixture so that they do not have to be handled over the D82 optical bench. The holder is inserted into the fill hole in the filter wheel assembly using the installation fixture as a handle. If the orientation of the holder is important, the mark on the holder should be oriented properly with respect to the mark on near the fill hole for the filter wheel. This orientation should be recorded in the filter installation documentation

Special Preparations

A laminar flow clean bench with normal lens cleaning paraphernalia.

Full clean room dress including hat, mask. and gloves should be used.

A straight screwdriver with a .090 to .100 wide blade for tightening the six 0-80 Long-Lok screws that hold a filter holder cover on a filter holder. The shank must be narrow and long enough to fit the installation fixture: 0.100 diameter maximum and 1.1 long.

Six 0-80 x 1/8 flat head Long-Lok screws for each filter holder cover that will be installed. These screws should be checked for burrs by starting the in a nut or threaded hole. Often times this type of screw has burrs sufficient to damage the thread in an aluminum filter holder.

Jelly ROLL Pen, Sakura/Japan - silver or gold.

Pentel Milkey gel roller K106 pen - white

Installing

The filter holder cover should have a spot hole with a white dot of paint in it. This is the fiducial mark. This is important only if the filter is tilted or the orientation is otherwise important.

The flange of the filter holder should have a dot painted with the Jelly ROLL Pen on the top and side of its flange as fiducial marks. These should be at the same alignment as the dot on the cover when all of the holes match up. Because of the clearance holes, there are only two possible correct orientations with the countersinks out. This is important only if the filter is tilted or the orientation is important.

The flange of the filter holder should have the filter number (Fnnn) painted both on the top and side of the filter holder flange with the Jelly ROLL Pen. These can be removed with ethanol. The filter cover has special black paint, so it should not be written on. The holder is black paint on the surface opposite to the flange.

The normal alignment procedure uses the first hole in holder clockwise from the fiducial mark as the position from which the alignment of the holder in the wheel is determined. When the holder is in the wheel and the filter is on the optical axis the position to the filter toward the outside of the wheel on the horizontal through the filter center will should be as follows:

For the inner filter wheel (FWI)

Filter positions 0, 3, 6, 9, 12, 15, ; horizontal out is 20 degrees clockwise from the hole.
Filter positions 1, 4, 7, 10, 13, 16, ; horizontal out is 0 degrees from the hole.
Filter positions 2, 5, 8, 11, 14, 17, ; horizontal out is 20 degrees counter clockwise from the hole.

For the outer filter wheel (FWO)

Filter positions 0, 3, 6, 9, 12, 15, ; horizontal out is 20 degrees counter clockwise from the hole.
Filter positions 1, 4, 7, 10, 13, 16, ; horizontal out is 20 degrees clockwise from the hole.
Filter positions 2, 5, 8, 11, 14, 17, ; horizontal out is 0 degrees from the hole.

If the filters need to be tilted, then a 3 degree wedge spacer (CIT 601035) should be the first thing inserted into the filter holder with its thinnest portion to the horizontal outside of filter wheel direction for the intended filter position indicated above.

If there will be room, insert a .010 black PTFE spacer.

Insert the filter and another .010 black PTFE spacer.

Then insert aluminum spacers and a bronze spacer bent slightly in a U to act as a spring. It is best to have the thickest spacer to the outside and the spring in between the spacers if possible. There should be at least .005 clearance with the spring spacer flattened.

Put the cover on with the fiducial marks matching. and screw it down with six 0-80 x 1/8 Nyloc flathead screws. Tighten the screws firmly and check that the do not protrude above the cover or through the flange.

Replacing a Window

Introduction

The windows are mounted in assemblies in the front of the D82 lid. The central large window is CaF2 while the two small target windows are glass. They are held by flanges that press them against O-rings. It is not necessary to use any lubricant on the o-rings. It is very important to use the correct length screws. This is especially true in the wall of the lid, where the holes almost go through and force from a screw bottoming could compromise the vacuum integrity of the wall.

Since the front of the lid is so close to the AO bench cover, the easiest way to access the windows is to lift the lid and turn it around to the back of the dewar.

Because of the geometry, the best way to extract a window from its assembly in the lid is with a vacuum cleaner.

Special Preparations

D82 should be ready to open. The proper posts to put in the guide tubes are the short pointed ones.

There must be a straight ball end 3/16 inch hex driver or the 1/4 - 20 lid and guide bolts at hand. If only a window is to be removed.

A straight 9/64 inch hex driver for the main window cover flange or its holder, or for the target window holders.

A straight 3/32 in hex driver for the target window cover flange.

Lint free optical wipes.

Vacuum cleaner with nozzle to pull window out.

Clean dry nitrogen gas to blow of any dust.

Procedure

Go as far in the "D82 Opening and Closing section, Procedure - Opening" as closing the plug valve.

Instead of unclamping a shield, lift the lid until its bottom clears the top of the cover for the AO bench and the ends of the posts are clear of the bottom of the guide tubes.

Rotate the lid 180 degrees so that the front faces the back of D82.

Lower the lid slowly until all four pointed posts engage in the guide tubes.

Lower the lid down until it is about an inch above the bottom of D82.

Using the slow speed of the hoist gently lower the lid until it is resting on the bottom of D82.

Turn off the hoist master switch.

Back off the six screws that hold the window cover ring (the inner bolt circle) but do not remove them. They all should be held with about one to two turns of threads.

With the vacuum cleaner wand, with a clean optical wipe rubber banded or taped to it over its end and a hole poked in the middle, turn on the vacuum and pull the widow forward with the suction.

The flange can now be remove and the widow grabbed by its edges. Clean powder free rubber clean room gloves are best for this. Watch out; the window can fall out when the flange is removed. Leave the o-ring if it stays in is groove.

If the o-ring is clean, it does not have to be disturbed, otherwise it should be cleaned and reinserted into its groove.

A clean widow should be slid into is pocket until it rests against the o-ring. Make sure that there is no lint on the o-ring contact surfaces.

Replace the cover ring and tighten the screw until they just touch.

Tighten all screws in a crisscross manner one half turn at a time until they are tight. The calcium fluoride window is very brittle.

Turn on the hoist master switch.

Lift the lid until its bottom clears the top of the cover for the AO bench and that the posts are clear of the guide tubes.

Rotate the lid 180 degrees so that the front faces the back of D82.

Lower the lid slowly until all four pointed posts engage in the guide tubes.

Continue in the "D82 Opening and Closing section, Procedure - Closing" at the step for checking the o-ring for the lid.

Replacing or Repairing a Cold Head

Introduction

There are two CTI-Cryogenics model 1050 cold heads mounted under the bottom of D82: a single stage cold head mounted in the middle that cools the outer shield bottom, and a two stage cold head, the high temperature stage of which cools the optical bench while the low temperature stage cools the detector head.

During normal operation, adequate cooling is provided by running these coldheads at between 1/3 and 1/2 their normal factory operating speed of 72 RPM. This greatly increases the service interval by reducing the rate of wear of the internal seals and bearings. As the seals wear and start to allow He gas to be bypassed, the cooling efficiency decreases. This can be compensated up to a point by increasing the speed of the head motor. However, higher speed will produce faster wear, demanding ever-higher speed. For this reason, the coldheads will have to be serviced after a number of years. The low head speed also decreases the He gas flow through the oil separator in the compressor. The high pressure gas bypass in the compressor comes before the oil separator, so only the gas actually going to the coldheads goes through the oil separator. The other problem that can occur is catastrophic failure of either the coldhead or the compressor. A compressor failure can contaminate the whole system with oil necessitating a full clean up of the heads.

After removing the lead hangers and their earthquake protection (if they are mounted) and casting off the electrical and He lines, the head may be removed or serviced in place. It is strongly advised that a jacking fixture be constructed that will allow the head to be lowered and lifted in a true vertical direction in a controlled manner. The cold finger extension should not be allowed to swing sideways inside D82.

A cold head can be disassembled in palace such that only the cold finger remains attached to the bellows and the motor assembly and displacer are removed. With this method of refurbishment, the vacuum does not have to be broken, though the temperature does have to be brought to ambient so that no condensation forms in the cold finger well. The refurbishment of the head in the field is not supported by CTI, but parts are available to educational institutions, and second party vendors like Austin sell repair kits. The Berkeley and Caltech radio groups routinely rebuilt the cold heads in place. They have decades of experience. Normally the stainless steel cold finger tube lasts for decades. If this avenue of repair is contemplated, a study of its viability should be done well in advance of it being needed. It is advised that spare heads be

available in case there are problems with rebuilding. Though the vacuum does not have to be broken for in place servicing, the cold head support plate should be blocked on both sides with .250 "C" washers so the cold head well and internal copper plate with the cold straps does not swing.

The removal of a complete cold head including the cold finger requires D82 to be opened. The removal of the single stage cold head does not require any of the shields to be lifted with the lid; the two-stage head requires the two high temperature shields to be lifted but not the optical bench shield.

A copper block clamps around copper boss attached to the end of the low temperature stage (second stage), of the two stage cold head. This block is clamped with one 1/4 inch socket head screw that must be loosened with a long straight hex driver to keep the block from turning. The high temperature (first stage) of the two stage cold head, and the single stage cold head are attached by split copper clamps having captive screws to their respective copper plates. Indium sheets and wire are used with these to improve the thermal conductivity of the contacts. There are split box radiation shields that cover the copper plates. They attached to the bottom of the high temperature radiation shield bottom. These shields have key holes so that there fastening screws do not have to be removed but just loosened.

Special Preparations - Coldhead Disassembled in Place

Eight .250 thick C washers.

CTI wrenches to remove He lines.

Hex wrenches to remove lead hanger restraints and earthquake restraints (if mounted).

Jacking fixture for coldhead. This is not a supplied item and will have to be designed and fabricated.

Rebuild kit.

Tools to disassemble the coldhead. Note that the hex head screws that hold the motor and displacer unit to the cold finger well fastened to D82 might need specially modified hex wrenches to access them with the head in place.

Cleaning supplies for inside coldhead, as required.

Valves, pumps, and He gas to bleed down the coldhead and recharge head and lines.
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Special Preparations - Coldhead Removing and Replacing

Eight .250 thick C washers.

CTI wrenches to remove He lines.

Hex wrenches to remove lead hanger restraints and earthquake restraints (if mounted).

Jacking fixture for coldhead. This is not a supplied item and will have to be designed and fabricated.

Items in "Back Filling D82 - Special Preparations".

Items in "Opening and Closing D82 - Special Preparations".

Spare Coldhead.

7/64 hex wrench for removing and attaching the copper post on the top of the two stage coldhead.

9/64 hex wrenches of various configurations to access cold head to bellows flange mounting screws.

3/32 hex wrenches to loosen cold head shield screws.

3/16 hex bit for 1/4 inch drive.

3/16 ball end hex bit for 1/4 inch square drive.

1/4 inch drive extension about 10 inches long.

1/4 square drive ratchet wrench.

1/4 square drive adjustable torque wrench, with torque to 150 in-lbs and small fixed head.

Long tweezers to pick up things accidentally dropped into the coldhead bellows in the D82 bottom.

Inspection mirror.

1/4 mill MLI to wrap the cold head first stage cylinder.

Aluminized Mylar tape for holding MLI.

Sheets of .005 indum.

Roll of .030 indum wire.

Tube of Apeizon N grease.

Procedure - Removing or Disassembling

Warm D82 following "Warming D82" instructions.

Remove the acoustic skirt.

Block the support plate on both sides with .250 "C" washers around the 1/4 threaded rods in the four restraining posts. The nuts do not have to be tightened as they are very hard to get to.

Remove the lead hanger earthquake restraints if they are mounted.

Remove the lead and lead hangers if they are mounted.

Remove the cold head electrical connection.

Remove the cold head He line connections.

Install jacking fixture that will be used to lower the head or its innards if it is to be disassembled in place.

If the motor and displacer are to be remove with the cold finger in place, the rebuild instructions should be followed (No rebuild instructions are supplied in this document). Remember that the inside of the head is at

high He gas pressure. The screws holding the head together might be considered hard to access, especially those near the motor.

If the head was rebuilt in place, skip to the step in "Replacing a Coldhead" where the jacking fixture is removed.

Backfill D82 following the instructions in "Backfilling D82".

Open D82 following the opening instructions in "Opening and Closing D82". If the single stage coldhead is to be changed, none of the radiation shields needs to be lifted with the lid. If the two stage coldhead is to be changed, then both of the high temperature shields, but not the optical bench shield need to be lifted with the lid.

If the two stage coldhead is to be removed, loosen the 1/4-20 socked head clamp screw for the copper block that attaches to the post on top of the second stage of the coldhead. Use the straight 3/16 hex bit on the 1/4 drive extension. Loosen the screw sufficiently, so that the clamp can be broken loose by rotating it a bit about the post using the wrench in screw head as a lever. When the cold head is lowered, the block will be constrained by the four containment screws in the bench.

Remove the split shield that goes around the tube of the coldhead. The shield is fastened to the bottom of the outer high temperature shield with 4 - 40 socket head cap screws that go through key holes in the shield. This allows the shield to be removed without removing the screws and the washers on them. The screws should be loosened a few turns but not removed using a 3/32 hex wrench. There are eight screws for the shield of the two stage coldhead and 20 screws for shield of the single stage head. The shields can be slid so the screws go through the keyholes. Be careful of the temperature sensor wires and the heat straps for the single stage if it is the one being worked on.

Remove the split copper clamp ring holding the coldhead flange to the copper block. For both coldheads, this is accessed under the bottom of the high temperature shields. Each half of the clamp is fastened with 8, 1/4 - 20 captive socket head cap screws. There is indium between the clamp and the copper block so the clamp ring halves might stick to the block. Use a 3/16 hex wrench to loosen the screws. Do not remove them from the clamp ring halves. There is indium between the clamp ring and the coldhead flange so that the ring halves might also stick to coldhead flange. A thin layer of Apiezon N grease has been use as a parting agent, so the flange, clamp ring, and block should separate without too much trouble.

Check to see that the block on the lower flange is free, and on the two stage coldhead, check that the clamp block on the upper stage is also free.

With the lowering fixture holding the coldhead, remove the 8 screws holding the coldhead to the bellows under the bottom of D82.

Lower the coldhead down vertically using the lowering fixture. Note that the o-ring at the bellows might stick slightly. Its groove is in the bellows, so it might fall after the coldhead is lowered. The copper blocks will be stopped by their containment screws. On the two stage coldhead, make sure that the block on the upper stage is sliding off freely.

Remove any remaining indium from the copper block and clamp ring halves.

Procedure - Replacing

If the two stage coldhead is being replace with a new one, the copper post on the top of the second stage should be transferred to the new coldhead. This is fastened in six places with 6-32 x 1/2 ss socket head cap screws with 4 Belleville washers and an AN washer. There is a sheet of .005 inch thick indium between it and the top of the cold head. A thin layer of Apiezon N grease should be on the bottom of the copper post

as a parting agent. A new sheet of indium will probably have to be used. The screws should be tightened so that the Belleville washers are flattened, and the retighten after an hour or so.

Cut an .005 inch thick indium ring to go on the coldhead flange that will be in contact with the copper block. Also cut two .005 inch thick indium ring halves to go between the copper clamp ring halves and the flange on the cold head.

Clean underside of the copper block and also the clamp ring halves.

Coat the underside of the copper block with a thin layer of Apiezon N grease out to outside diameter of the copper clamp rings.

Coat the clamp ring surface that comes nearest to the copper block (the surface where the screws come through) with a thin layer of Apiezon N grease.

Cover the lower tube of the coldhead with two full wraps of 1/4 mill MLI in the same manner as the original, and fasten it with aluminized Mylar tape.

Stick the indium half rings inside the clamp ring halves with Apiezon N grease. Use just enough to assure that the indium will not fall off when the rings are being reinstalled, but be sure to coat the whole surface where the indium will touch. This will act as a parting agent.

Stick the indium ring to the top surface of the coldhead flange that will mate with the copper block using enough Apiezon N grease to assure that the indium will not fall off when the coldhead is lifted into place.

Check the Viton o-ring in the bottom of the bellows flange. The o-ring is greased with Dow Corning Vacuum grease. This is silicone grease and is almost impossible to remove, so try to keep it from getting on anything but the o-ring.

Put the head in the lifting fixture at the proper rotational orientation. Make sure that the flange that will mate with the o-ring is clean.

Lift the head so that it touches the copper block. In the case of the two stage head, the copper top post should be engaged with the copper clamp block.

Make sure that the flanges are centered, and continue to raise the coldhead until the o-ring touches.

Check that the indium ring on the cold head flange has not slipped.

Adjust the coldhead rotation so the vacuum flange holes line up and insert the eight 10-32x78 screws with lock washers.

Tighten them evenly.

Install the two halves of the clamp rings making sure that the indium half rings have not slipped and tighten the 16, 1/4 - 20 captive screws so there is about a 1/16 inch gap between them and the copper block. These screws should have 4 Belleville washers (B0637-032) and a flat washer each. Note that these screws had 3M Teflon spray painted on their threads. This should not have to be renewed if the bolts are reused.

Wind two full turns of .030 indium wire in the gap around the outside of the clamp ring screws.

Check the rotation of the copper block under the high temperature radiation shield. This should have its sides parallel to the side of bottom of the vacuum shell so that it does not hit its retaining screws.

Tighten the clamp ring screws evenly to 80 in-lb torque.

If the two stage head was replaced, align the clamp block so that its side is parallel to the side of the bottom of the vacuum shell and tighten the clamp screw to 60 in-lb torque.

Retighten the clamp ring screw to 80 in-lb torque after an hour or so.

Reinstall the split radiation shield around the coldhead tube on the underside of the outer warm radiation shield. Watch out for the temperature sensor wires. Make sure that all of the washers are on the outside of the flange. Tighten so that the Belleville washers are flat. Do not over tighten.

Close D82 starting at the appropriate place in the closing instructions in "Opening and Closing D82", but do not put on the acoustic skirt yet.

Pump D82 following the instructions in "Evacuating D82".

After the vacuum is sufficient, a few millibars, remove the coldhead lifting fixture.

Replace the He lines to the cold head.

Replace the electrical cable to the cold head.

Replace the lead hangers with their lead, if desired.

Replace the lead earthquake restraints if the lead hangers were installed.

Remove the eight C washers restraining the coldhead.

Replace the acoustic skirt.

Repair and Replacement of an Animatics Smart Motor Assembly

Introduction

D82 has 11 motor assemblies fastened to its bottom. These drive the shafts of ferro-fluid feedthroughs bring rotary motion into the vacuum space. The shaft of each feedthrough has a drum with 100 graduations around its circumference attached to it for alignment with the motor assemblies. All of the motors and their electromechanical brakes are identical except for the removable memory modules in the motors and the placement of the brake switch box. The limit-stop mechanism attached to each motor is specific to its mechanism inside D82 and has been individually adjusted to its particular shaft input into D82.

Motor -

All of the motors are Amimatics model SM2330-J motors. The J indicates a non-standard winding. This winding gives a higher torque for a given current and a larger back EMF for a given speed. The purpose is to reduce current demand and to limit the maximum speed that can be attained from the motor in runaway conditions. The motor has a module on its tail end that contains the motor control and drive electronics. This module can be removed and replaced with no loss of settings by undoing the three screws at back of the motor and keeping the same memory module. It also has the readout for a 2000 step incremental encoder and a single turn index mark attached to the tail shaft. Removing the motor module does not affect the encoder. The memories for the motors, which are numbered, plug into the motor under the power-communications connector. These memories contain the proper address and program for the particular mechanism to which the motor is attached. Positive motor counts correspond to a counterclockwise rotation looking into the back of the motor. There 2000 counts per revolution.

Communications to the motor is by RS485 which is translated to RS232 in the power-communications connector. All of the RS485 connections are daisy chained except for motor 7 (PMR - pupil mask rotator) which is separate and is wired to a different terminal server. There is a short RS485 cable tucked under the bottom of D82 that can be used to daisy chain this motor with the rest of the others if it is so desired. Of course the software must be changed. The motor power is distributed from parallel connected jacks in the distribution box on the front leg of D82. The voltage should not fall below 24 VDC under any conditions. The electromechanical brakes are not guaranteed to open below that voltage. The nominal unloaded voltage of the power supply is about 27 VDC.

Brake -

The electromechanical brake is fasten to the front of the motor and is normally on (the shaft is locked when there is no power to the brake). For this reason, it is not possible to turn the motor shaft without the brake being purposefully released. A plastic box connected to the side of the motor contains the solid state relay for actuating the brake and a plug that allows access to the set screws that attach the motor shaft to the brake. The brake receives its 24 VDC power from a two pin connector attached to the power-communication connector plugged into the motor. The control signal comes through a jumper cable from the 7 pin IO jack on the motor.

Limit Stop -

There are three types of limit stop mechanisms. They are all fastened to the front of the motor brake and in turn fasten to the bottom shell of D82. There is a shim plate between the limit stop and the bottom of D82 for all of the motors.

The limit stop for motor 3 (SHR - shutter) is special. It has no limit switches just a swing arm with a slot that engages a shaft. The limit is purely mechanical with a small fraction of a turn range of motion.

The two other limit stops differ in the gear ratio from the motor to the limit stop shaft. Because of the large number of turns, the limit stop for motors 1 (CAM - camera), 2 (GRS - grism), 8 (SLS - slit selector), and 9 (SLM - slit mask) have a 6 to 1 ratio; all of the rest have a 3 to 1 ratio. The motor gear drives the gear on the electro-mechanical limit stop shaft through an intermediate cluster gear. A number counter whose least significant digit reads in 1/10 turns is also connected to the end of the electromechanical limit stop shaft.

The electro-mechanical limit stop itself is a modified version of a commercial part from Sterling instruments. There have been 6 modifications:

1) A new shaft with a long tail has been installed so the a gear clamp type handle can be attached if desired. The other end is .2 inch shorter than standard.

2) All of the stop washers have been hand filed flat and deburred so that the stack of them has the same height independent of rotation. Some of the stop washers have .002 shaft spacers between them.

3) A oil filled porous bronze bushing has been installed into the toggling switch actuator to stop it gauling and welding to the shaft.

4) The number of stop washers has been modified to be appropriate for the number of turns required in a particular stop.

5) A tapped hole has been added for a cable clamp.

6) The Microswitch actuator levers have been notched so they do not jam on the plunger screw plungers.

There are electrical limits for clockwise (CW) and counterclockwise (CCW) followed by mechanical limits which are spring plunger screws to soften the mechanical contact. Each electrical limit has two Microswitches wired in parallel to the normally open contacts for redundancy. The limits are actuated by contact closure, which means that they will not work if they are unplugged or the wire broken. Looking from the back of the motor with the D connector down the left limit is green wire which goes to the CW limit switch. The right limit is the red wire which goes to the CCW limit switch. Note that CCW is positive motor counts looking from the back of the motor.

Maintenance

The only regular maintenance that is anticipated is the oiling of the limit stop washers to prevent wear and sticking. These have been oiled with MIL-L-6085A instrument oil. The amount of oil is that which will wick between all stop washers and wet the porous bronze bearing with no excess. Since the stop washers hold quite a bit of oil, the motion is intermittent and the temperature is low, it is anticipated that oiling will not be need more frequently than every five years, if that.

Alignment of Motor Assembly

Each motor assembly is individually aligned before it is attached to D82. To do the alignment the motor should be set up with a power supply giving 24 VDC and a PC running the Anamatics software. The proper memory for that motor should be installed in the motor.

Alignment - Motor Assembly 3 (SHR - shutter)

Motor 3 is a special case. When run in the negative direction it the fork on the shaft should hit the stop at -3 counts from the index mark.

Procedure

If the motor is assembled to its limit stop and is just to be checked. Run the homing routine after the initialization routine and the position should read -3 and the index mark should be at 0. If the brake is released (UA-0) and the shaft turned by hand, the stop should be hit -3 counts after the index is triggered turning in the negative count direction.

If the limit stop has not been assembled to the motor, run the initialization routine then run the motor in the negative step direction until the index mark is hit.

Set the origin to the index mark (j=@P O=j).

Move the motor to -3 counts; the brake should be set.

Assemble the limit stop assembly to the motor with the stop rod in the fork arm on the motor shaft. Make sure that the bake control box is oriented properly with respect to the limit stop.

Rotate the fork CCW looking INTO the SHAFT end of the motor against the rod and while holding clamp the fork to the shaft. Make sure that the wafer spring coupling has proper purchase on the motor shaft, with a .032 thick shim washer between it and the fork arm.

Check the setting in the manor described above.

Alignment - All Motor Assemblies Except Motor Assembly 3

Except for certain parameters that are specific to each motor, such as the number stop washers and turns between limits, all of the limit assemblies are aligned by the same procedure. First the electromechanical limit stop, then the number counter, and finally the motor to the assembly. The philosophy in the setting of the limit is that the motor index is set as far as practical from the electrical limits so that there is no uncertainty in which turn the motor homes to, and that an electrical limit is activated before the mechanical stop and that the mechanical stop will be hit before an internal mechanism stop.

The procedure assumes that completely new parts are being used. If pre-aligned parts are used the appropriate steps can be skipped.

Procedure

Check that the assembly has the correct gear ratio for its position on D82.

If the electromechanical limit stop mechanism is new, it should be rebuilt to the drawings and wired. The number of washers should be chosen so that the proper number of turns between CW and CCW switch closures can be easily achieved by rotating the concentric dog collars relative to each other. An initial set up with the dogs on these collars 180 degrees apart will allow the largest symmetrical range of adjustment. These will be pined after the switches and hard stops are adjusted.

Set the Microswitches as far away from the toggle bar as possible.

Set the Microswitch actuator levers so they touch the Microswith buttons. Make sure that the buttons are not depressed or they might not open after they are actuated.

Screw in both pusher screws in the actuating toggle bar so they just touch the Microswitch actuator levers but do not bend them. The two screws should extend about the same amount.

Lock the screws with their jam nuts.

Set the plunger screws so that each one just touches the toggle bar after both Microswitches on the side of that plunger screw actuate when the bar is rotated. Be warned that the hex screw in the end of the plunger screw is for assembling the plunger screw and not adjusting its height.

Make sure that the screws holding the Microswitches are tight.

Put a small drop of Loctite 290 (Penetrating for post-installation) on the 4 micro switch mounting screw heads, the 2 toggle bar pusher screws at the locknuts, the edge of the 2 locknuts, and the 2 plunger screws at the toggle bar on the opposite side to the plungers. After the Loctite soaks in, wipe off all of the excess.

Put several drops of MIL-L-6085A instrument oil on the edge of the washer stack so that all of the washers are oiled. Try to keep the oil confined to the washers. Wipe off any excess.

Loosen the set screw (the one furthest from the washer stack) that holds the concentric bosses to the shaft and push the bosses gently against the washer stack and then retighten the screw. There should be no play.

Rotate the shaft the full range from CW to CWW limit and back. If the washers drag and actuate the limit switches before all of the tabs hit, reduce the pressure of the concentric bosses on the washer stack slightly.

Rotate the shaft the full range from CCW to CCW limit and back several hundred times to wear in the washers.

Readjust the pressure of the concentric bosses so the stack of washers has about .002 to .005 axial play. The curved spring washer should be compressed enough to be spring loading the stack.

Rotate the shaft the full range from CCW to CCW limit and back. The toggle bar should not deflect the limit switch actuator levers a measurable amount anywhere in the full range or rotation between the limits. If necessary readjust.

If the electromechanical limit stop assembly has not already been attached to the gear assembly, it can be done temporarily, as the large gear and number counter can be used as an aid in setting the limits.

The range of rotation between the earliest Microswitch actuation from the CW to CCW limits should be set. This is done by rotating the outer collar of the concentric dog collars. Do not loosen the set screw holding the inner collar to the shaft or the washer stack axial adjustment will be lost. Loosen only the set screw on the outer collar, the one nearest the washer stack.

After checking that the electromechanical limit stop is set up properly, remove it from the assembly and drill and pin the concentric dog collars to the shaft using the roll pin supplied. There is a spot hole in the outer collar for this purpose. Carefully wrap the mechanism before pinning so that chips do not get into the bearings or in the washer stack. Note that the bearings are only shielded on one side.

Attach the electromechanical limit stop back on the assembly. Tighten the 4 clamps tightly (because of the gear ratio, a large amount of torque can be transmitted to the stop if the electrical limit fails) and stake with Loctite 290. Wipe off any excess.

Clamp the gear very hard to the electromechanical limit stop shaft with approximately .010 axial clearance from the larger gear on the cluster. This should be done with the stop at the CW limit looking from the motor side, so the clamp screw is accessible for minor adjustment if needed.

For convenience, it is useful to just activate the CW limit while the number counter is at the number for the CW limit for that assembly, and then temporarily fasten the flex coupling to the electromechanical limit stop shaft with one set screw.

The motor should be attached with the appropriate screws and lock washers. Its gear and clamp should be loose on the shaft.

The motor should be powered up, the settings loaded, then set to the index mark. The brake should be set.

With the counter reading the correct number for that assembly, the gear on the motor shaft should be clamped.

Run the homing routine and check that the motor is at the index mark.

The number counter should read the appropriate value for 0 motor counts for that assembly to within a few tenths of the last digit on the number counter. If not, something is wrong.

Check that the CW and CCW limits are activated at about the correct motor position reading. They should be within 100 motor counts. This is especially important for motor 10 (PSI - Pre Sits Inner) and 11 (PSO - Pre Slits Inner), because there is a smaller range between the mechanical limits of the pre slit mechanism inside D82 and the outside limits for these mechanisms Also, the gearing for these mechanisms is delicate an will be unduly strained if the inside stops are hit under full motor power. Note the gear on the motor shaft can be readjusted so that both electrical limits are the same number of motor counts outside the software limits for both CW and CCW rotations.

Run the motor back to 0 counts.

Readjust the number counter reading to its proper reading for that assembly.

Tighten all 4 set screws in the number counter flexible coupling and stake them with Loctite 290.

There should be a .010 shim washer between the wafer spring coupling and the gear on the motor shaft.

Removal and Replacement of Motor Assembly on D82

Introduction

Any of the motors on the bottom of D82 can be removed without warming up the instrument. If certain precautions are taken, a motor can also be installed with proper alignment to the internal mechanism without warming up the instrument. The motors are attached to the ferro-feedthrough shaft with a clamped wafer spring coupling and to the bottom of D82 with four screws. There is a .040 shim plate between the motor assembly and the bottom of D82. This is necessary to prevent binding between the index dial drum on the feedthrough shaft and the frame of the motor assembly.

Each of the feedthroughs has a 100 division index dial drum clamped to it. This drum should NEVER be unclamped from the feedthrough shaft; if it is, the ability to align a motor assembly to its internal mechanism will be lost for some of the mechanisms and much difficulty added to the alignment of the others. If the feedthrough shaft is kept from turning or the number of turns accurately counted, then the motor assembly can be installed to an accuracy of about 0.1 drum divisions (equals 0.001 turns, equals 2 motor counts). In fact, all or the mechanisms except FWI, FWO, PMS, PMR (motors 4, 5, 6 & 7) can have any turns ambiguity resolved by turning the feedthrough shaft CW to the internal mechanism stop and then counting turns from there. Turns ambiguity for FWI and FWO can be resolved by looking at transmission and thermal background and by taking spectra of thermal background through the filters using a grism. By using the pupil imaging mode, turns ambiguity can be resolved on the PMS and PMR. Of course, D82 has to be operational and a lot of time will be wasted, so do not lose count of turns.

Procedure - Removing Motor Assembly

Remove enough of the acoustic skirt to get access to the motor.

Record the reading on the drum dial on the feed through shaft to 1/10 divisions (interpolate by eye). Make sure you use the correct scribe line on the motor assembly body. Record the reading of the number counter on the shaft of the electromechanical limit stop to 1/10 of a number. As an aid, note that increasing numbers are above on the counter drums when the digits are right side up.

If the mechanism is working, try to get to a standard configuration. If possible, run the motor to 0 motor counts. If that cannot be done release the brake, and turn the motor by hand using the exposed gearing to turn the shaft to what would be zero motor counts, or at least to 0 on the drum dial and an even integer on the number counter. In any case, try to get the screw on the top clamp of the wafer spring coupling to where it can be accessed easily.

Once again record the reading on the drum dial on the feed through shaft to 1/10 divisions (interpolate by eye). Make sure you use the correct scribe line on the motor assembly body. Record the reading of the number counter on the shaft of the electromechanical limit stop to 1/10 of a number. As an aid, note that increasing numbers are above on the counter drums when the digits are right side up.

Turn off the motor power.

Remove the RS-485 cable to the motor.

Remove the motor power cable from the motor.

Loosen the top clamp of the wafer spring coupling fastening it to the feed through shaft. From now on, be careful not to turn the feedthrough shaft.

Loosen the 4 screws that hold the motor assembly to the bottom of D82, and lower it vertically. Make sure that the coupling is sliding easily on the feedthrough shaft and the drum dial is not hanging up. Note that there are lock washers on the screws and a .040 shim plate between the motor assembly and the bottom of D82.

It would be a good idea to immobilize the drum dial with a piece of tape to the bottom of D82 after the assembly is removed.

Check the assembly that was just removed to see if the adjustments are correct. There could be a problem if the electromechanical limit stop and the number counter has lost proper relation to the motor index mark. Record any anomalies.

Procedure - Installing Motor Assembly

Using the setting of the drum dial and the number counter recorded before the motor assembly was removed, calculate the correct motor counts for that reading. Use the "NIRC2 Motor Position" parameter list for this.

Take the motor assembly to be installed on D82 and plug in the correct memory module The adjustments of this assembly should have been previously checked out .

Connect the motor to a PC running the Anamatics software.

Home the motor.

Run the motor to the motor count that was just calculated. The brake should be set to lock the shaft.

Check that the number counter reads the number that was recorded. If it does not, something is wrong and something has to be corrected.

Disconnect the motor from the PC.

Check that the clamp screw on the open end of the wafer spring coupling is still loose.

If the dial drum was taped to the bottom of D82, remove the tape carefully. It is important not to lose track of which turn the feedthrough is at.

Have the screws with their lock washers ready to hold the assembly.

Put the .040 shim plate on the top of the assembly.

Carefully raise the assembly with shim plate, clearing the dial drum and making sure that the wafer spring coupling properly engages the feedthrough shaft.

Insert the 4, 10-32 screws with their lockwasher and bring them to just touch.

Adjust the position of the assembly so that the shafts are coaxial to the eye.

Tighten the 4, 10-32 screws.

Find the proper scribe line on the motor assembly to use in aligning the drum dial.

Read the drum dial and record. It should be close to the reading that was last recorded before the motor assembly was removed, the one used to calculate the motor counts.

Turn the drum dial the shortest was to the reading that was last recorded before the motor assembly was removed, the one used to calculate the motor counts. Make sure that you use the proper scribe line on the motor assembly.

Clamp the wafer spring coupling to the feed through shaft, making certain that the drum dial still has the same reading to 1/10 of a division.

Make sure that the motor power is turned off.

Connect the motor power cable.

Connect the RS-485 cable.

Turn on the motor power.

Use the software to initialize the motor and unlock the break.

By hand, see that the motor turns freely using the gear to turn it.

Home the motor and check that it is at 0 motor counts.

Read the drum dial and the number counter on the electromechanical limit stop shaft and check that they agree with the NRC2 Motor Position parameter file.

Run the motor over its range to check the mechanism.

Reinstall the acoustic skirt.