P/N 4411-0013

LN/CCD Detector

Operation manual

Manual Version 2
Revision A
August 25, 1998

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General Information

Figure 1. LN/CCD Detector.

Introduction

Liquid nitrogen cooled CCD detectors (LN/CCDs) are ideal for low to ultra-low light level applications requiring very long integration times. They have a wide spectral range, a high dynamic range, high thermal and temporal stability, and excellent geometric accuracy and stability.

Special-purpose LN/CCD detectors utilize X-ray or UV sensitive devices. Operation of these detectors is nearly identical to operation of the standard LN/CCD detector.

CAUTION

If you have a detector with a UV scintillator coated CCD, protect it from excessive exposure to UV radiation. This radiation slowly bleaches the scintillator, reducing sensitivity.

Environmental Conditions

- Storage temperature ≤55°C
- Operating environment 30°C > T > -50°C
- Relative humidity ≤50%. High humidity climates may require continuous flushing of the spectrometer's exit port with nitrogen. See the window information below.

General Features

- Compact and lightweight design allows easy interfacing with various spectrometers and alignment with optical systems.
- Widest range of temperature control: QE vs. dark charge.
- Maximum user safety: Three different valves protect against pressure buildup either in the LN container or in the vacuum vessel.
- Minimum requirements for frequent pumping: Various adsorbents and desiccants are added to trap contaminants.
- A safe pumping interface: PI uses a helium-leak tested valve that ensures ease in interfacing to vacuum pumps with a minimal chance of opening to the atmosphere.
- The CCD array is placed as close as possible to the dewar window in order to allow interfacing to most spectrometers or lenses with an on-dewar shutter.

WARNINGS

Never remove the detector's front window; ice will form immediately, destroying the array. Operations requiring contact with the device can only be performed at the factory.
Never operate the detector cooled without proper evacuation. This could *destroy* the CCD!

LN/CCD detectors have several sections. The front enclosure contains the CCD array seated on a cold finger. This finger is in contact with the LN dewar and has a heater to regulate the CCD temperature. The front enclosure opens into the vacuum jacket that surrounds the internal LN dewar.

The dewar is filled through a sealable top opening, and has two pressure reliefs operating at 1 and 10 psi to safely vent N_2 gas. A special "all-directional" dewar option is also available, which allows the dewar to be operated in any orientation.

The electronics enclosure contains the preamplifier and array driver board, keeping all signal leads to the preamplifier as short as possible, and providing complete RF shielding.

Detector Windows

Three windows separate the CCD from the outside. Each has a specific function, and two are optional or removable.

Shutter window

This window on the front of the shutter housing protects the shutter and also ensures that the shutter enclosure remains in a dry nitrogen environment, if applicable. This prevents condensation on the outside surface of the dewar window (in labs with high humidity). This window can be easily removed by the user.

Vacuum window

This window maintains the vacuum in the dewar. It is made of the highest quality quartz available. The following optional coated vacuum windows are available:

- UV/AR coated for operation in the 200 - 420 nm range.
- VIS/AR coated for operation in the 400 - 750 nm range.
- NIR/IR coated for operation in the 580 - 1050 nm range.
- Broad-band MgFl coated for operation in the 200 - 1100 nm range.

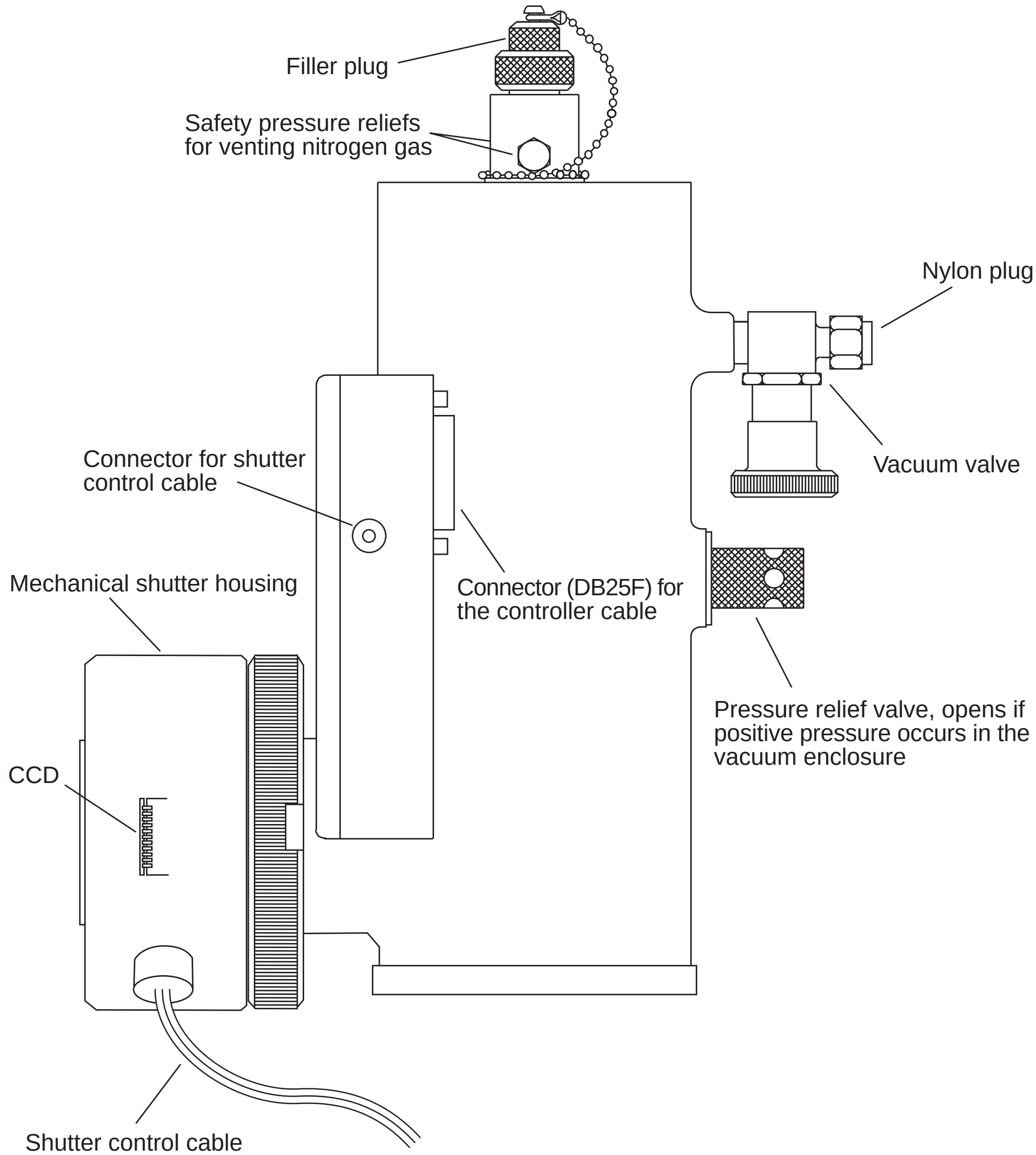
Wedge windows can be provided if specified at time of order. Also, if a coated vacuum window is specified, the other detector windows may not be installed.

Array window

This is provided primarily for protection of the array in case of accidental loss of vacuum when the array is very cold. The standard window is made out of the highest quality quartz. This window can be replaced with any of the optional windows mentioned above, or PI can provide the CCD without the protection window.

If you see problems that resemble window interference patterns, contact the factory.

Figure 2. LN/CCD detector, side view.



Chapter 2

Detector Setup

General Instructions

Two items are applicable to both imaging and spectroscopic systems.

Connecting the detector

Each detector is supplied with a cable to connect to the controller. Make sure that the controller is off, then connect the larger end of the cable to the port marked “detector” on the controller. Tighten the screws in place. Connect the smaller end of the cable to the detector, and tighten the screws.

Setting the controller

Any user who will be running both TE/CCDs and LN/CCDs with their controller must ensure that the internal power supply switches of the controller are set properly (applies only to those Controllers which have internal switches). Consult the controller manual for instructions on setting these switches.

Note: If you have purchased one detector only, the Controller switches will have been set correctly at the factory. No user adjustment will be needed.

Imaging Applications

This section describes how to connect lenses to the detector for imaging applications. Instructions for spectroscopic applications appear later in this chapter.

Connecting lenses

Detectors for use in imaging systems (cameras) are shipped with the lens mount already attached. Standard Princeton Instruments lens mounts use the Nikon bayonet format, as shown in Figure 3. This can be converted to most other formats using commercially available adapters. If your optical system cannot be converted to this format, contact the factory. *Other mounts may be available. Consult the factory for specific information relating to your needs.*

To mount the lens on the camera, locate the large indicator dot on the side of the lens. There is a corresponding dot on the front side of the adapter. Line up the dots and slide the lens into the adapter. Turn the lens counterclockwise until a click is heard. The lens is now locked in place.

If the front part of the lens mount rotates with the lens, tighten the set screws until it is fixed in place. Fine adjustments are covered in Chapter 4.

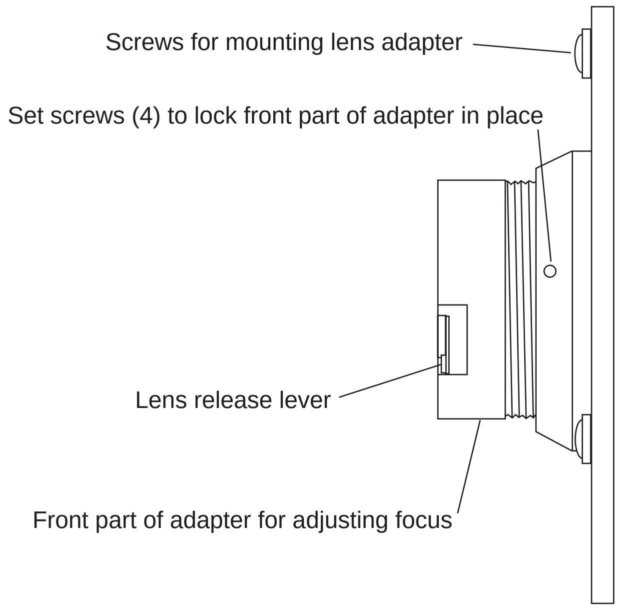


Figure 3. The Nikon lens adapter.

To remove the lens, locate the lens release lever at the front of the lens mount. Press the lever toward the camera housing, and at the same time rotate the lens clockwise. Then pull the lens straight out.

Many standard microscope adapters are also available through Princeton Instruments. Attach the adapter to the lens mount provided with the detector. Connect the adapter to the microscope. See the adapter literature for further directions.

WARNING

The LN/CCD dewar must never be tilted more than 30° from vertical, unless the “all-directional” dewar option has been purchased. For this reason, an end-on type and a side-on type are available for different mounting situations. If mounting the dewar to your system requires you to exceed the 30° limit, you may have the wrong type of dewar. Contact the factory.

Overexposure protection

Cameras that are exposed to room light or other continuous light sources will quickly become saturated. Set the lens to the smallest aperture (highest f-number) and cover the lens with a lens cap to prevent overexposure. Continue with the cooling instructions in Chapter 3.

Spectroscopic Applications

The detector must be properly mounted to the spectrometer to take advantage of all the available grouping features. Additional precautions must also be taken to prevent overexposure of the detector.

At the time of purchase, both the dewar and the adapter were selected for your specific application. Consult the diagrams to determine which type of adapter is needed.

WARNING

> The LN/CCD dewar must never be tilted more than 30° from vertical, unless the "all-directional" dewar option has been purchased. For this reason, an end-on type and a side-on type are available for mounting to vertical and horizontal image planes, respectively. If mounting the dewar to your system requires you to exceed the 30° limit, you may have the wrong type of dewar. Contact the factory.

Focal Plane Distance

The distance to the focal plane from the front of the mechanical assembly depends on the specific configuration as follows.

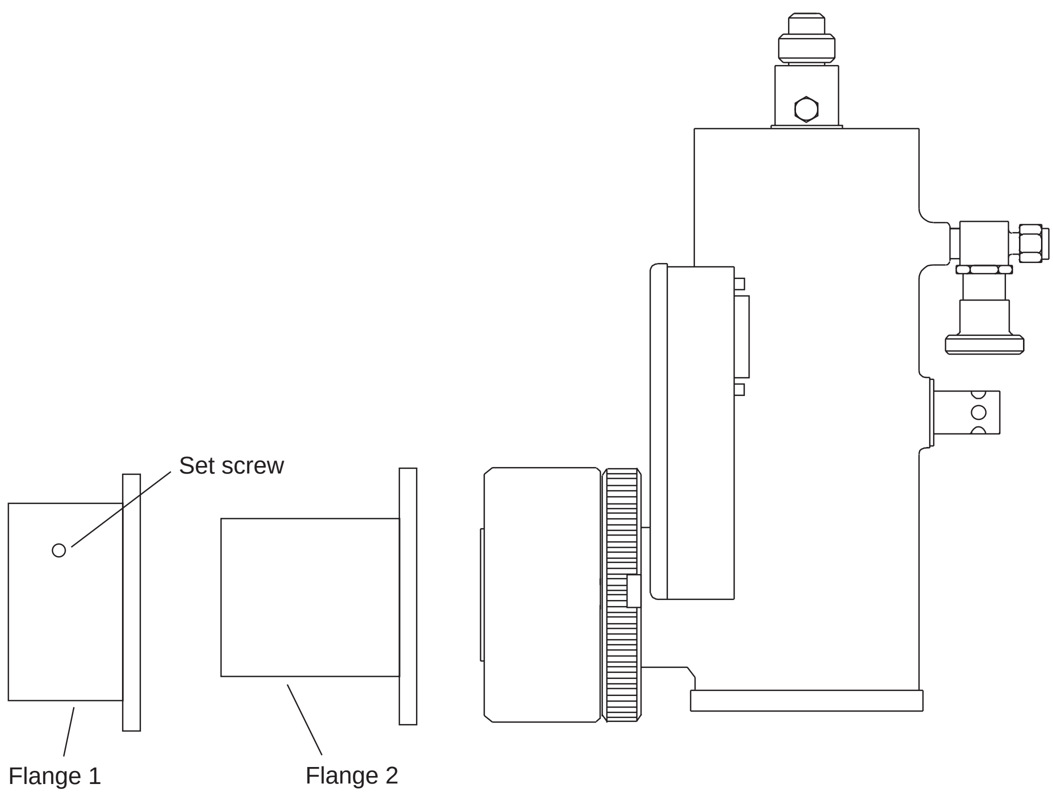
Mounting Flange to Focal Plane (no shutter or adapter): 0.440±.01″

Front of Shutter to Focal Plane: 0.894±.01″

Front of 7050-0032 Large Detector Adapter to Focal Plane: 0.590±.01″

Note: The large shutter has a 3.88″ bolt circle. The 7050-0032 adapater, all PDAs and ICCDs have a 3.60″ bolt circle.

Figure 4. Adapter for a deep focal plane spectrometer.



Deep focal plane

For spectrometers with a focal plane 25 mm or more beyond the exit interface, the shutter housing remains connected to the detector. Such spectrometers include the Princeton Instruments Model 320PI, Acton (adapters are available for all Acton models), the ISA HR320, ISA HR640, Chromex 250IS, and most instruments that are 1 meter or longer. (If you are not sure of the depth of the exit focal plane, contact the spectrometer manufacturer.) Adapters for these spectrometers are generally in two pieces, as shown in Figure 4.

To mount flange 2, place it over the shutter housing and bolt it to the shutter using the screws provided.

Next, loosen the set screw(s) on flange 1, then mount this flange to the spectrometer. Slide flange 2 into flange 1. Do not tighten the set screw(s) until focusing and alignment are completed in Chapter 4.

Shallow focal plane

For spectrometers with a focal plane distance less than 25 mm, the shutter provided can either be mounted on the entrance slit of the spectrometer or operated as a stand-alone shutter.

The detector mount provided in these cases does not allow focusing via the adapter. Focusing must be accomplished by adjusting the spectrometer. Consult the chart below to determine the type of mount for your CCD.

CCD	Type of Mount
EEV 576	Type 1
All other EEV	Type 2
All SITe (Tektronix)	Type 2

For a type 1 detector, mount the flange to the detector using the two half-rings and the screws provided as shown in Figure 5. Note that the tapered side of each half-ring faces the adapter. Next, screw the 10-32 hex screws halfway into three of the six tapped holes in the spectrometer’s exit plane. Position the detector so the three hex head screws line up with the openings in the adapter flange. Slide the detector over the screws and rotate into the proper orientation. Leave the detector free to rotate until it is aligned in Chapter 4.

For a type 2 detector, mount the adapter to the spectrometer first. Then insert the front of the detector into the adapter, and thread it into place using the large captive ring nut on the detector, as shown in Figure 6.

Figure 5. Shallow focal plane spectrometer, type 1 detector.

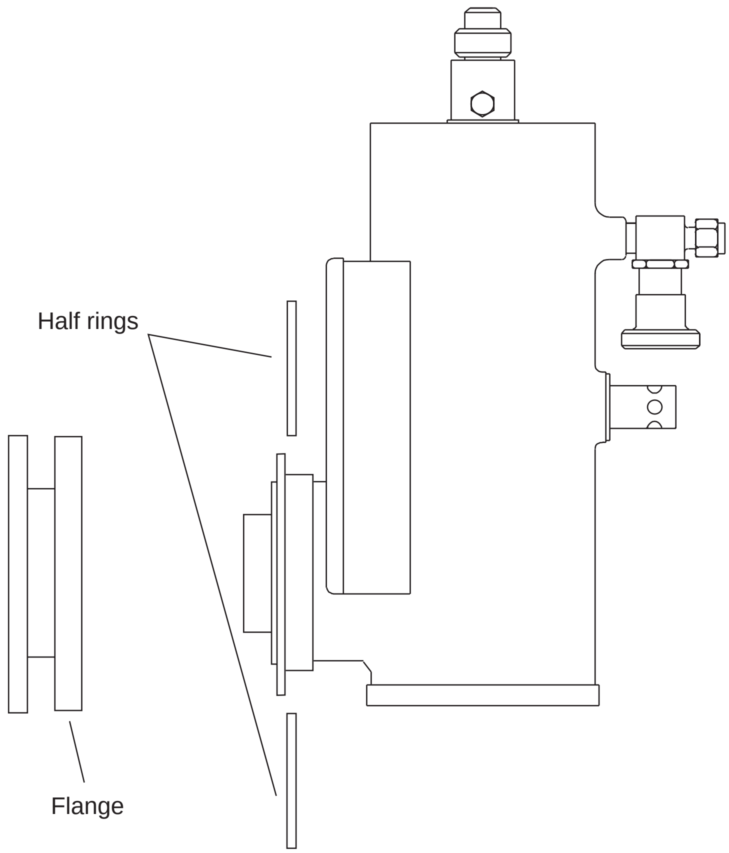
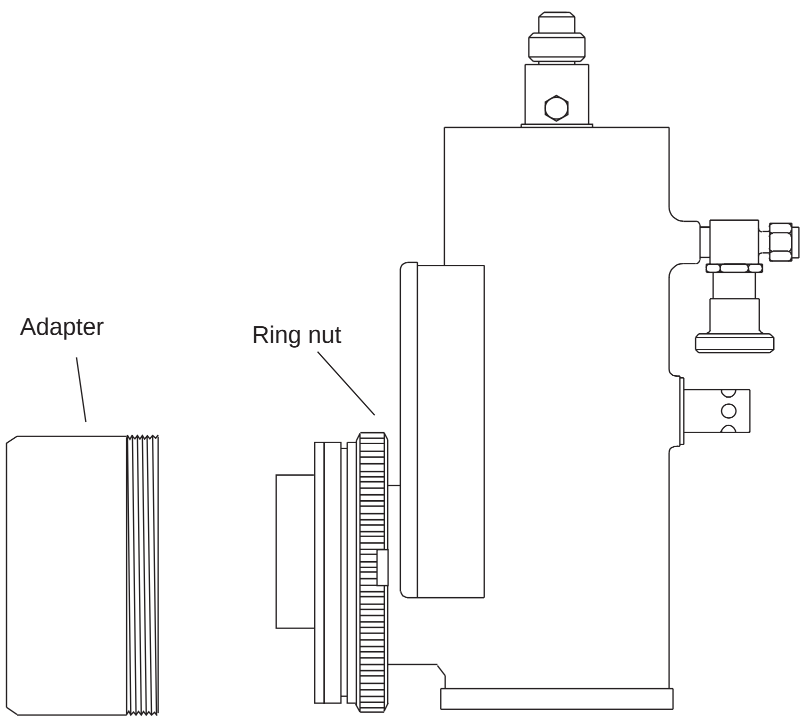


Figure 6. Shallow focal plane spectrometer, type 2 detector.



Entrance slit shutter

This shutter can either be mounted on the entrance slit of the spectrometer or used as a stand-alone shutter. Shutters for stand-alone operation have two tapped holes for mounting to a stand: one metric, the other English.

Entrance slit shutter mounts come in two types. The first type is for use with CP-200 and HR-250 Spectrometers, and is shown in Figure 7.

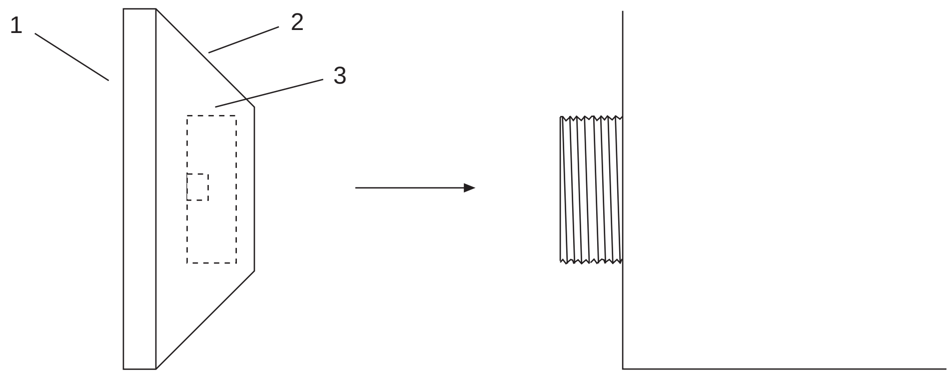


Figure 7. One type of entrance slit shutter mount.

Remove part 1 by removing the four Phillips screws. Place part 2 over the entrance slit, and mount it by threading part 3 to the spectrometer. Replace the shutter and part 1.

The second type of shutter mount requires no disassembly. It is used with all Acton spectrometers. Mount it to the detector as shown in Figure 8.

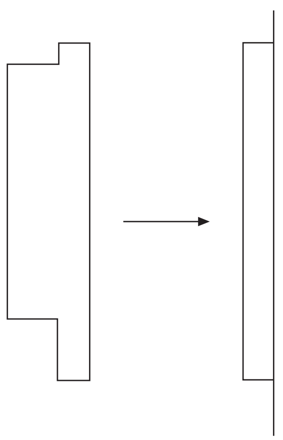


Figure 8. A second type of entrance slit shutter mount.

Connect the shutter cable to the side of the detector. Longer cables are available from the factory.

Overexposure protection

Detectors that are exposed to room light or other continuous light sources will quickly become saturated. This most often occurs when a shutter is not used. To reduce the incident light, close the entrance slit of the spectrometer completely.

Chapter 3
Filling the Dewar

ATTENTION

> It is generally good practice to turn on the controller and start at least one data collection while the detector is cooling down, and then to keep the controller in operation for the entire time the dewar contains LN2. This will establish and maintain the "keep cleans" mode of the controller so that, even when the CCD is not actively taking data, it will be continouously cleaning (shifting charge on the array to clear dark charge and cosmic ray artifacts).

Introduction

LN/CCD detectors use liquid nitrogen to reduce the temperature of the CCD. The liquid nitrogen is stored in a dewar which is enclosed in a vacuum jacket for minimal external thermal losses. The chip temperature is regulated by a heating element driven by closed-loop proportional control circuitry. A thermal sensing diode attached to the cooling block of the detector monitors the chip temperature. The temperature can be thermostated over a 40° to 50° range Celsius. The exact range depends on the CCD device, as indicated in the following table.

Table 1. Approximate temperature range vs. CCD model.

CCD Model	Approximate Range
1024HER, 1024EHRB	-50°C to -100°C
All other arrays.	-80°C to -120°C

CAUTION

> LN/CCDs, because of their low operating temperatures, must ***always*** be connected to an operating controller. If the controller power is turned off with liquid nitrogen remaining in the dewar, the CCD will quickly become saturated with charge, which cannot be readily removed without warming the detector to room temperature.

Holding Times

With small CCDs, e.g., 1152 × 298, 1024 × 256, 576 × 384, etc., the LN hold time using a 500 ml dewar is approximately 12 hours at the lowest temperature setting. With larger CCDs, e.g., 512 × 512, 1024 × 1024, or 1152 × 1242, the hold time of the same dewar is reduced to 9-10 hours. PI's large capacity dewar (1.5 liters), standard for some arrays, has a hold time of 25 hours or more, again depending on the array size and operating temperature. The 1024HER and 1024EHRB arrays, due to their higher operating temperature, have an 18 hour hold time.

To maximize the holding time when leaving the detector overnight, in addition to topping off the dewar, you will want to turn off the heater switch (on the front panel of the ST-138 Controller; in the case of the ST-133 Controller, you must turn the cooling ON and OFF through software). *You must leave the controller power on in either case.* This will bring the CCD to its minimum operating temperature and will minimize LN evaporation. This should keep the detector cold for 36 to 48 hours. The following day, turn on the heater switch (ST-138) or turn the cooling back ON (ST-133) to return the CCD to its operating temperature.

Setting the Operating Temperature

ST-133 Controller

Temperature control is done via software. Once the desired array temperature has been set, the software controls the thermoelectric cooling circuits in the camera so as to reduce the array temperature to the set value. On reaching that temperature, the control loop locks to the set temperature for stable and reproducible performance. The green **TEMP LOCK** indicator on the Analog/Control module panel lights to indicate that temperature lock has been reached (temperature within 0.05°C of set value). If using WinView/32, there will also be a **Locked** indication in the Detector Temperature dialog box (Figure 9). This on-screen indication allows easy verification of temperature lock in experiments where the computer and controller are widely separated. There is also provision for reading out the actual temperature at the computer so that the progress of the cooldown can be monitored.

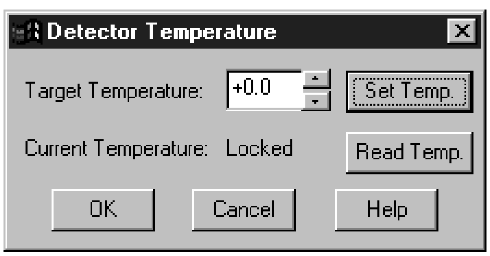


Figure 9. WinView/32 Detector Temperature dialog box.

The time required to achieve lock can vary over a considerable range, depending on such factors as the camera type, CCD array type, type of cooling, etc. Once lock occurs, it's okay to begin focusing. However, you should wait an additional twenty minutes before taking quantitative data so that the system has time to achieve optimum thermal stability.

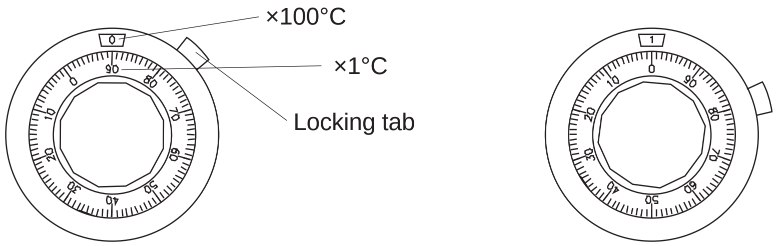
ST-138 Controller

- Turn the cooler switch on the front of the controller off. Then turn the power switch on.
- Locate the temp knob on the front of the controller. The dial reads in units of minus degrees centigrade. See the diagram to locate the locking tab (1). Turn this tab counterclockwise until the Temp knob is free to rotate.

  Note: For initial data collection, set this knob to -80°C.
- On the top side of the Temp knob is a rectangular window that denotes hundreds of °C. Each complete turn of the knob is -100°C. Around the moveable part of the knob are numbers from 0 to 99, in increments of 2. Turn the knob until the correct value

(0 or 1) appears in the hundreds' box. Then turn the knob until the desired value between 0 and 99 appears below the box. Turn the locking tab clockwise to lock the Temp knob in place.

Figure 10. The temp. knob, located on the front of the controller.



- In Figure 10, the knob on the left is set to -90°C. The locking tab is shown in the unlocked position. On the right, the temperature is set to -100°C and the locking tab is in the locked position. Note that the rectangular window reads "1" in this case.

Note: Working at excessively low temperatures, i.e., below -120°C, is not recommended. Dark charge at this temperature is completely insignificant and any further reduction in temperature substantially reduces the spectral response (QE), particularly in the red and for BI and BIDD devices. Transfer efficiency is also reduced at these temperatures.

- Turn the Cooler switch on. If the LN/CCD is set below -140°C the Low Temp Limit indicator (red LED) will light. Set the temperature to a higher value to deactivate the indicator.

Begin Data Collection

- Begin with the detector blocked off. For an imaging system, set the lens at the smallest possible aperture (largest f-number). For a spectroscopic system, close the entrance slit of the spectrometer completely.
- Set the software to the Freerun and Asynchronous modes (consult the software manual if you are not familiar with these modes). Choose a fast exposure, and begin data collection.
- Continue data collection until the CCD has reached the operating temperature. Collection may then be stopped, but the controller must *always* be left on. If the controller is turned off the CCD will become saturated, requiring the detector to be warmed to room temperature.

Note: Exposing the CCD to bright light (10× saturation) when cold (<-70°C) will cause the dark current in the exposed pixels to be 3 to 10 times higher than normal for that operating temperature. This effect is due to the formation of temporary traps. The effect can be reversed by allowing the detector to warm up to room temperature.

Filling the Dewar

WARNING

Even minimal contact with LN can cause damage to eyes and skin. Avoid contact with the splashing that will invariably accompany pouring LN into a room temperature dewar.

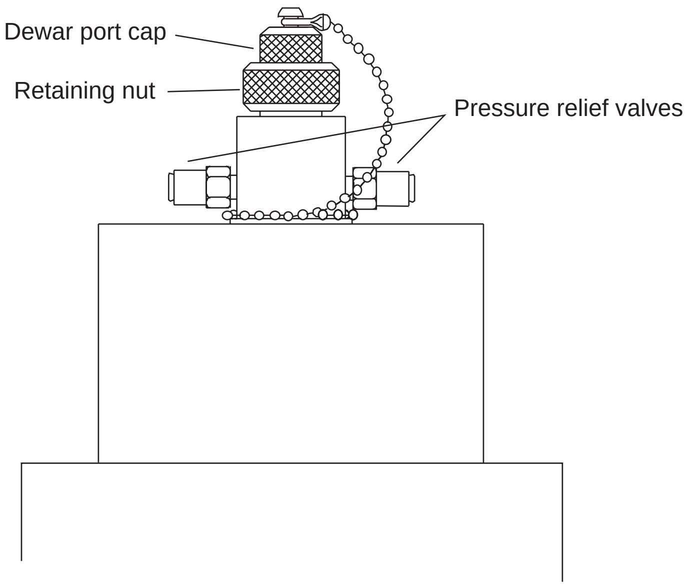


Figure 11. Dewar ports and valves.

- After the detector has been properly evacuated, loosen the retaining nut (Figure 11) a few turns, then remove the LN dewar port cap by pulling it straight out.

CAUTION

Always be careful when removing the LN port cap if there is LN present in the dewar. Pressure due to nitrogen gas can cause the cap to fly out when the retaining nut is loosened, possibly spraying you with liquid LN.

- It is recommended that an LN transfer dewar with a pouring spout be used to transfer LN from the storage tank to the detector. If you are going to use a funnel, place a thin vent tube into the dewar through the funnel to reduce splashing due to boiling LN.
- Pour approximately 100 ml of LN into the dewar. Stop for 5-10 minutes until you observe a “geyser-like” vapor burst from the dewar opening. This burst is normal and has to do with reaching a thermal equilibrium between the LN and the dewar container surfaces.
- Fill up the dewar (approximately 0.5 liters of LN for standard dewar, 1.5 liters for large capacity dewar, or 0.75 liters for a large all-directional dewar). To test the LN level, insert a straight piece of wire (a cryogenic “dip stick”) into the dewar briefly, then remove it. The LN level will be indicated by the condensation on the wire.
- Once the dewar has been filled, replace the filler cap and hand-tighten the retaining nut.

- Once a temperature of -80°C has been achieved, maintain the CCD at that temperature for 2-3 hours, then reset the dial to the desired temperature. This procedure prevents any residual water vapor (if introduced during shipment or through erroneous pumping in your lab, e.g., if your trap is inefficient) from condensing on the CCD window.

  If the dewar is continuously refilled, this procedure is unnecessary and the dial can be set at the desired temperature without the intermediate -80°C stage.

Note: The pressure relief valves (Figure 11) underneath the protective covering will occasionally emit a plum of N_2 gas and mist. *Continuous* hissing indicates that the vacuum in the dewar jacket is probably inadequate. In this case, *first remove all LN from the dewar*, then reconnect the detector to the vacuum pump.

The cooler status indicator will turn from orange to green to indicate that the temperature is thermostated to within ±0.050°C. For an LN/CCD to reach -100°C normally requires 45-55 minutes.

Note: Temperature regulation does not reach its ultimate stability for at least 30 minutes after the green indicator LED has turned on. After this period of time the desired temperature is maintained with great precision.

Dewar options

Princeton Instruments, Inc. offers standard and large capacity dewars, to be specified at the time of purchase. The standard capacity dewar hold 0.5 liters of LN, while the large capacity holds 1.5 liters. This extra volume translates to roughly 3 times the hold time of the standard dewar. The large capacity dewar is now standard for many systems, so you may find that you have been shipped a large capacity dewar without having purchased this option. Other than for the slightly increased size of this dewar, there is no performance compromise.

LN Autofill

Princeton Instruments also offers an automatic LN feeding system where the LN flows from a large tank (31-liter capacity) to the dewar every preset period of time, e.g., 6 hours. The entire filling procedure is fully automatic and only requires refilling the tank every 2-4 weeks. See Appendix C for instructions concerning this system.

All-directional Dewar

Also available is the “all-directional” dewar, in both standard and large capacity versions. These dewars can operate in *any* angular orientation, but hold only about half as much LN as the normal versions, 0.25 liters for the standard and 0.75 liters for the large capacity. This reduced capacity translates to half the hold time as well.

Note: There is no simple way to verify whether you have been shipped an all-directional system simply by observing the detector. If you are uncertain, check the shipping paper-work to verify that your dewar is an all-directional model.

For operation of the all-directional dewar in a 90° orientation you can refill the dewar only through a special 90° funnel provided by PI. For operation at greater than 90° angles, there are only two refilling choices:

1. The dewar must be returned to a 0° orientation for refilling.
2. The dewar can be connected to the automatic refill system described above. Keep in mind that in severe orientations, e.g., upside down, refilling will be less efficient.

Chapter 4
Focusing

Detectors for both imaging and spectroscopic applications must be focused for maximum resolution. Imaging applications require adjustment of both the lens and the lens adapter. Spectroscopic applications demand both focusing and alignment of the spectrum.

Baseline Signal

With the detector completely blocked, the CCD will collect a dark charge pattern, dependent on the exposure time and detector temperature. The longer the exposure time and the warmer the detector the larger and less uniform this background will appear.

Note: Do not be concerned about either the DC level of this background or its shape unless it is very high, i.e., > 1000 counts. What you see is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. Every device has been thoroughly tested to ensure its compliance with PI's demanding specifications.

CAUTION If you observe a sudden change in the baseline signal you may have excessive humidity in the detector vacuum enclosure. Turn off the controller, remove the liquid nitrogen, and pump the detector for 30 to 60 minutes. If problems persist call the factory.

All CCD arrays have been tested for uniformity and do not exhibit any vignetting (reduction of response) at the extreme ends of the array. If you do measure such reduction in response across the array, it may be the result of one or more of the following conditions:

- Condensation of water on the edges of the array window has occurred. This should not happen unless the cooling/pumping instructions, previously mentioned, were not followed or if the dewar has sprung a leak (a rare situation).
- The arrays are held with a special mask that has been designed to minimize reflection and stray light. These masks were designed to allow light rays to enter through the dewar window even at very wide angles ($\geq$ f/1.5). If vignetting is observed, it is possible that your experiment exceeds these angular constraints. PI measures the array response with a collimated uniform light source to prevent such false bias results.

Shutter

Most experiments will utilize the shutter provided by Princeton Instruments, Inc. It is important to realize the limitations of the shutter, including its mechanical lifetime. These shutters are designed to be easily replaced. In case a shutter does cease functioning, contact the factory.

Every shutter housing has a window to protect the shutter mechanism from external dust and humidity. Since each window causes a small signal loss, all PI shutters have a removable window. Added caution must then be used in the handling and storage of the detector.

Note: Electromechanical shutters typically have a lifetime of a million cycles or more. Avoid running the shutter unnecessarily. Also avoid using shorter exposure times and higher repetition rates than are required.

WARNING

Disconnecting or connecting the shutter cable to the detector while the controller is on can destroy the shutter or the shutter driver in the controller!

Overheating

The 25 mm shutter for spectroscopy has a built-in thermal interlock to prevent overloading of its coil. If run at a high repetition rate, the shutter may heat enough to trigger the interlock, disabling the shutter.

If your shutter suddenly stops running, stop the experiment and wait. The shutter should resume functioning when it has cooled down sufficiently, typically within an hour. Avoid repeating the conditions that lead to the shutter overheating, or take breaks between data collections.

Larger shutters do not normally exhibit thermal overloading, so they do not require a thermal interlock.

Imaging Systems

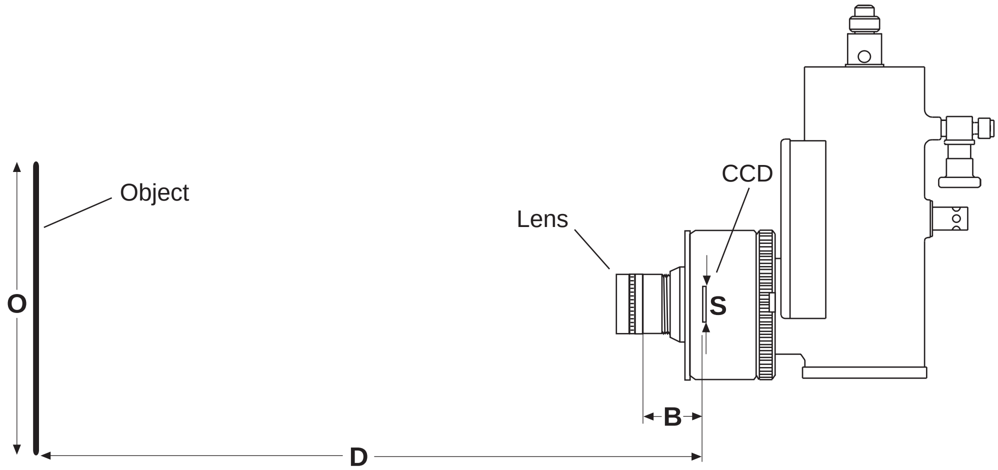
- If the software is not yet running, set it to the Freerun and Asynchronous modes.
- Slowly uncover the lens. If the image becomes washed out cover the lens quickly, and choose a shorter exposure.
- Adjust the exposure until a suitable value is found. Check the brightest regions of the image to determine when the full scale of the A/D converter is being used.
- Place a suitable target in front of the lens. An object with text or graphics works best.
- Set the focus adjustment of the lens to the correct distance between the camera and the object. The lens mount is in two sections to further adjust the focus. Loosen the set screws with a 0.050″ Allen wrench. Then rotate both the lens and the front part of the adapter until the image comes into focus. Tighten the set screws. All focusing may now be done with the adjustment on the lens.

Microscope adapters follow a similar procedure, except in this case the front part of the lens mount should not need adjustment. See the adapter literature for focusing directions.

Imaging field of view

When used for two-dimensional imaging applications, PI CCD cameras closely imitate a standard 35 mm camera. Since the CCD is not the same size as the film plane of a 35 mm camera, the field of view at a given distance is somewhat different.

Figure 12. Imaging field of view.



D = distance between the object and the CCD

B = 46.5 mm (Nikon bayonet only)

F = focal length of lens

S = horizontal or vertical dimension of CCD

O = horizontal or vertical field of view covered at a distance D

M = magnification

The field of view is:

$$O = S/M, \quad \text{where} \quad M = \frac{FD}{(D-B)^2}$$

Spectroscopy Systems

Focusing and Alignment of Array Detectors

The detector mounting hardware provides two degrees of freedom, focus and rotation. The approach taken is to slowly move the detector in and out of focus and adjusting for optimum while watching a live display on the monitor, followed by rotating the detector and again adjusting for optimum. The detailed procedure follows.

- Mount a light source such as a mercury pen-ray type in front of the entrance slit. Any light source with line output can be used. Standard fluorescent overhead lamps have good calibration lines as well. If there are no “line” sources available, it is possible to use a broad band source such as tungsten for the alignment. If this is the case, use a wavelength setting of 0.0nm for alignment purposes.
- With the spectrograph properly connected to the controller, turn the power on, wait for the spectrograph to initialize. Then set it to 435.8 nm if using a mercury lamp or to 0.0 nm if using a broadband source.

  Hint: Overhead fluorescent lights produce a mercury spectrum. Use a white card tilted at 45 degrees in front of the entrance slit to reflect overhead light into the spectrometer. Select 435.833 as the spectral line.

- Set the Exposure Time of the array to a convenient value somewhere in the range of 0.1 s to 1 s.
- Set the slits to 25 µm.
- Run the Detector in live mode and watch the display on the monitor.

  Hint: If using WinView or WinSpec, simply select RUN with Freerun and asynchronous timing (SYNCHRONOUS not selected). If using WinView/32 or WinSpec/32, select FOCUS with Freerun and Safe Mode (asynchronous) timing selected.

- Slowly move the detector in and out of focus. You should see the spectral line go from broad to narrow and back to broad. Leave the detector set for the narrowest achievable line.

  Note: Focusing the detector is achieved differently on different spectrometers. On models where the adapter is made of two pieces that slide together, focusing is achieved by slowly sliding the detector in and out of the exit focal plane. One-piece adapters rely on a focusing adjustment on the spectrometer. See the spectrometer manual for details.

- Next adjust the rotation. You can do this by rotating the detector while watching a live display of the line. The line will go from broad to narrow and back to broad. Leave the detector rotation set for the narrowest achievable line.

  Alternatively, take an image, display the horizontal and vertical cursor bars, and compare the vertical bar to the line shape on the screen. Rotate the detector until the line shape on the screen is parallel with the vertical bar.

Note: When aligning other accessories, such as fibers, lenses, optical fiber adapters, first align the spectrograph to the slit. Then align the accessory without disturbing the detector position. The procedure is identical to that used to focus the spectrograph, i.e. do the focus and alignment operations while watching a live image.

Appendix A

Outline Drawings

Figure 13. Dewar Outlines.

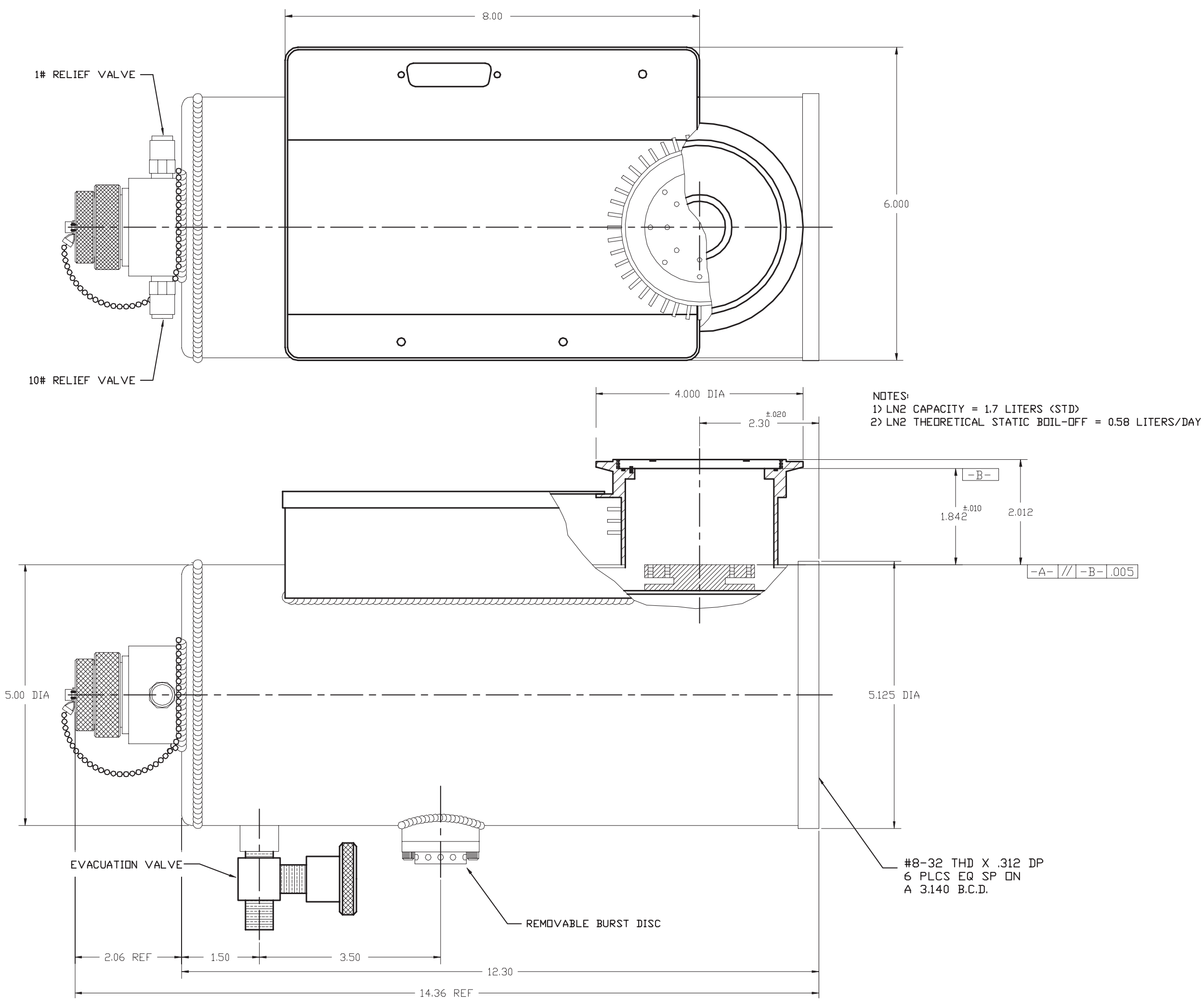


Figure 14. Side-On dewar, narrow fill port.

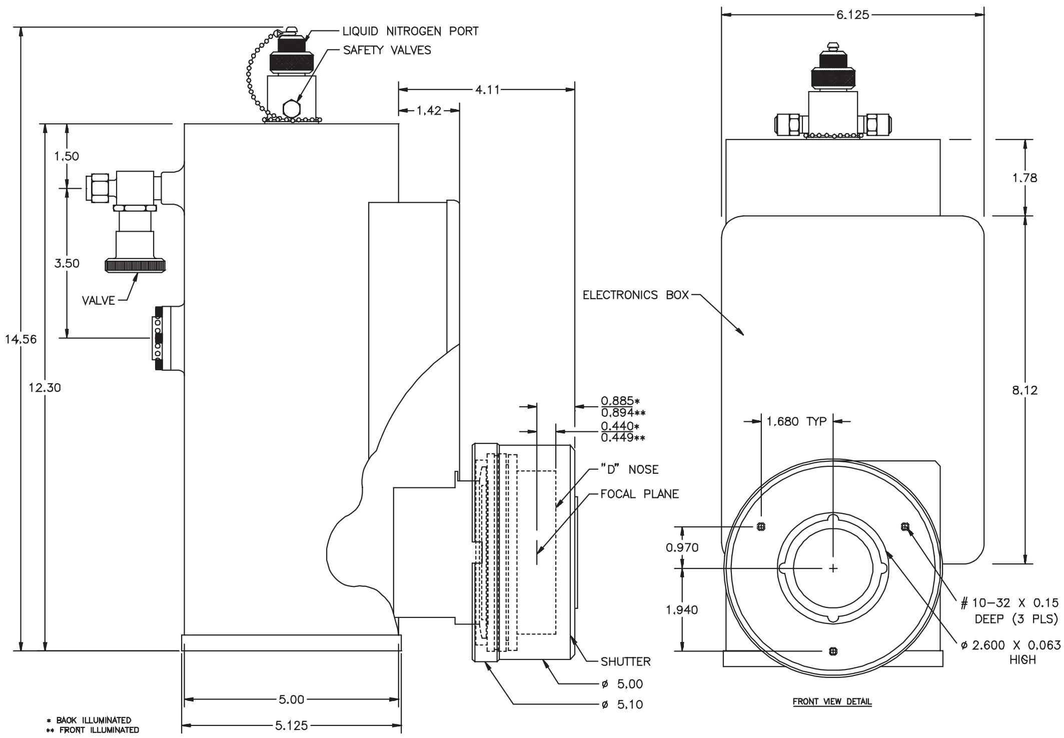
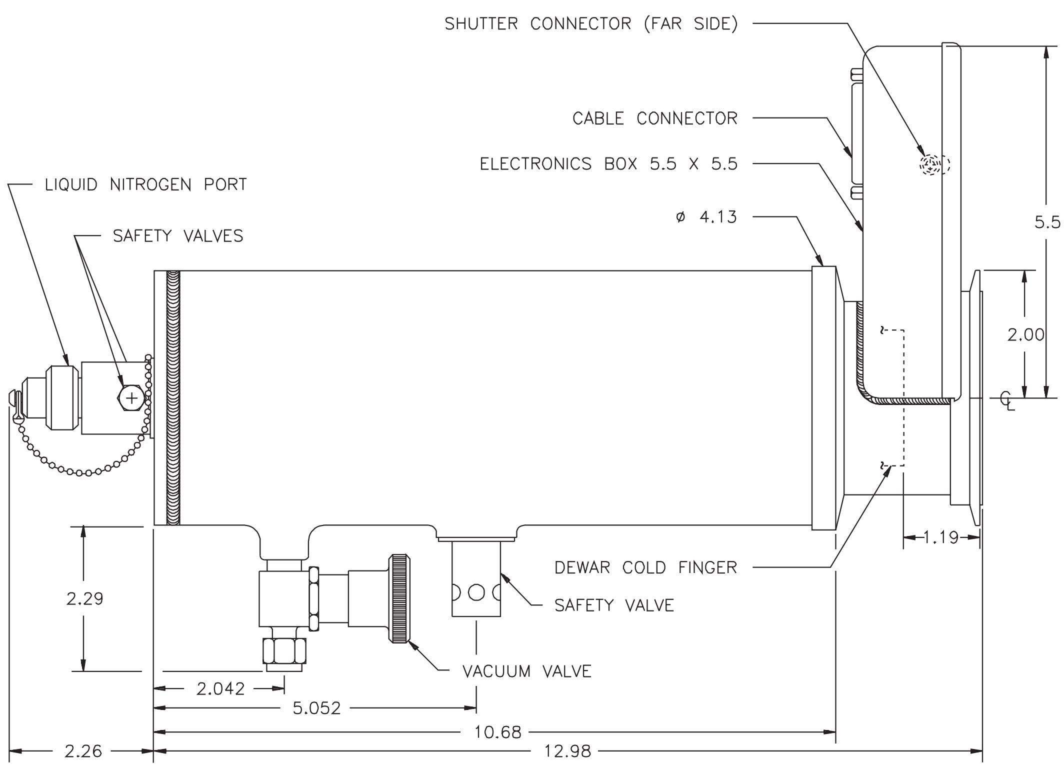


Figure 15. End-On dewar.



Appendix B
Vacuum Restoration

Introduction

All Princeton Instruments, Inc. LN/CCD detectors must operate in a vacuum. A pressure of ~10 mTorr is needed to prevent condensation and contaminants from collecting on the CCD, which could ruin it.

All dewars are pumped for 72 hours at the factory while being baked at the maximum allowable temperature. This procedure removes impurities, especially water vapor, from the vacuum chamber. In addition, the vacuum vessel contains two traps to adsorb contaminants over the lifetime of the dewar (years). Finally, the PI design ensures trapping of any remaining contaminants on very low temperature surfaces to ensure a clean array surface.

All dewars are helium-leak tested to ensure a total seal. The vacuum valves are of the highest commercial vacuum grade. Each valve is individually tested and certified by the manufacturer for its vacuum integrity. As a result of the care taken to ensure vacuum quality, users can reasonably expect a long period of operation without need for concern about the vacuum. However, it could happen that vacuum deterioration could eventually occur, in which case restoring the original vacuum level would be required. If this happens, we recommend that you contact the factory and arrange to have the unit returned to the factory for repumping and vacuum testing.

If your facility has the necessary equipment and personnel with the necessary vacuum pumping expertise, it may be possible to repump the vacuum at your facility as described in the following procedure.

CAUTION

Your vacuum system *must* have a trap (ideally cryogenic) placed between the detector and the pump to prevent contamination due to backstreaming from the pump.

Note: New detectors will experience a higher outgassing rate than detectors that have been in operation for several months. Therefore, if a detector does not retain LN for the minimum holding time, it should be pumped.

WARNING

Operating the detector without proper vacuum may cause serious or irreversible damage. Do not operate the detector unless the vacuum chamber is evacuated.

Procedure

WARNING Do not attempt to pump down the detector with liquid nitrogen present in the dewar. Carefully pour out any remaining LN and wait for the detector to reach room temperature. Pump down according to the instructions below.

- Remove the nylon plug on the open end of the vacuum valve. Save the plug.
- Connect this end of the vacuum valve to the vacuum system. This is a ¼″ Swagelock connector. Do not open the vacuum valve yet.
- Begin pumping. The vacuum equipment should first be pumped down to a reasonable level before the vacuum valve is opened.
- When a reasonable vacuum level is reached (~20 mTorr), open the vacuum valve by turning the brass knob counterclockwise a few turns.
- If you are using a simple forepump (rotary), pump down to 5-20 mTorr. If you have a dual pump station, e.g., forepump/diffusion pump or forepump/turbo pump, pump down to 10^{-5} to 10^{-6} Torr for better performance. Initially, overnight pumping may be required to reach these levels.
- When evacuation is complete, firmly tighten the vacuum valve by hand. *Do not overtighten.* The vacuum block is now sealed.
- Remove the vacuum system from the Swagelock connector. Replace the nylon plug to prevent accidental loss of vacuum.

Appendix C
Autofill System

Figure 16.
Autofill System.

General Information

Two regulated power supplies provide power for the sensor and logic circuitry, ensuring reliable operation under varying AC line and transient conditions. A dual wound transformer allows for operation from 105-125 V or 210-250 V, as set at the factory.

All operational controls for the LN2 level controllers are located on the front panel of the Autofill Controller, with power, sensor and control connections at the rear. Maintenance is minimized by use of a single printed-circuit board plug-in module containing all of the electronic components.

Specifications

Cabinet: Height 2-1/8″, Width 6-1/8″, depth 6-3/4″, brushed aluminum panel, with blue enamel cover.

Panel Mounting: Available mounted one or two units on 3½″ × 19″ brushed aluminum standard rack panel.

Power: 105-125 VAC, 50-60 Hz (210-250 VAC Optional).

Fuse: 3 Amperes.

Cord: 8’ 3-wire with polarized plug.

Outlet: 115 VAC, 3 wire receptacle.

Sensor: Encapsulated 5/32″ O.D. × 1¼″ long, on SN2 Upper Sensors and SNTDF Sensors.

LN Input to Autofill Dewar: ¼″ NPT fitting.

Operational Check

- Plug the unit into a suitable power source (see specifications).
- Set the Power switch to the ON position and verify that the power indicator is illuminated.
- Verify that the solenoid indicator is illuminated. This indicator should be illuminated when the sensors are not in cryogenic liquid.
- If an alarm is installed, check that the buzzer is making noise when the alarm sensor is not immersed in cryogenic liquid. A switch is provided to turn the buzzer off.

Sensor Installation Notes

Sensors work on the principles of thermal conductivity. They are internally heated to help differentiate between the gas and liquid phase of the cryogenic liquid. If they are in liquid, the heat is conducted away. When they are surrounded by gas, they warm up and the controller interprets this condition to mean that they are out of the cryogenic liquid. When mounting, the sensor tips ***must not*** come in contact with thermallly conductive materials, such as steel. Also, the sensors should ***not*** be covered with any material.

Operation

Manual Mode on all Controllers

In the Manual position, the transfer line solenoid is activated, allowing the cryogenic liquid to flow into the reservoir. The liquid will continue flowing until it is manually turned off.

SN1 - Single Sensor LN2 Level Controller

In the Auto position, the solenoid output is activated when the sensor is not in liquid. If the sensor is in liquid, the output is off.

SN2 - Dual Sensor LN2 Level Controller

In the Auto position, with one sensor placed at the lower limit and the other sensor placed at the upper limit, the solenoid output is activated when the liquid level is below the lower sensor. The level will rise until it is above the upper sensor and the output will be turned off.

SNT - Time Cycle LN2 Level Controller

In the Auto position, with the sensor placed at the lower limit, the solenoid output is activated when the liquid level is below the sensor. As the level begins to rise above the sensor, the timing will start. The time interval is adjustable from the front control knob. Its nominal range is 0 to 6 minutes. The solenoid output will turn off when the set time expires.

SNTDF - Time Cycle Delayed Fill Level Controller

In the Auto position, with the sensor placed at the upper limit, the timer will start when the liquid level is below the sensor. The time interval is adjustable from the front control knob. Its nominal range is 0 to 20 hours. When the time runs out, the solenoid output will become activated and replenishment will begin. When the liquid level is above the sensor, the output will turn off.

Alarm Options

All LN2 level controllers can have either a standard alarm option or a valve operator alarm option. The standard alarm is a low-level alarm. It is activated when the sensor is not in liquid. If a *high* alarm is custom ordered, then the alarm indicates when the sensor is in the liquid.

Valve Operator Alarm Option

This option operates like the standard alarm but you also have a valve operator socket on the back panel. This socket is normally activated. When the alarm is activated, the socket is turned off. The alarm switch has no effect on this socket.

Figure 17. Autofill Schematic.

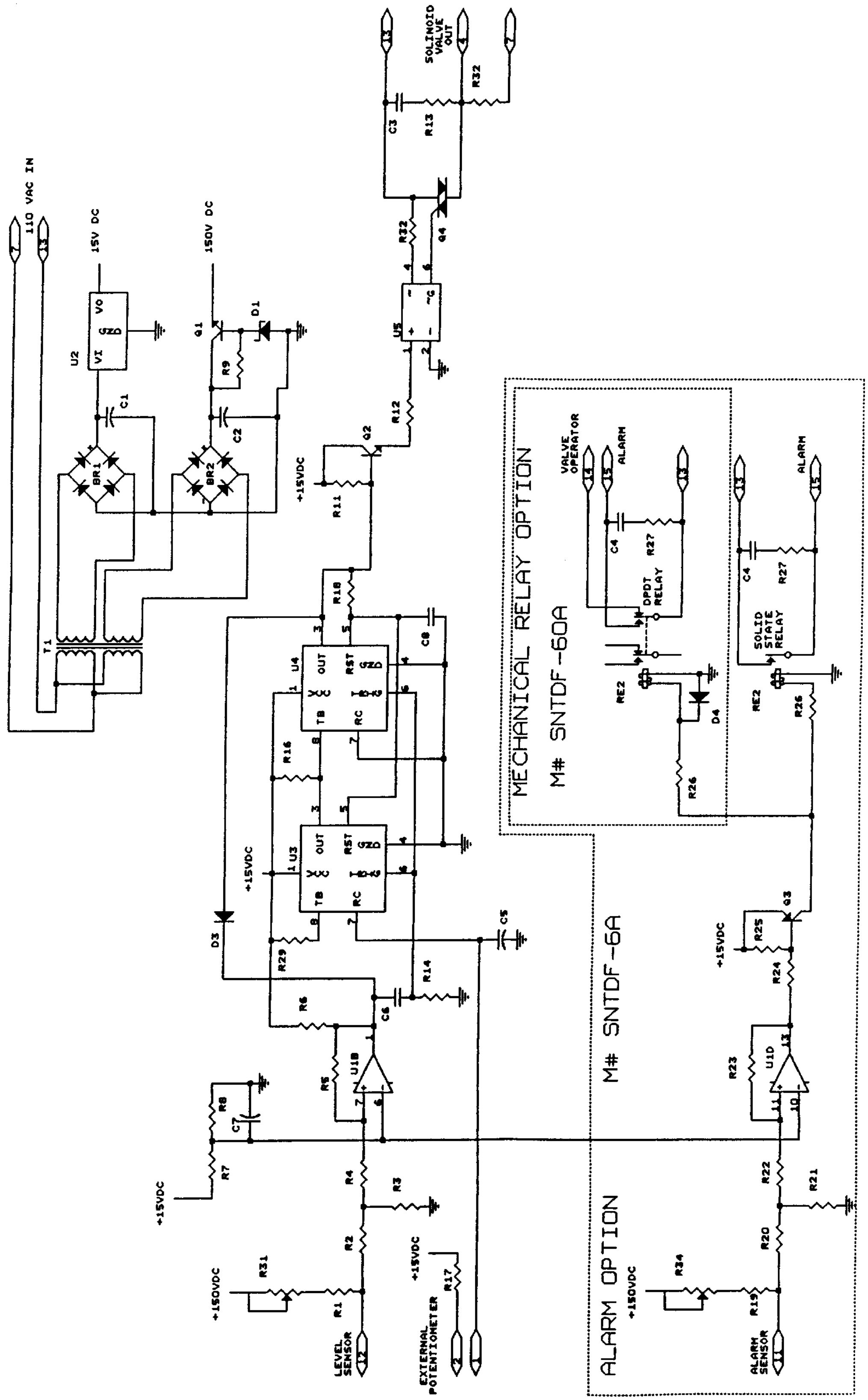
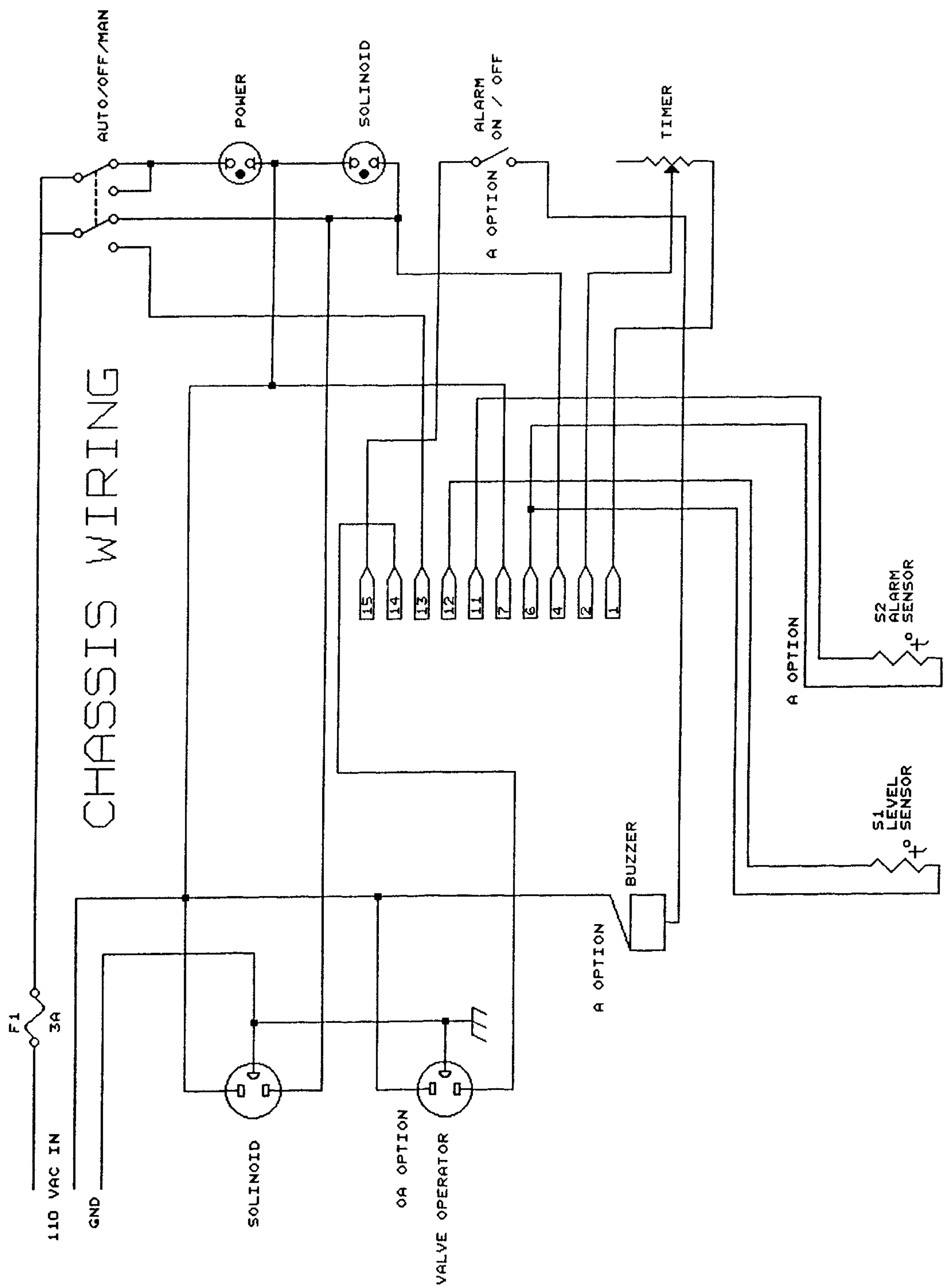


Figure 18. Autofill Chassis Wiring diagram.



Warranty and Service

Warranty

This equipment is warranted to be free from defects of material and workmanship. It is sold subject to the mutual agreement that the liability of Princeton Instruments, Inc., is limited to replacing defective parts and/or repairing malfunctioning equipment at its factory, provided the equipment is returned, transportation prepaid, within twelve (12) months of its factory ship date.

The purchaser agrees that Princeton Instruments, Inc. shall assume no liability for consequential damages resulting from its use or from packaging of shipments returned to the factory.

Components which are damaged by misuse are not warranted. Units which have been modified by a customer are not warranted.

UV coatings are not covered by this warranty.

Equipment Repairs

It is recommended that units requiring service in the United States be returned to the factory located in Trenton, New Jersey. Before instrumentation is returned for service, please consult a service engineer at the factory. In many cases, the problem may be cleared up over the telephone.

If the unit needs to be returned, the service engineer will ask for a detailed explanation of the problems encountered and a purchase order to cover any charges. You will then receive a Returned Materials Authorization (RMA) number. Place this number on the package so the returned equipment can be easily identified when received at the factory. You must also include with the equipment a completed RMA form explaining the symptoms or problems encountered. Without this document, repair turnaround time will be considerably longer.

If the unit is under warranty, the customer is only responsible for the transportation and insurance charges to Princeton Instruments. Princeton Instruments is responsible for the return transportation charges. If the unit is out of warranty, the customer is responsible for all transportation charges (including insurance and duty fees, when applicable) as well as all charges incurred to perform the repairs. In this case, the customer can decide the insurance value.

International customers should contact your local manufacturers representative or distributor for repair information. *See next page for contact information.*

Contact Information

Princeton Instruments’ manufacturing facility is located at the following address:

Princeton Instruments, Inc.
3660 Quakerbridge Road
Trenton, NJ 08619 (USA)

Tel: 609-587-9797
Fax: 609-587-1970

Tech Support E-mail: techsupport@prinst.com

For technical support and service outside the United States, see our web page at www.prinst.com. An up-to-date list of addresses, telephone numbers, and e-mail addresses of Princeton Instruments’ overseas offices and representatives is maintained on the web page.

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