Princeton Instruments

NTE/CCD Detector

ROPER SCIENTIFIC™
BEYOND IMAGING

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Introduction

Manual Overview

This manual provides the user with all the information needed to install a NTE/CCD Detector and place it in operation. Topics covered include a detailed description of the NTE Detector, installation, microscopy applications, cleaning, specifications and more.

Chapter 1*, *General Information provides an overview of the NTE/CCD Detector.

Chapter 2, Detector Setup provides detailed directions connecting the detector, installing it for spectroscopy or imaging, and over-exposure protection considerations.

***Chapter 3*, Cooling the Detector** discusses how to establish and maintain temperature control with a ST-133 or ST-138 Controller. Also provides information on the effects of long-term vacuum degradation on cooling capability and temperature control.

Chapter *4*, Focusing discusses how to focus the detector in both spectroscopy and imaging applications.

Chapter 5, Microscopy Applications discusses how to mount the NTE/CCD Detector to a microscope. Includes discussion of various adapters, focusing considerations and sensitivity to damage from EMF spikes generated by Xenon or Hg arc lamps.

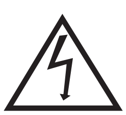
***Chapter 6,* Operation** discusses a number of topics, including effects of high humidity, UV effects on the scintillator coating, baseline signal and noise.

***Chapter 7,* Cleaning** contains directions for cleaning the detector's housing and optics.

Appendix A, Specifications includes detector specifications.

Appendix B, Outline Drawings includes outline drawings of Spectrograph mount, C-mount, F-mount, and fiber-optic coupled detectors.

Safety Related Symbols Used In This Manual



Caution! Risk of electric shock! The use of this symbol on equipment indicates that one or more nearby items pose an electric shock hazard and should be regarded as potentially dangerous. This same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.

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Chapter 1

General Information

Figure 1. NTE/CCD Detectors and Cameras

Description

The NTE/CCD air-cooled detector or camera is ideally suited for medium light level applications. State-of-the-art CCD arrays are available for the NTE/CCD that enable outstanding performance in a wide range of applications for spectroscopy, biological imaging, and physical science investigations.

Design

NTE/CCD detectors have three distinct sections. The front vacuum enclosure contains the CCD array seated on a cold finger. This finger is in turn seated on a four-stage Peltier thermoelectric cooler. The back enclosure contains the heat exchanger. An internal fan cools the heat exchanger and the waste heat exits the unit through openings in the detector housing.

The electronics enclosure contains the preamplifier and array driver board. This keeps all signal leads to the preamplifier as short as possible, and also provides RF shielding.

The NTE/CCD detector is available in both C-mount and F-mount configurations. *See Chapter 5 for detailed information on microscopy*.

Chapter 2
Detector Setup

This chapter covers the setup procedures for both imaging and spectroscopic applications.

General Instructions

The following 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, and then connect the larger end of the cable to the port marked **Detector** on the controller. The detector end of the cable is secured by a slide-lock latch. The controller end of the cable, depending on the model of controller, is secured by a slide-lock latch or by screws. Tighten the screws in place.

Controller Internal Switches

Any user who will be running both NTE/CCDs ***and*** LN/CCDs with an ST-138 controller must ensure that the internal power supply switches inside the controller are set properly. Consult the controller manual for instructions on setting these switches. In the case of the ST-133 Controller there are no internal switches.

Note: If the system includes an ST-138 that was ordered with the NTE/CCD, the internal switches will be properly set. These switches are only a consideration if an already available controller is to be used with both NTE and LN detectors.

Gain Control

A gain control switch is provided on most NTE/CCD detectors. This allows the user to select one of three settings, LO, MED and HI, which change the detector gain to 0.5×, 1× and 2×. This switch is active when the detector is being controlled by an ST-138. If an ST-133 controller is being used, the switch is deactivated and gain control is accessed in the software.

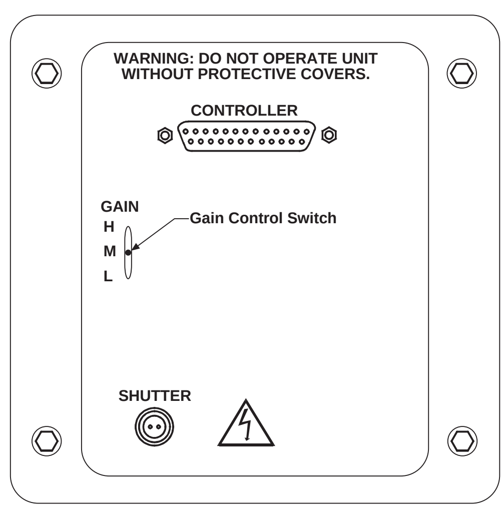


Figure 2. NTE Detector Rear Panel

The gain of the detector should generally be set so that the overall noise is ~1 count RMS. In most instances this will occur with the switch set to MED. If the array is a 1340 × 100 or 1340 × 400 *configured with the low-noise output*, LO will probably be a more suitable Gain setting. In situations where the A/D range exceeds that of the array, it will generally be better to set the Gain to HI so that the signal can be spread over as much of the A/D range as possible. This is a particularly important consideration in absorbance measurements. Users who consistently measure low-level signals may wish to select HI, which reduces some sources of noise. Users who measure high-level signals may wish to select LO to allow digitization of larger signals. Customized values of gain can be provided. Contact the factory for additional information.

Spectroscopy Setup

This section describes how to set up the detector for spectroscopy applications. Instructions for imaging applications appear later in this chapter. Microscopy applications are discussed in Chapter 5.

Spectrograph Theory

In a typical spectrograph, light enters the entrance slit and is collected by a collimating mirror. Essentially, what a spectrograph does is to form an image of the entrance slit in the exit focal plane with each position in the plane representing a different wavelength. Collimated light strikes the grating and is dispersed into individual wavelengths (colors). Each wavelength leaves the grating at a different angle and is reimaged by a focusing mirror onto a CCD detector at the exit focal plane. As each wavelength images at a different horizontal position, the spectrum of the input light is spread across the CCD. Individual wavelengths focused at different horizontal positions along the exit port of the spectrograph are detected simultaneously. Rotating the diffraction grating scans wavelengths across the CCD, allowing the intensity at individual wavelengths to be easily measured.

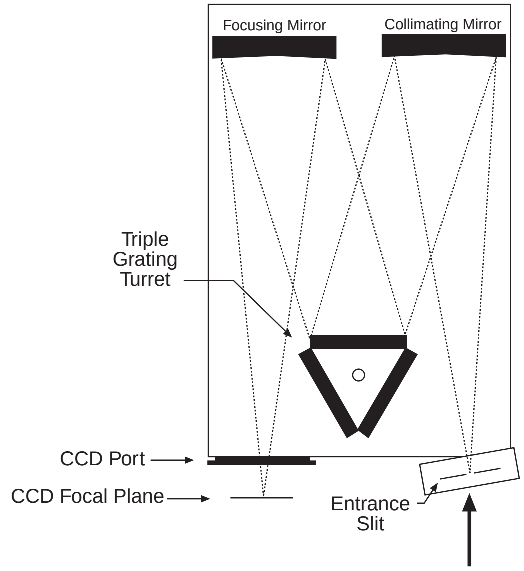


Figure 3. Annotated Spectrograph Drawing

Array Orientation

For spectroscopy, the detector should be mounted so that the short axis of the CCD is parallel to the entrance slit. The long axis will therefore correspond to the wavelength axis of the spectrum. Because the NTE/CCD Detector is ordinarily not internally shuttered in spectroscopy applications, the orientation of the CCD can be readily determined by visual inspection of the faceplate. The faceplate cutout closely corresponds to the dimensions of the underlying CCD array, which will itself be visible through the window.

Square-format CCDs can also be used for spectroscopy, although they are more often used in imaging applications. For square format CCDs (e.g. 512 × 512 or 1300 × 1340), the user may orient the CCD to achieve binning along either direction of the CCD. Binning along the rows (perpendicular mode) minimizes cross-talk and is therefore better for multi-spectral applications. The drawback to this method is that scanning is slower and noise may increase somewhat.

Binning along columns (parallel mode) provides maximum scan rate and lowest noise. NTE/CCD users can easily switch between these orientations by simply rotating the detector 90°.

Deep Focal Plane Spectrographs

Spectrographs with the focal plane 25 mm or more beyond the exit interface are called *deep focal plane* spectrographs. Such spectrographs include Acton (adapters are available for all Acton models), 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 spectrograph manufacturer.)

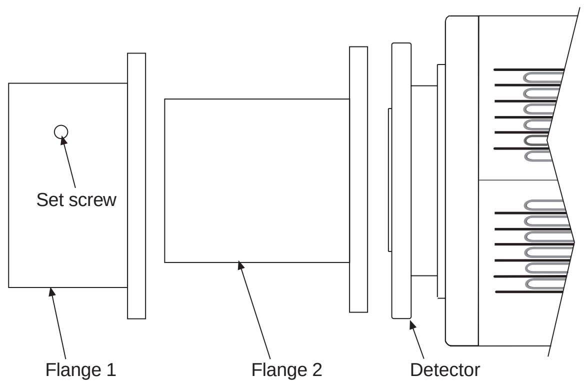


Figure 4. Adapter for a Deep Focal Plane Spectrograph

Adapters for these spectrographs are generally in two pieces, as shown in Figure 4. The generic assembly directions that follow can be used as a general guide.

Mounting Directions

1. Bolt Flange 2 to the NTE/CCD Detector using the screws provided.
2. Next, loosen the setscrews (3) on Flange 1.
3. Mount Flange 1 to the spectrograph.
4. Slide Flange 2 into Flange 1.

Do not tighten the setscrews until focusing and alignment are achieved as discussed in Chapter 4.

Shallow Focal Plane

Shallow focal plane spectrographs are ones with a focal plane that is less than 25 mm beyond the exit interface. The detector mount provided in these cases does not allow focusing via the adapter. Focusing must be accomplished by adjusting the spectrograph. The generic assembly directions that follow can be used as a general guide. However, note that detailed instructions for your specific adapter are provided in the bag of adapter parts.

Mounting Directions

1. Mount the flange to the detector using the two half-rings and the screws provided. Note that the tapered side of each half-ring faces the adapter (Figure 5).
2. Next, thread the 10-32 hex screws halfway into three of the six tapped holes in the spectrograph's exit plane.
3. Position the detector so the three hex head screws line up with the openings in the adapter flange.
4. Slide the detector over the screws and rotate into the proper orientation.
5. Leave the detector free to rotate until it is aligned as described in Chapter 4.

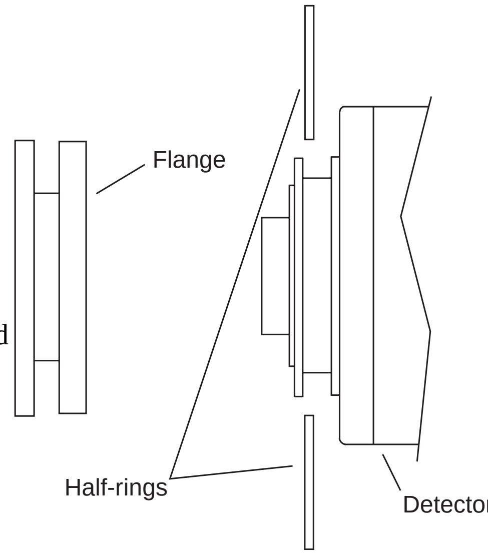


Figure 5. Shallow Focal Plane Spectrograph Mounting Hardware

Entrance Slit Shutter

An entrance slit shutter can either be mounted on the entrance slit of the spectrograph 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 (Figure 6) is for use with CP-200 and HR-320 Spectrographs.

First Shutter Type Mounting Directions

1. Remove the Adapter Mount Cover by removing the four Phillips head screws.
2. Place the Adapter Mount Body over the entrance slit.
3. Mount it by threading the Retainer to the spectrograph.
4. Replace the shutter and the Adapter Mount Cover.

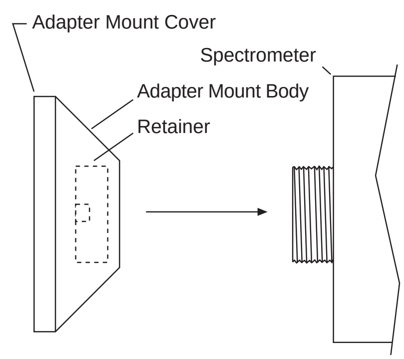


Figure 6. One Type of Entrance Slit Shutter Mount

Second Shutter Type Mounting Directions

The second shutter mount, used with all Acton Research spectrographs, requires no disassembly. Mount it to the spectrograph as shown in Figure 7.

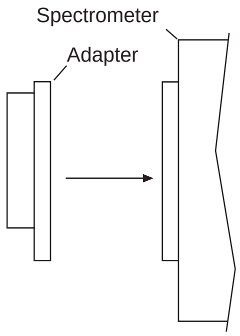
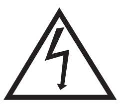


Figure 7. Entrance Slit Shutter for Acton Spectrographs

The shutter cable should be connected to the Shutter Power connector on the rear panel of the NTE/CCD Detector or to the Shutter Power connector on the ST-133 Controller. In many systems, cable length considerations will make it more convenient to connect to the Shutter Power connector on the detector.



WARNING: Dangerous live potentials are present at the Remote **Shutter** power connector. To avoid shock hazard, the Controller power should be OFF when connecting or disconnecting a remote shutter.

Overexposure Protection

Detectors that are exposed to room light or other continuous light sources will quickly become saturated. This most often occurs when operating without a shutter. Saturation is not harmful to a non-intensified detector. To reduce the incident light, close the entrance slit of the spectrograph completely.

Imaging

This section describes how to connect lenses to the detector for imaging applications. Instructions for spectroscopic applications appear later in this chapter. Microscopy applications are discussed in Chapter 5.

NTE/CCD Detectors use either a C-mount or a Nikon bayonet adapter. If you cannot use the adapter you received, contact the factory for technical support or replacement. *See page 50 for Information on accessing the Roper Scientific Technical Support Dept.*

Nikon (F-mount) Bayonet

To attach an F-mount lens to the detector, the unit must be equipped with an F-mount adapter. *The adapter type must be specified at the time of purchase.*

To Mount the Lens on the Detector:

1. Locate the large indicator dot on the side of the lens.
2. Note the corresponding dot on the front side of the adapter.
3. Line up the dots and slide the lens into the adapter.
4. Turn the lens counterclockwise until a click is audible. The lens is now locked in place.
5. In addition to the focusing ring of the lens, there is provision for focusing the adapter itself. The adjustment is secured by #4-40 setscrews on the *inside* of the adapter. Directions for focusing the lens *and* the adapter are provided in Chapter 4.

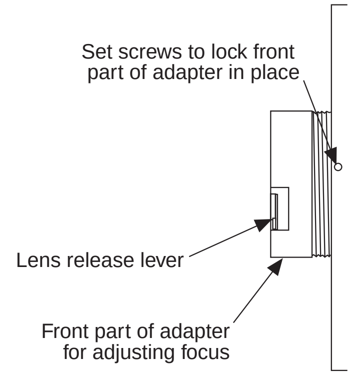


Figure 8. Nikon Lens Adapter

To Remove the Lens:

1. Locate the lens release lever at the front of the lens mount.
2. Press the lever toward the detector housing and simultaneously rotate the lens clockwise.
3. Then pull the lens straight out.

Although microscopes more commonly are used with a C-mount adapter, operation with a detector having an F-mount adapter may also be possible. See Chapter 5, *Microscopy Applications* and the adapter literature for further directions.

C-mount

NTE/CCD detectors can be ordered with an integral C-mount adapter. C-mount lenses simply screw into the front of these detectors. Tighten the lens by hand only. See Chapter 5 for information on connecting to a microscope.

Note: C-mount detectors are shipped with a dust cover lens installed. Although this lens is capable of providing surprisingly good images, its throughput is low and the image quality is not as good as can be obtained with a high-quality detector lens. Users should replace the dust-cover lens with their own high-quality laboratory lens before making measurements.

Overexposure Protection

Set the lens to the smallest aperture (highest F-number) and cover the lens with a lens cap to prevent overexposure.

Chapter 3
Cooling the Detector

Introduction

The NTE/CCD detector is designed for cooled operation. A four-stage Peltier effect thermoelectric cooler, driven by closed-loop proportional-control circuitry, cools the CCD. A thermal sensing diode attached to the cooling block of the detector monitors its temperature. An internal fan draws air through the heat-exchanger to remove the waste heat and the warm air is exhausted through openings in the side of the housing.

Note: The power requirements of the NTE CCD Detector can not be met by a standard ST-133 or ST-138 Controller. Special high-power versions of these controllers have been developed for use with the NTE CCD Detector.

Setting the Temperature

ST-133 Controller

The temperature is set directly from the application software. It takes from 10-20 minutes for the NTE/CCD to reach and lock at the set temperature. The TEMP LOCK indicator on the back of the controller then lights to indicate that lock has been achieved. Application software, such as WinView/32 or WinSpec/32, may also provide a temperature locked indication (both WinView/32 and WinSpec/32 do this).

Note: Temperature regulation does not reach its ultimate stability for at least 30 minutes after temperature lock is established. Also note that the thermoelectric cooler has no capability to heat the CCD. These detectors are therefore more thermally stable at lower temperatures.

ST-138 Controller

The temperature is set by means of a dial on the front panel of the controller. Directions follow:

1. Turn the cooler switch on the front of the controller off.
2. Turn the power switch on.
3. Locate the Temp knob on the front of the controller. The dial reads in units of minus degrees Centigrade. See Figure 9 to locate the locking tab. Turn this tab counterclockwise until the Temp knob is free to rotate.

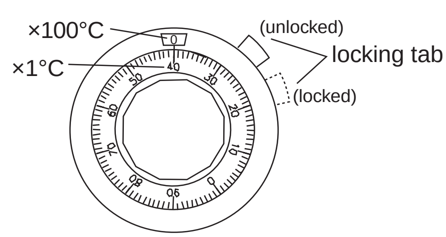


Figure 9. ST-138 Temperature Knob

4. On the top side of the Temp knob is a rectangular window that denotes hundreds of degrees 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) appears in the hundreds' box.
5. Then turn the knob until the desired value between 0 and 70 appears below the box.
6. Turn the locking tab clockwise to lock the Temp knob in place.

Figure 9 exhibits the position of the dial for a temperature of -50°C. Position 1 shows the locking tab in the unlocked position. Position 2 is the locked position.

Once cooling has been initiated, it takes from 10-20 minutes for the NTE/CCD to reach and lock at the set temperature. With an ST-138 controller, the cooler status indicator will turn from orange to green. Once lock is established, temperature is stable to within ±0.050°C.

Cooling Troubleshooting

Detector doesn't achieve Temperature Lock

If the indicator doesn't turn green after 30 minutes, the temperature setting may be at a temperature colder than the specified limit or the environment could be particularly warm. If this occurs, try a higher temperature setting. *Make sure you are selecting a temperature that is acceptable for your particular detector and CCD array.*

Cooling and Vacuum Level

With time, there will be a gradual deterioration of the detector's vacuum. This, in turn, will eventually affect temperature performance and it may no longer be possible to achieve temperature lock at the lowest temperatures. In the kind of low-light imaging applications for which cooled CCD detectors are so well suited, it is highly desirable to maintain the system's temperature performance because lower temperatures provide less thermal noise and better signal-to-noise ratio.

Vacuum deterioration occurs primarily as a result of outgassing of components in the vacuum chamber. Because outgassing normally diminishes with time, the rate of vacuum deterioration in new detectors will be faster than in old ones. As a result, each time the detector is repumped, the new vacuum will remain good for a longer time than the previous one. In any case, should you notice a gradual deterioration in temperature control performance, the detector should be repumped.

- If you have the appropriate equipment and personnel with the necessary expertise available, you may wish to pump down the detector at your facility. *Contact the factory Technical Support Dept. for information on how to refresh the vacuum. See page 50 for contact information.*

If the necessary equipment and expertise is not available, simply contact the factory to make arrangements for returning the detector to have the vacuum restored.

WARNING The CCD array is subject to damage from condensation if exposed to the atmosphere when cold. For this reason, the detector should be kept properly evacuated or backfilled with dry nitrogen, free of oil or other contaminants.

Detector loses Temperature Lock

The internal temperature of the detector is too high. This might occur if the operating environment is particularly warm or if you are attempting to operate at a temperature colder than the specified limit. If this happens, an internal thermal overload switch will disable the cooler circuits to protect them. Typically, detector operation is restored in about ten minutes. Although the thermal overload switch will protect the detector, users are advised to power down and correct the operating conditions that caused the thermal overload to occur. *With some versions of the software, the* ***indicated*** *temperature when the camera is in thermal overload (thermal switch is in the cut-out state) is -120° C.*

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Chapter 4
Focusing

Introduction

Detectors for either imaging or 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 detector to the spectrograph.

One of the limitations of scientific non-video rate detectors has been their difficulty in focusing and locating fields of view.

The ST-133 Controller solves the focusing problem by its combination of high-speed operation with the implementation of true video output. The high-speed image update on the video monitor makes focusing and field location as simple as with a video detector. This video output also makes possible archiving an experiment on a VCR, producing hardcopy data on a video printer, or even implementing autofocusing stages. Note that video is only available at fast A/D rates, such as 1 MHz.

The video output must be selected by the Application software. In the case of WinView/32 or WinSpec/32, this is done by selecting **Video** from the Acquisition menu. For setup, you will want the fastest possible acquisition and display, achieved by operating with **Free-Run** in the **Focus** mode with **Safe** (Asynchronous) timing. There is also provision in these application programs for intensity-scaling the video output, that is, selecting the specific gray levels to be displayed on the 8 bit video output.

The ST-138 Controller, if operated with WinView 1.6, provides one solution to this problem with its Moviemode feature, which provides fast real-time image display and easiest focusing. In this mode, the controller uses a built-in lookup-table to select the data to be displayed. Each two-byte pixel is mapped to 8 bits in hardware before transfer to the computer. The 8 bit data can then be sent directly to the monitor for display, resulting in a display rate up to several frames per second, many times faster than systems without this option. If operating with WinView/32 or WinSpec/32, select **Free-Run** and **Safe** and operate in the **Focus** mode for the fastest possible data acquisition.

Focusing and Alignment in Spectroscopy

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 adjust for optimum while watching a live display on the monitor, followed by rotating the detector and adjusting for optimum. The following procedure, which describes the focusing operation with an Acton SpectroPro® 300i (SP300i), can be easily adapted to other spectrographs.

1. Mount a light source, such as a mercury pen-ray type, in front of the entrance slit of the spectrograph. 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.

2. With the Model SP300i properly connected to the controller, turn the power on and 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 spectrograph. Select 435.833 as the spectral line.

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

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

6. 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.
7. 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).

Focusing in Imaging Applications

Lens Performance Considerations

Imaging applications require that a lens be mounted to the detector. Because the lens characteristics affect system performance, it may be helpful to review some basic lens concepts. Basically, light from a subject enters the front of the lens and is focused to a sharp image on the focal plane (CCD surface). The ability of the lens to do this well depends on a number of factors, as follows.

Throughput: The throughput of a lens is determined by its aperture, which can ordinarily be set to a number of different values, or f/ stops. The higher the number the smaller the aperture and the lower the throughput. Depth of field considerations make it imperative that focusing be done at maximum aperture (smallest f/).

Resolution: This is a measure of the sharpness of the lens, that is, of its ability to resolve two closely spaced lines. Resolution is commonly expressed as the Modulation Transfer Function (MTF), which specifies the number of line pairs per mm that can be resolved for a given valley depth between the two lines of each pair. In comparing the MTF of two lenses, it is important that the specified valley depth for both be the same. For any real lens, resolution is a function of f/, with maximum sharpness most often occurring at some mid-range value. Thus, a lens that offers f/ settings from f/2.8 to f/22 will probably be sharpest at f/8 or f/11. For this reason, even though focusing should be done at maximum aperture, actual data acquisition should be done with a mid-aperture setting.

Depth of Field: A measure of how the sharpness of a lens varies with respect to the distance of an object from the lens. For any given aperture, there is a depth of field, usually marked on the barrel of the lens. Objects within the zone will be sharply imaged. Objects closer or further than the depth of field will not be as sharp. The further an object is from the point of sharpest focus, the less sharp its image on the CCD will be. *The point of maximum sharpness is located 1/3 of the way into the depth of field zone.* For example, if the indicated depth of field for the selected aperture extends from 3 ft to 6 ft, the point of maximum sharpness will be at 4 ft.

For good focusing sensitivity, the depth of field should be small (large aperture). If the aperture is small, the depth of field will be deep, making it difficult to establish the point of sharpest focus. For example, with a 50 mm lens, at f/4 the depth of field will extend from 8 ft to infinity. By focusing at full aperture, the depth of field will be as shallow as possible. As a result, the effects of even very small focusing adjustments will be readily observed, allowing the focus to be set with precision. Once the optimum focus setting has been achieved, the aperture can be reduced to the point of maximum sharpness. In some experiments, you may wish to adjust the aperture for optimum signal level. However, the experiment setup parameters established with the applications software can also be used to adjust the signal level, allowing the lens aperture and focus to be optimized.

Imaging Field of View

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

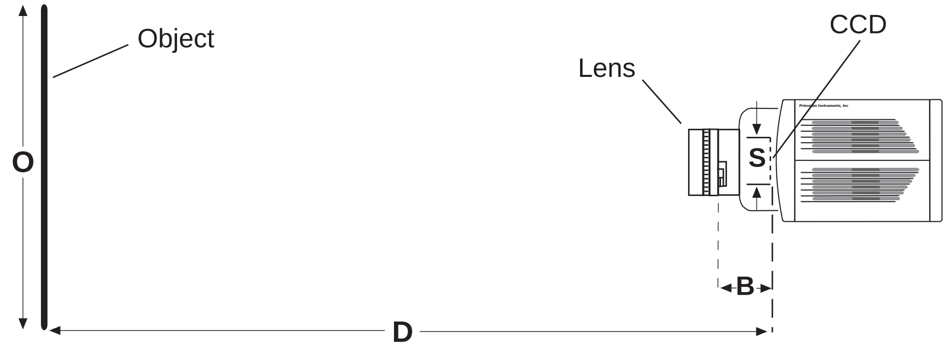

Figure 10. Imaging Field of View

D = distance between the object and the CCD (the CCD is 46.5 mm behind the front edge of the Nikon lens adapter, 17.5 mm for the C-mount adapter)

B = 46.5 mm for the Nikon adapter, 17.5 mm for the C-mount adapter

F = focal length of lens

S = CCD horizontal or vertical dimension

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

M = magnification

The field of view is: $$O = S/M, \quad \text{where} \quad M = \frac{FD}{(D - B)^2}$$

F-Mount Adapter Focusing Procedure

Note: This procedure sets the focus for the F-mount adapter, not the lens. Once set, it should not need to be disturbed again.

1. The lens should be mounted to the detector as described in Chapter 2.
2. Mount a suitable target at a known distance in front of the lens. Typically, a photo resolution chart is used. However, even a page of small print will generally serve quite well for this purpose.
3. Try rotating the detector lens mount. If it doesn't rotate, it will be necessary to loosen the securing setscrews. The lens mount adjustment is secured by setscrews. To change the focus setting, proceed as follows.
    - Remove the lens from the lens mount.
    - Loosen the two setscrews with a 0.050″ Allen wrench*. Do not remove the screws; loosen them just enough to allow the lens mount to be adjusted.

* The screws are #4-40 setscrews. A 0.050″ hex key is required to loosen or tighten them.

- Remount the lens to the adapter and set the *lens focus adjustment* to the target distance.

4. Power up the system and, using the application software, select **FreeRun**, and **Safe** mode (Asynchronous).
5. Choose a fast exposure (0.1 s) and begin data collection by selecting **Focus** (WinView/32).
6. Note the image on the computer monitor. If it is washed out because the CCD is saturated, reduce the exposure time. If it is too dark, increase the exposure time.
7. Double check to be sure the *lens focus* is set to the *target distance* and readjust if necessary.
8. Taking care not to disturb the *lens focus*, adjust the *lens mount focus* for maximum sharpness in the observed image.
9. Being very careful not to disturb the *lens mount focus*, remove the lens from the mount and tighten the setscrews to secure the lens mount focus setting.
10. Remount the lens.

This completes the procedure for adjusting the *lens mount focus* setting. It should not be necessary to disturb the adjustment again. In actual measurements with real subjects, the focusing will be done entirely with the *lens focus adjustment*. Microscope adapters follow a similar procedure except, in this case, the front part of the lens mount should not need adjustment. See Chapter 5 for additional information.

Lens Focusing Procedure

Except for the lens mount focus procedure that applies to F-mount lenses as described in the described above, there is no difference between focusing considerations for an F-mount lens and a C-mount lens. Simply use the focusing ring on the lens to produce the sharpest image at full aperture. Then stop the lens down to its sharpest aperture (probably at a mid-range aperture setting) and adjust the Exposure Time for the best possible image as observed at the monitor. In microscopy applications, it will also be necessary to review the discussions in Chapter 5.

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Chapter 5
Microscopy Applications

Introduction

This chapter discusses the setup and optimization of your digital imaging system as applied to microscopy.

Since scientific grade cooled CCD imaging systems are usually employed for low light level microscopy, the major goal is to maximize the light throughput to the detector. In order to do this, the highest Numerical Aperture (NA) objectives of the desired magnification should be used. In addition, you should carefully consider the transmission efficiency of the objective for the excitation and emission wavelengths of the fluorescent probe employed. Another way to maximize the transmission of light is to choose the detector port that uses the fewest optical surfaces in the pathway, since each surface results in a small loss in light throughput. Often the trinocular mount on the upright microscope and the bottom port on the inverted microscope provide the highest light throughput. Check with the manufacturer of your microscope to determine the optimal path for your experiment type.

A rule of thumb employed in live cell fluorescence microscopy is "if you can see the fluorescence by eye, then the illumination intensity is too high". While this may not be universally applicable, it is a reasonable goal to aim for. In doing this, the properties of the CCD in your detector should also be considered in the design of your experiments. For instance, if you have flexibility in choosing fluorescent probes, then you should take advantage of the higher Quantum Efficiency (QE) of the CCD at longer wavelengths (QE curves can be found on the Princeton Instruments detector data sheets). Another feature to exploit is the high resolution offered by detectors with exceptionally small pixel sizes (data available on the Princeton Instruments detector data sheets). Given that sufficient detail is preserved, you can use 2x2 binning (or higher) to increase the light collected at each "super-pixel" by a factor of 4 (or higher). This will allow the user to reduce exposure times, increasing temporal resolution and reducing photodamage to the living specimen.

Another method to minimize photodamage to biological preparations is to synchronize a shutter on the excitation pathway to the exposure period of the detector. This will limit exposure of the sample to the potentially damaging effects of the excitation light.

Mounting the Detector on the Microscope

The detector is connected to the microscope via a standard type mount coupled to a microscope specific adapter piece. There are two basic detector-mounting designs, the C-mount (standard) and the F-mount (optional). The C-mount employs a standard size thread to connect to the detector to the adapter while the F-mount uses a tongue and groove type mechanism to make the connection.

C-Mount

For a detector equipped with a C-mount thread, use the standard C-mount adapter that is supplied by the microscope manufacturer to attach the detector to the microscope. The adapter can be screwed into the detector and then the assembly can be secured to the microscope using the standard setscrews on the microscope. The detector can be mounted on the trinocular output port, the side port or the bottom port of the inverted microscope. When mounting larger detectors perpendicular to the microscope on the side port, it is ADVISED that you provide some additional support for your detector to reduce the possibility of vibrations or excessive stress on the C-mount nose. For the bottom port of the inverted microscope, the C-mount is designed to support the full weight of the detector, however, IT IS ADVISED that you provide some additional support for the larger detectors since the detector is in a position where it could be deflected by the operator’s knee or foot. This kind of lateral force could damage the alignment of the nose and result in sub-optimal imaging conditions.

Most output ports of the microscope do not require additional optical elements to collect an image; however, please check with your microscope manual to determine if the chosen output port requires a relay lens. In addition, all optical surfaces should be free from dust and fingerprints, since these will appear as blurry regions or spots and hence degrade the image quality.

F-Mount

For a detector with the F-mount type design, you will need two elements to mount the detector on your microscope. The first element is a Diagnostic Instruments Relay Lens. This lens is usually a 1x relay lens that performs no magnification. Alternatively, you may use a 0.6x relay lens to partially demagnify the image and to increase the field of view. There is also a 2x relay lens available for additional magnification. The second element is a microscope specific Diagnostic Instruments Bottom Clamp. Table 1 shows which bottom clamps are routinely used with each of the microscope types. They are illustrated in Figure 11. If you feel that you have received the wrong type of clamp, of if you need a clamp for a microscope other than those listed, please contact the factory.

Microscope Type	Diagnostic Instruments Bottom Clamp Type
Leica DMR	L-clamp
Leitz All types	NLW-clamp
Nikon Optiphot, Diaphot, Eclipse	O-clamp
Olympus BH-2, B-MAX, IMT-2	V-clamp
Zeiss Axioscope, Axioplan, Axioplan 2, Axiophot	Z-clamp
Zeiss Axiovert	ZN-clamp

Table 1. Bottom Clamps for Different Microscopes

To assemble the pieces, first pick up the detector and look for the black dot on the front surface. Match this dot with the red dot on the side of the relay lens. Then engage the two surfaces and rotate them until the F-mount is secured as evidenced by a soft clicking sound. Next place the long tube of the relay lens into the bottom clamp for your microscope, securing it to the relay lens with the three setscrews at the top of the clamp as shown in Figure 12. This whole assembly can now be placed on the microscope, using the appropriate setscrews on the microscope to secure the bottom clamp to the output port of the microscope.

The F-mount is appropriate for any trinocular output port or any side port. When mounting the detector perpendicular to the microscope on the side port, it is ADVISED that you provide some additional support for your detector to reduce the possibility of vibrations or excessive stress on the F-mount nose. Roper Scientific DOES NOT advise using an F-mount to secure the detector to a bottom port of an inverted microscope due to possible failure of the locking mechanism of the F-mount. *Contact the factory for information about a special adapter for operating in this configuration.*

Adjusting the Parfocality of the Detector

Once the detector has been mounted, you should get a clear, focused, transmitted light image through the eyepiece. Then divert the light to the detector and lower the illuminating light intensity. To adjust the parfocality on an F-mount system, begin collecting images with a short exposure time and focus the light on the detector by rotating the ring on the Diagnostic Instruments relay lens without touching the main focusing knobs on the microscope. On a C-mount system, the detector should be very close to parfocal, although some C-mounts will be adjustable using setscrews on the microscope to secure the adapter slightly higher or lower in position.

In the case of a detector with an F-mount lens adapter, focusing is normally done by means a focus adjustment on the relay-lens adapter.

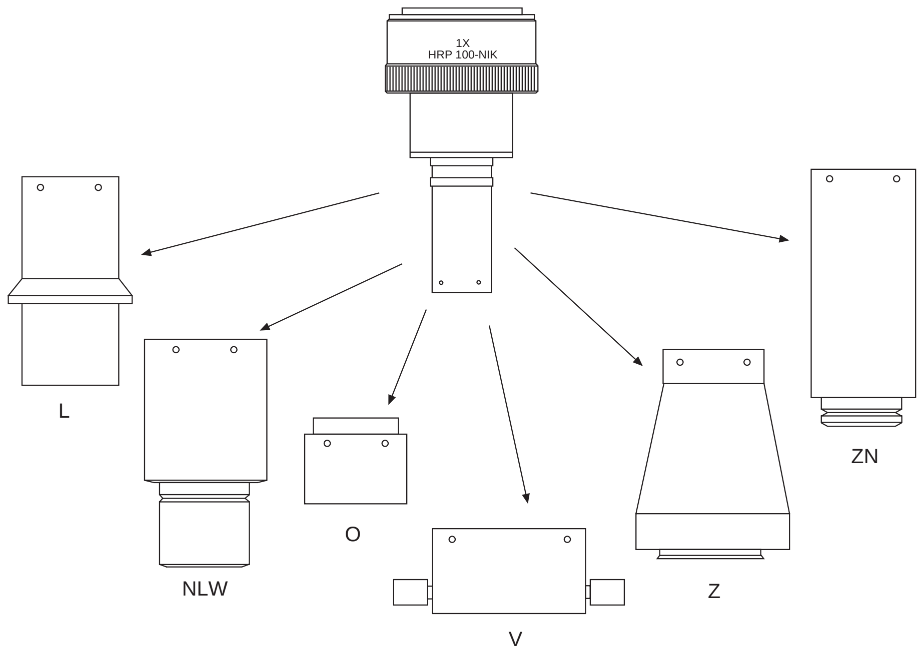

Figure 11. Diagnostic Instruments Bottom Clamps for Different Microscopes

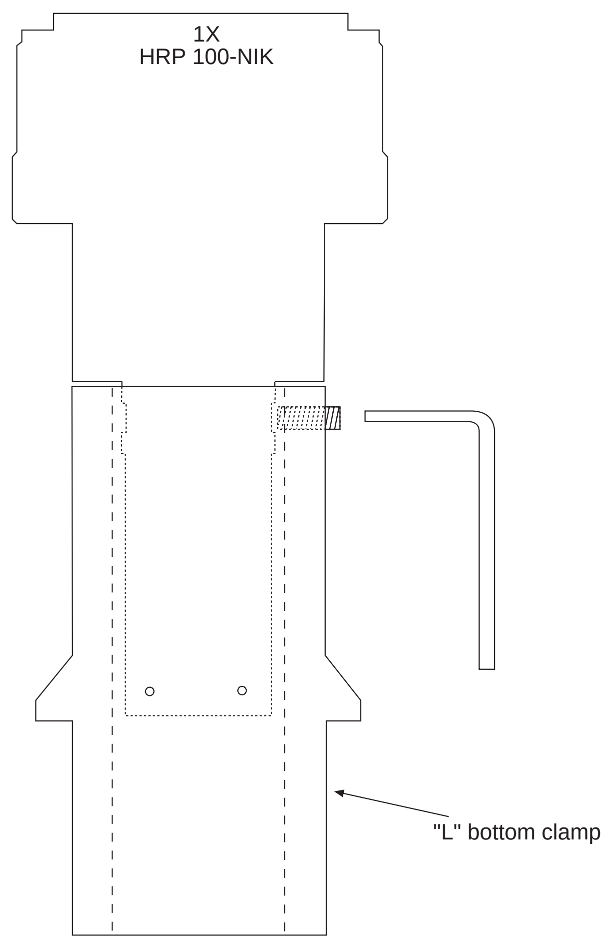

Figure 12. Bottom Clamp Secured to Relay Lens

Note: The detector lens mount itself also has a focus adjustment. Although it is unlikely that you would ever need to use this adjustment in operation with a microscope (it is preferable that you use the relay-lens focus adjustment), it could be used if necessary. The procedure for using the adjustment is provided in Chapter 4.

CAUTION

Microscope optics have very high transmission efficiencies in the infrared region of the spectrum. Since typical microscope light sources are very good emitters in the infrared, some microscopes are equipped with IR blockers or heat filters to prevent heating of optical elements or the sample. For those microscopes that do not have the better IR blockers, the throughput of infrared light to the CCD can be fairly high. In addition, while the eye is unable to see the light, CCD detectors are particularly efficient in detecting infrared wavelengths. As a result, the contaminating infrared light will cause a degradation of the image quality due to a high background signal that will be invisible to the eye. Therefore, it is recommended that you add an IR blocker prior to the detector if you encounter this problem with the microscope.

WARNING

Before You Start, if your system includes a microscope Xenon or Hg arc lamp, it is **CRITICAL** to turn off all electronics adjacent to the arc lamp, especially your digital detector system and your computer hardware (monitors included) before turning on the lamp power.

Powering up a microscope Xenon or Hg arc lamp causes a large EMF spike to be produced that can cause damage to electronics that are running in the vicinity of the lamp. We advise that you place a clear warning sign on the power button of your arc lamp reminding all workers to follow this procedure. While Roper Scientific has taken great care to isolate its sensitive circuitry from EMF sources, we cannot guarantee that this protection will be sufficient for all EMF bursts. *Therefore, in order to fully guarantee the performance of your system, you must follow this startup procedure.*

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Chapter 6
Operation

Introduction

Once the NTE/CCD Detector has been installed and its optics adjusted as explained in the preceding chapters, operation of the detector is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinView/32 or WinSpec/32) and then do actual data acquisition in the **Acquire** mode. There are many of possible software considerations that are addressed in the software manual. In addition, there are a few considerations that might have applicability as follows.

High Humidity

In high humidity climates it is not unusual to require continuous flushing of the spectrometer's exit port with nitrogen to prevent condensation on the window. If condensation occurs, it will obscure the light and degrade the data.

UV Effect on Scintillator

CAUTION

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

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.

After temperature lock is established, wait 30 minutes for the detector temperature to completely stabilize. Then try taking a few dark charge readings.

Note: Do not be concerned about either the DC level of this background or its shape unless it is very high, i.e., >400 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 Roper Scientific's demanding specifications.

CAUTION

> If you observe a sudden change in the baseline signal you may have excessive humidity in the vacuum enclosure of the detector. Turn off the system and have the detector repumped before resuming normal operation. *Contact the factory Technical Support Dept. for information on how to refresh the vacuum. See page 50 for contact information.*

Shutter

Spectroscopy

There is no provision for mounting an internal shutter in an NTE/CCD detector configured for spectroscopy. The detector mounts directly to the spectrometer mounting adapter leaving no room for an internal shutter. A spectrograph entrance slit shutter is available for use in spectroscopy measurements that require a shutter. These shutters are mounted as described on page 14.

Imaging

In imaging applications an adapter is mounted to the detector and then the lens, either C-mount or F-mount, is mounted to the adapter. An F-mount adapter and a C-mount adapter differ not only in their lens-mounting provisions, but also in depth because the focal plane of F-mount lenses is deeper than that of C-mount lenses. Nevertheless, an internal shutter can be installed in both types of adapters. Ordinarily, a shutter would be specified at the time of ordering and the detector would be shipped with the lens adapter and shutter already installed.

35 mm Shutter

As shown in Figure 13, NTE cameras having an F-mount nose use a 35 mm opening shutter. This shutter does not completely clear a 1300×1340 array (~38 mm diagonal) and the array is not fully illuminated. ***This does not mean that the shutter is too small.*** The F-mount lens actually limits the field size ahead of the 35 mm shutter. *The difficulty is that the F-mount standard itself doesn't provide sufficient coverage to completely illuminate the 1300 × 1340 array.*

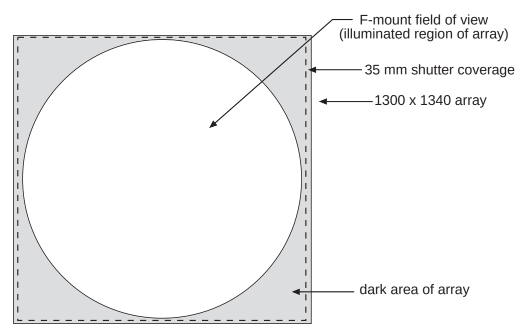

Figure 13. Coverage on 1300×1340 Array for F-mount Design

Note that a camera having the 35 mm shutter can only be used with an ST-133 equipped with the 70 V shutter option. An ST-133 that has the 70 V shutter drive option can be identified by the **70 V OPT** label on its rear panel as shown in Figure 14.

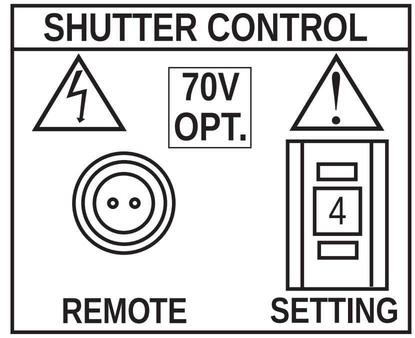

Figure 14. Back Panel of ST-133 with 70 V Shutter Drive Option

Note that there is a Shutter Setting push switch that sets the shutter drive voltage. Each shutter type, whether internal or external, requires a different setting. Consult the table below to determine the proper setting for your shutter. *The Shutter Setting dial is correctly set at the factory for the camera's internal shutter if one is present.*

1	External Shutter
2	Small Internal Shutter
4	35 mm Vincent Shutter (supplied with NTE camera having 1300 × 1340 CCD)
5	Large Internal Shutter

Table 2. ST-133 Shutter Drive Selection

WARNING

An incorrect setting may cause the shutter to malfunction or be damaged. An ST-133 with the 70 V Shutter option cannot be used with a camera having the small (standard) shutter, even by selecting a lower number, because the shutter could be permanently damaged by the high drive voltage and larger stored energy required to drive the 70 V shutter.

Shutter Life

Note that shutters are mechanical devices with a finite lifetime, typically on the order of a million cycles, although some individual shutters may last a good deal longer. How long a shutter lasts in terms of experimental time will, of course, be strongly dependent on the operating parameters. High repetition rates and short exposure times will rapidly increase the number of shutter cycles and decrease the time when the shutter will have to be replaced. Possible shutter problems include complete failure, in which the shutter no longer operates at all, or the shutter may stick open or closed causing overexposed or smeared images. It may even happen that one leaf of the shutter will break and no longer actuate.

Shutter replacement is usually done at the factory. If you find that the shutter on your detector is malfunctioning, contact the factory to arrange for a shutter-replacement repair. Note that shutters are not covered by the warranty.

WARNING

Disconnecting or connecting the shutter cable to the detector while the controller is on can destroy the shutter or the shutter drive circuitry. ***Always power off the controller before adjusting the shutter cable.***

Shutter Overheating

The 25 mm remote-mounted 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.

Chapter 7

Cleaning

WARNING Turn off all power to the equipment and secure all covers before cleaning the units. Otherwise, damage to the equipment or injury to you could occur.

Controller and Camera

Although there is no periodic maintenance that *must* be performed on the NTE/CDD Detector, users are advised to wipe it down with a clean damp cloth from time to time. This operation should only be done on the external surfaces and with all covers secured. In dampening the cloth, use clean water only. No soap, solvents or abrasives should be used. Not only are they not required, but they could damage the finish of the surfaces on which they are used.

Optical Surfaces

Optical surfaces may need to be cleaned due to the accumulation of atmospheric dust. We advise that the *drag-wipe* technique be used. This involves dipping a clean cellulose lens tissue into clean anhydrous methanol, and than dragging the dampened tissue over the optical surface to be cleaned. Do not allow any other material to touch the optical surfaces.

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Appendix A
Specifications

Controller Requirement

Requires ST-133 or ST-138 with high power modification. Standard ST-133 or ST-138 Controllers cannot meet the NTE's power requirements.

CCD Arrays

Note: The following list may not be current. Contact the factory for up-to-date information on available chips and chip performance specifications.

EEV 100 × 1340*
EEV 400 × 1340*
EEV 512 × 512FT CCD57
EEV 1024 × 1024 CCD47-10
EEV 1024 × 1024FT CCD47-20
EEV 1300 × 1340* *
TEK 512 × 512D

General

Focal Depth (optical)

Spectroscopy: 0.593"
F-Mount: 46.5mm
C-Mount: 17.5mm

Environmental

- Storage temperature: <55°C
- Operating environment: 5°C < T < 30°C
- Relative humidity: ≤50%; non condensing

Temperature Stability

±0.04°C over entire temperature range; dark charge stabilized to ±1.2%.

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* Incorporates both high-capacity and low-noise amplifiers. Choice of output amplifier must be specified at time of ordering.

* * Requires /F mount nose and 35mm Vincent shutter. This shutter requires ST-133 having 70 V shutter drive modification. ST-133s having this modification cannot be used with cameras having smaller (standard) shutter.

Power

Maximum internal heat dissipation in watts: 90

Cooling

- The internal fan circulates cooling air over the heat exchanger. Openings in the side of the housing provide the necessary circulation access. Fan capacity at full power is 30 cfm. Attainable lock temperature will vary depending on array size. Cooling performance is improved with fresh vacuum. *Contact the factory Technical Support Dept. for information on refreshing the vacuum. See page 50 for contact information.*

Appendix B

Outline Drawings

Note: *Dimensions are in inches.*

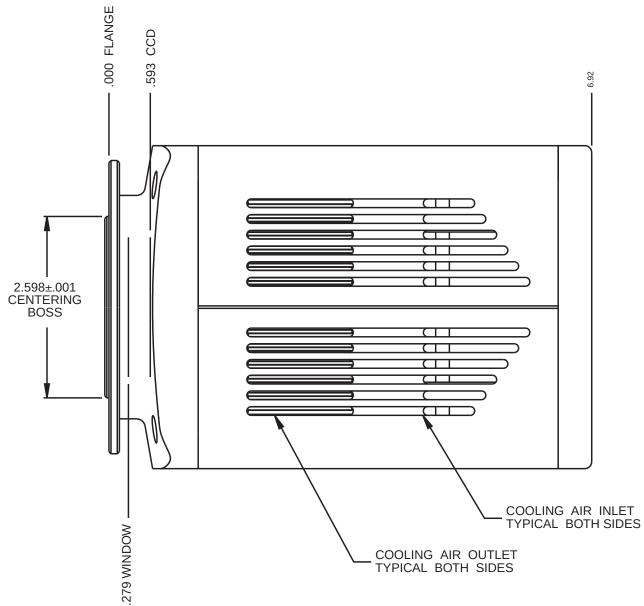

Figure 15. Spectrometer Mount: Side View

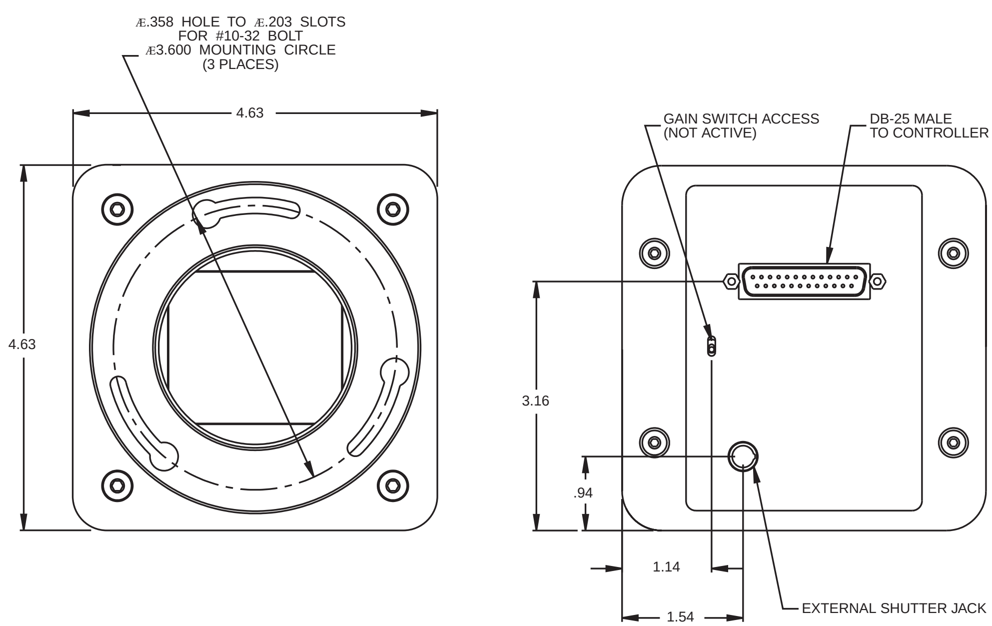

Figure 16. Spectrometer Mount: Front and Back View

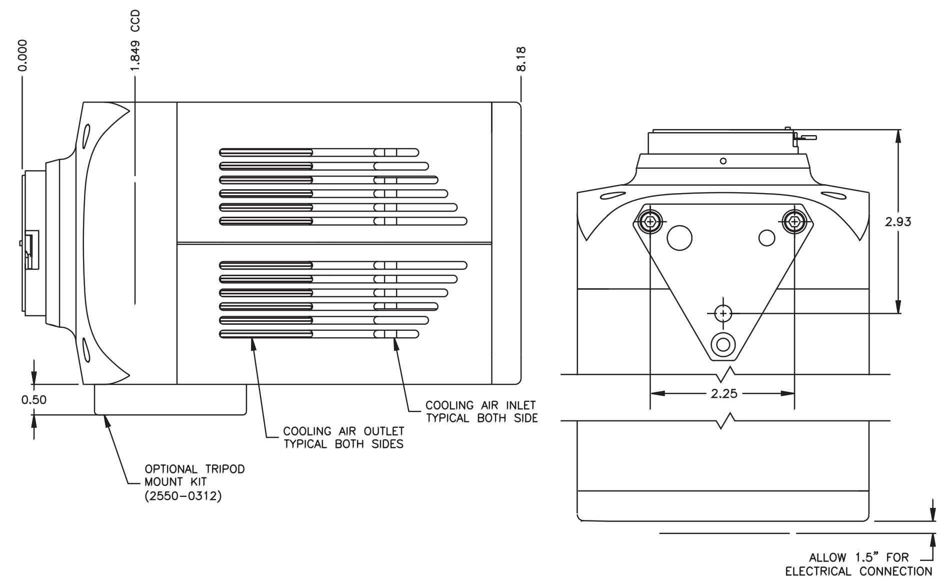

Figure 17. F-Mount: Side View

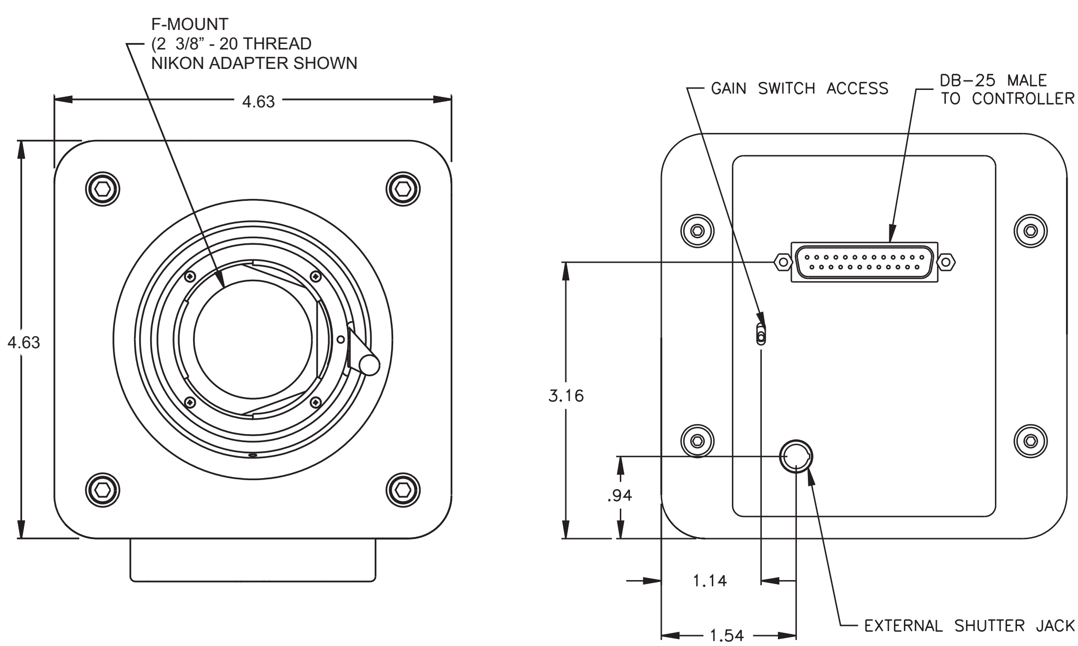

Figure 18. F-Mount: Front and Back View

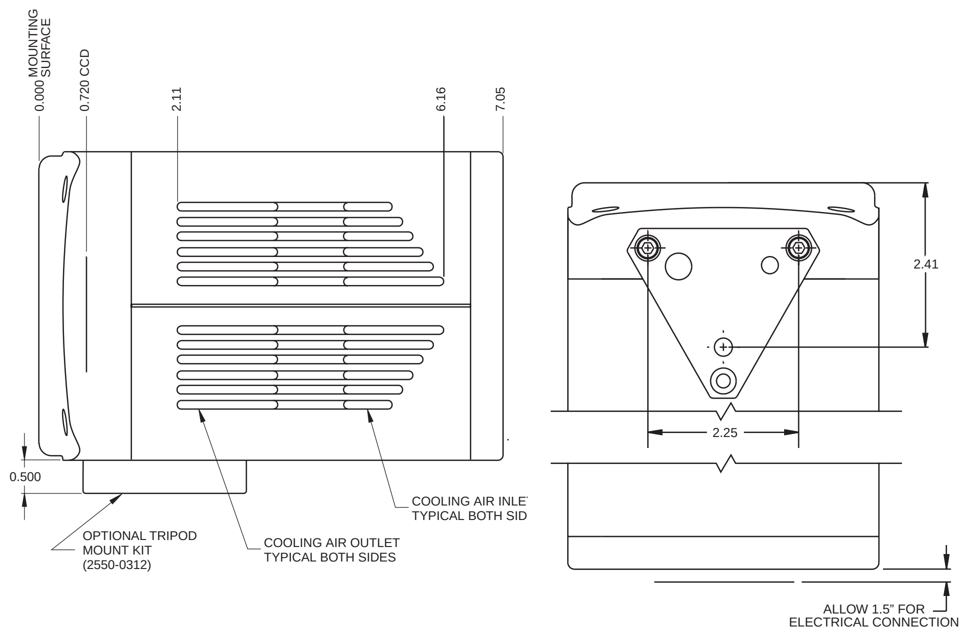

Figure 19. C- Mount: Side View

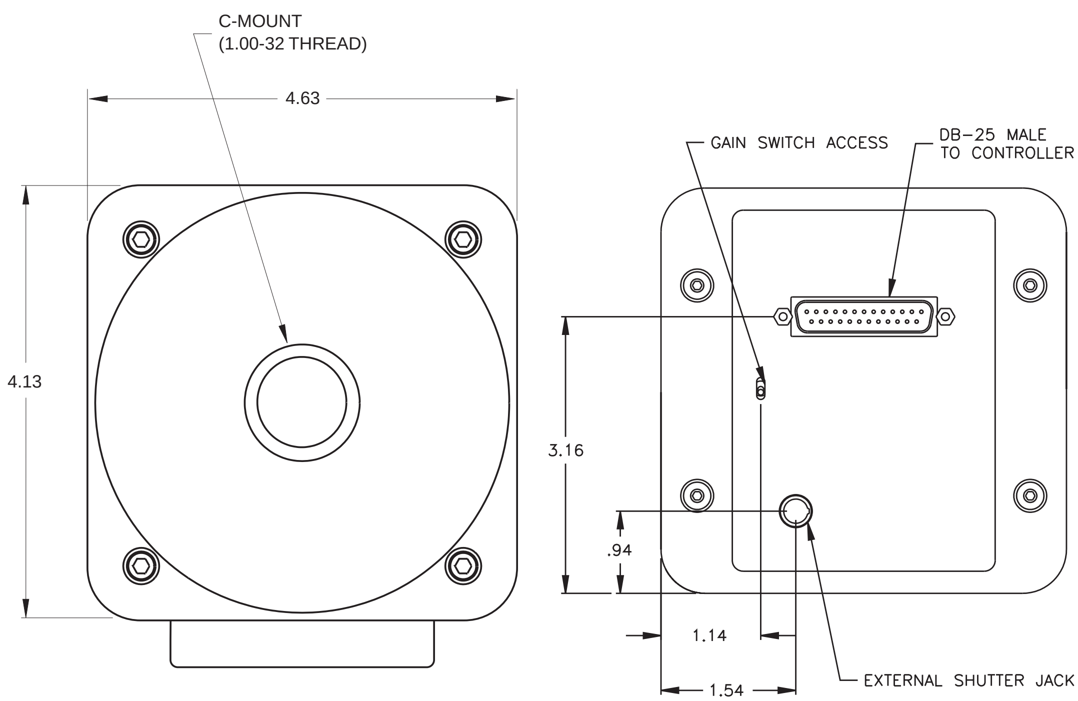

Figure 20. C-Mount: Front and Back View

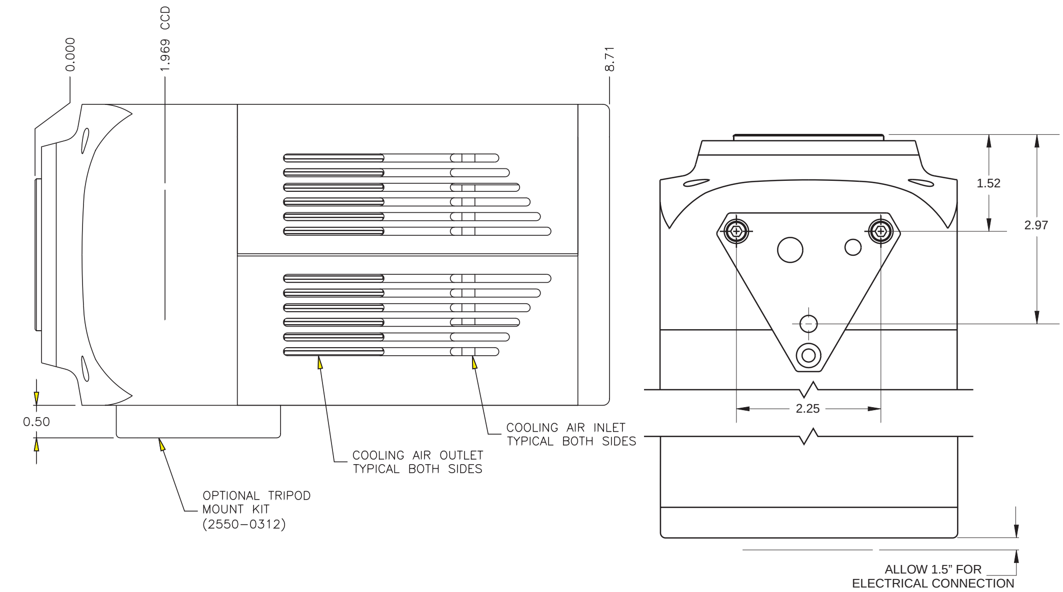

Figure 21. Fiber Optic Coupled: Side and Bottom Views

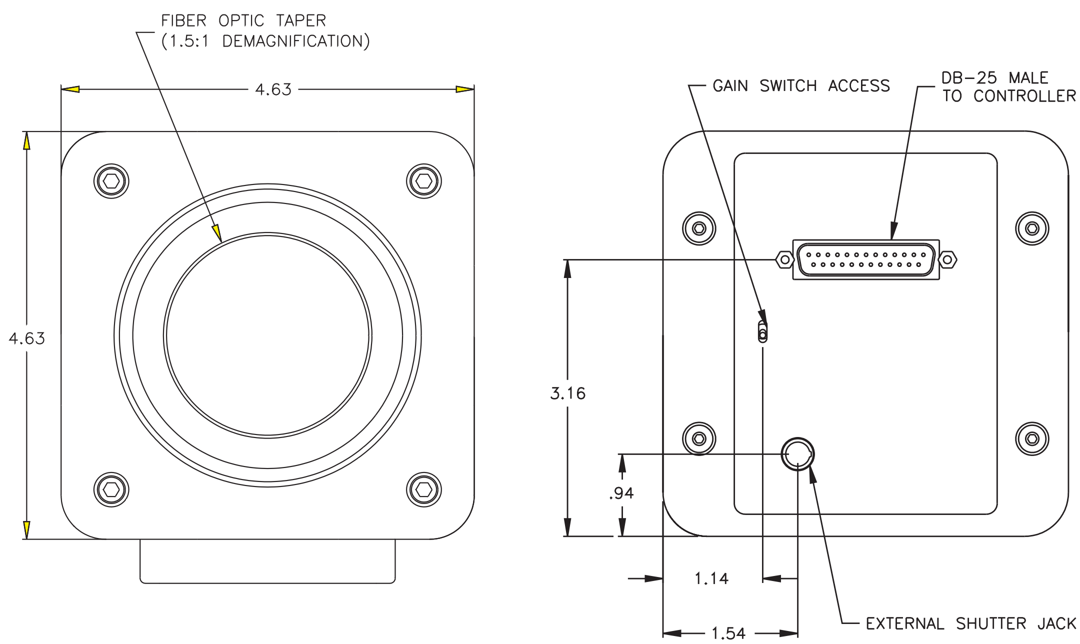

Figure 22. Fiber-Optic Coupled: Front and Back View

DECLARATION OF CONFORMITY

We,

ROPER SCIENTIFIC

(PRINCETON INSTRUMENTS)

3660 QUAKERBRIDGE ROAD

TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133A 1MHz HIGH POWER CONTROLLER

w/NTE CAMERA HEAD,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

IEC 1010-1:1990, EN 61010-1:1993/A2:1995

EN 55011 for Group 1, Class A, 1991,

EN50082-1, 1991 (EN 61000-4-2, EN 61000-4-3, EN 61000-4-4)

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC.

Date: August 20, 2002
TRENTON, NJ

(PAUL HEAVENER)
Engineering Manager

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Warranty & Service

Limited Warranty: Roper Scientific Analytical Instrumentation

Roper Scientific, Inc. ("Roper Scientific," us," "we," "our") makes the following limited warranties. These limited warranties extend to the original purchaser ("You", "you") only and no other purchaser or transferee. We have complete control over all warranties and may alter or terminate any or all warranties at any time we deem necessary.

Basic Limited One (1) Year Warranty

Roper Scientific warrants this product against substantial defects in materials and / or workmanship for a period of up to one (1) year after shipment. During this period, Roper Scientific will repair the product or, at its sole option, repair or replace any defective part without charge to you. You must deliver the entire product to the Roper Scientific factory or, at our option, to a factory-authorized service center. You are responsible for the shipping costs to return the product. International customers should contact their local Roper Scientific authorized representative/distributor for repair information and assistance, or visit our technical support page at www.roperscientific.com.

Limited One (1) Year Warranty on Refurbished or Discontinued Products

Roper Scientific warrants, with the exception of the CCD imaging device (which carries NO WARRANTIES EXPRESS OR IMPLIED), this product against defects in materials or workmanship for a period of up to one (1) year after shipment. During this period, Roper Scientific will repair or replace, at its sole option, any defective parts, without charge to you. You must deliver the entire product to the Roper Scientific factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Roper Scientific. International customers should contact their local Roper Scientific representative/distributor for repair information and assistance or visit our technical support page at www.roperscientific.com.

Shutter Limited One Year Warranty

Roper Scientific warrants for a period of up to one (1) year after shipment the standard, factory-installed camera shutter of all our products that incorporate an integrated shutter. This limited warranty applies to the standard shutter installed in the camera system at the time of manufacture. *Non-standard shutters, special product request (SPR) shutters, and third-party shutter drive equipment carry NO WARRANTIES EXPRESSED OR IMPLIED.* Roper Scientific will supply, at no cost to the customer, up to one (1) replacement shutter during the warranty period. Roper Scientific will, at Roper Scientific's option, either ship a ready-to-install shutter to the customer site for installation by the customer according to the instructions in the product User Manual or arrange with the customer to return the camera system (or portion of the camera system) to the factory (or factory-authorized service center) for shutter replacement by us or a Roper Scientific-authorized agent. Responsibility for shipping charges is as described above under our Limited One (1) Year Warranty.

VersArray (XP) Vacuum Chamber Limited Lifetime Warranty

Roper Scientific warrants that the cooling performance of the system will meet our specifications over the lifetime of the VersArray (XP) detector or Roper Scientific will, at its sole option, repair or replace any vacuum chamber components necessary to restore the cooling performance back to the original specifications at no cost to the original purchaser. *Any failure to "cool to spec" beyond our Basic (1) year limited warranty from date of shipment, due to a non-vacuum-related component failure (e.g., any components that are electrical/electronic) is NOT covered and carries NO WARRANTIES EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Sealed Chamber Integrity Limited 24 Month Warranty

Roper Scientific warrants the sealed chamber integrity of all our products for a period of twenty-four (24) months after shipment. If, at anytime within twenty-four (24) months from the date of delivery, the detector should experience a sealed chamber failure, all parts and labor needed to restore the chamber seal will be covered by us. *Open chamber products carry NO WARRANTY TO THE CCD IMAGING DEVICE, EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Vacuum Integrity Limited 24 Month Warranty

Roper Scientific warrants the vacuum integrity of all our products for a period of up to twenty-four (24) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twenty-four (24) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Image Intensifier Detector Limited One Year Warranty

All image intensifier products are inherently susceptible to Phosphor and/or Photocathode burn (physical damage) when exposed to high intensity light. Roper Scientific warrants, with the exception of image intensifier products that are found to have Phosphor and/or Photocathode burn damage (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all image intensifier products for a period of one (1) year after shipment. *See additional Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

X-Ray Detector Limited One Year Warranty

Roper Scientific warrants, with the exception of CCD imaging device and fiber optic assembly damage due to X-rays (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all X-ray products for one (1) year after shipment. Se*e additional Basic Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Software Limited Warranty

Roper Scientific warrants all of our manufactured software discs to be free from substantial defects in materials and / or workmanship under normal use for a period of one (1) year from shipment. Roper Scientific does not warrant that the function of the software will meet your requirements or that operation will be uninterrupted or error free. You assume responsibility for selecting the software to achieve your intended results and for the use and results obtained from the software. In addition, during the one (1) year limited warranty. The original purchaser is entitled to receive free version upgrades. Version upgrades supplied free of charge will be in the form of a download from the Internet. Those customers who do not have access to the Internet may obtain the version upgrades on a CD-ROM from our factory for an incidental shipping and handling charge. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

Owner's Manual and Troubleshooting

You should read the owner’s manual thoroughly before operating this product. In the unlikely event that you should encounter difficulty operating this product, the owner’s manual should be consulted before contacting the Roper Scientific technical support staff or authorized service representative for assistance. If you have consulted the owner's manual and the problem still persists, please contact the Roper Scientific technical support staff or our authorized service representative. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

Your Responsibility

The above Limited Warranties are subject to the following terms and conditions:

1. You must retain your bill of sale (invoice) and present it upon request for service and repairs or provide other proof of purchase satisfactory to Roper Scientific.
2. You must notify the Roper Scientific factory service center within (30) days after you have taken delivery of a product or part that you believe to be defective. With the exception of customers who claim a “technical issue” with the operation of the product or part, all invoices must be paid in full in accordance with the terms of sale. Failure to pay invoices when due may result in the interruption and/or cancellation of your one (1) year limited warranty and/or any other warranty, expressed or implied.
3. All warranty service must be made by the Roper Scientific factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Roper Scientific factory and receive a return authorization number (RMA). Products or parts returned for service without a return authorization evidenced by an RMA will be sent back freight collect.
5. These warranties are effective only if purchased from the Roper Scientific factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Roper Scientific is not responsible for installation, setup, or disassembly at the customer’s location.

7. Warranties extend only to defects in materials or workmanship as limited above and do not extend to any product or part which has:
   - been lost or discarded by you;
   - been damaged as a result of misuse, improper installation, faulty or inadequate maintenance or failure to follow instructions furnished by us;
   - had serial numbers removed, altered, defaced, or rendered illegible;
   - been subjected to improper or unauthorized repair; or
   - been damaged due to fire, flood, radiation, or other “acts of God” or other contingencies beyond the control of Roper Scientific.
8. After the warranty period has expired, you may contact the Roper Scientific factory or a Roper Scientific-authorized representative for repair information and/or extended warranty plans.
9. Physically damaged units or units that have been modified are not acceptable for repair in or out of warranty and will be returned as received.
10. All warranties implied by state law or non-U.S. laws, including the implied warranties of merchantability and fitness for a particular purpose, are expressly limited to the duration of the limited warranties set forth above. With the exception of any warranties implied by state law or non-U.S. laws, as hereby limited, the forgoing warranty is exclusive and in lieu of all other warranties, guarantees, agreements, and similar obligations of manufacturer or seller with respect to the repair or replacement of any parts. In no event shall Roper Scientific’s liability exceed the cost of the repair or replacement of the defective product or part.
11. This limited warranty gives you specific legal rights and you may also have other rights that may vary from state to state and from country to country. Some states and countries do not allow limitations on how long an implied warranty lasts, when an action may be brought, or the exclusion or limitation of incidental or consequential damages, so the above provisions may not apply to you.
12. When contacting us for technical support or service assistance, please refer to the Roper Scientific factory of purchase, contact your authorized Roper Scientific representative or reseller, or visit our technical support page at www.roperscientific.com.

Contact Information

Roper Scientific's manufacturing facility for this product is located at the following address:

Roper Scientific
3660 Quakerbridge Road
Trenton, NJ 08619 (USA)

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

Technical Support E-mail: techsupport@roperscientific.com

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

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