Version 6.0

Camera Guide:
Dage MTI Cameras

Imaging Research Inc.

Dage MTI Cameras

Introduction

The Dage MTI CCD72S and CCD72 are medium-resolution analog video cameras. Both models have integration capability (for periods up to 3 sec) so that the camera can be used for routine fluorescence microscopy, UV gels, or other low light applications. The Dage MTI CCD72 model includes a control unit that allows the camera response to be tailored to match specimen characteristics.

The Dage MTI 300RC and 300TRC are also medium-resolution cameras, but have a smaller, ½ inch CCD chip. Both models have integration capability and both models include a remote control unit that provides variable control over camera gain and offset (black level). The 300TRC is cooled, allowing extended sensor integration times while improving signal-to-noise and dynamic range.

This chapter describes the installation, use and adjustment of the Dage MTI 72- and 300-series cameras. Most of the functions and features described here are exclusive to these cameras. The **MCID™ Elite** imaging system, however, provides many other features related to camera-based image acquisition in general (e.g., frame averaging for noise reduction, real-time image alignment). These are described in the online *MCID Elite Reference Manual* (*Chapter 2: Acquiring Camera Images*).

Connecting

Camera signals are transmitted to the **MCID Elite** imaging board (Matrox Genesis) via the GEN-INPUT cable (older cables may be labeled M5-INPUT). The GEN-INPUT cable has a female 7W2 connector on one end, and six color-coded coaxial cables with BNC connectors at the other end. The 7W2 connector has two coaxial pin contacts and five regular pin contacts, and plugs into the video input socket on the Genesis board. The output from the video camera connects to one of the numbered coaxial cables, each of which acts as an input line to **MCID Elite**. The six coaxial input cables are labeled as "0", "1", "2", "3", "INT" and "TTL+".

Dage MTI CCD72S

The Dage model CCD72S consists of a camera module and 12-volt AC power adapter. Connect the AC adapter to the 12-pin "DC In/Sync" terminal on the rear panel of the camera module. Connect the VID OUT terminal on the power adapter to the "0" (red) input line of the GEN-INPUT cable. Connect the "INT" (gray or white) input line to the "GATE" socket on the power adapter.

Dage MTI CCD72

The Dage MTI CCD72 camera consists of a camera module, a camera control unit (CCU), a power cable, and a CCU cable. To connect the CCU cable, connect the end with the yellow "CCU" label (the male end) to the "CAMERA" terminal on the rear panel of the control unit. Connect the other end (female) to the "CONTROL" terminal on the camera module. Connect the female end of the power cable to the AC power socket on the rear of the control unit, and connect the "0" (red) input line of the GEN-INPUT cable to one of

the “VID OUT” terminals on the rear of the control unit. Use the VIDEO EXTENSION CABLE if the GEN-INPUT cable won’t reach. Connect the “INT” (gray or white) input line to the “GATE” terminal on the back of the control unit.

The control unit contains controls that allow the camera response to be tailored to match specimen characteristics. Our default settings for the controls are as follows:

ENHANCE:	MIN
BANDWIDTH:	MAX
GAMMA:	1.0
STRETCH:	OFF
POLARITY:	POS
BLACK LEVEL:	VAR, MAN
GAIN:	MAN
GAIN HI/LO (Rear Panel):	LO

If your camera was purchased from Imaging Research, its gain and offset were adjusted for typical autoradiographic specimens by our technical staff. These gain and offset settings are written on a sticker on the bottom of the camera control unit. Although the settings may vary from camera to camera, a typical setting would have gain at about 300 and black level at about 900 on the camera control unit.

Dage MTI 300RC and 300TRC

The Dage MTI 300RC and 300TRC cameras consist of a camera head (the 300TRC head is cooled), a remote camera control unit, a power supply, a power cord, and a custom integrating cable. The integrating cable has a BNC connector at one end, and a female DB9 connector at the other.

Plug the power cord into the power supply and plug the power supply into the “POWER” socket on the rear of the control unit. Connect the camera head to the 26-pin “CAMERA” socket. Connect the “0” (red) input line of the GEN-INPUT cable to the “VID” terminals on the rear of the control unit (attach the VIDEO EXTENSION CABLE if the input cable won’t reach). If you wish to use the camera as an integrating device, plug the DB9 end of the integrating cable into the “AUX” socket, and connect the BNC end to the “INT” (gray or white) input line.

The remote camera control unit allows analog control over camera gain (the amount of light amplification) and black level (the size of the no-light signal; also called “offset”). If your camera was purchased from Imaging Research, its gain and black level were adjusted for typical autoradiographic specimens by our technical staff. These settings are marked on a sticker on the bottom of the camera control unit. Never set the gain to the “Auto” position, and never set the black level to “Fix”.

Figure 1: *The Input Device Selection Dialog box lists all of the cameras installed in MCID Elite, and it is used to select which camera to use when acquiring images. You can select, add, or delete any input from the list. You can also edit the definition of a specific input, and assign specific operations and settings to it.*

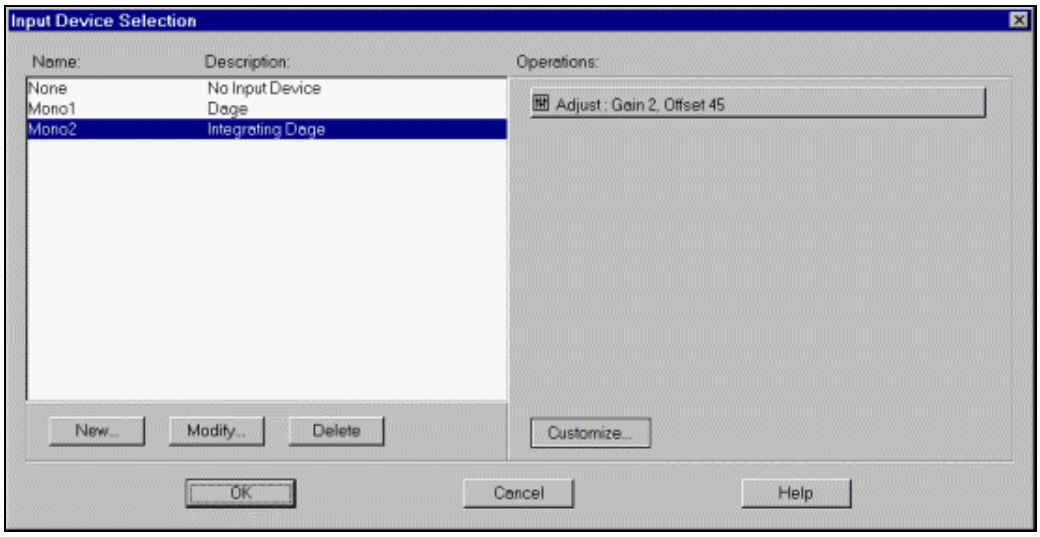
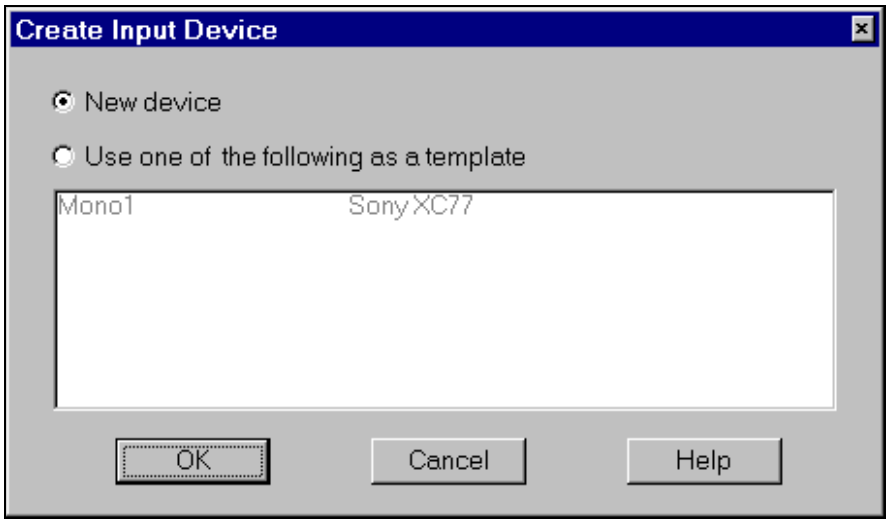


Figure 2: *The Create Input Device dialog allows you to install a new camera from scratch, or to copy the all of the settings associated with an existing device.*



Installing in MCID Elite

Once a camera is connected, you must add the camera to the **MCID Elite** list of input devices and set the appropriate "Input Sync" to match the output and resolution of your camera. In other words, you must tell **MCID Elite** that you have connected a camera to particular input line and tell it what kind of video signal to expect from it.

The **MCID Elite** imaging system's interface to cameras is controlled through the *Settings > Input select* menu command. The *Input Device Selection* dialog box (Figure 1) contains a list of all installed input devices, and it is used to select which camera to use when acquiring images. You can select, add, or delete any input from the list. You can also edit the definition of a specific input, and assign specific operations and settings to it. For details, see *Chapter 2: Acquiring Camera Images* in the online *Reference Manual*.

The Dage MTI video cameras can be set up to be used as two separate input devices: one that integrates and one that does not. We recommend this configuration, since some digitizing operations are only available in one mode or the other. Real-time image alignment, for example, cannot be performed in integrating mode.

Any of these cameras can be installed as an 8-bit device (yielding 256 gray levels) and/or a 10-bit device (yielding 1024 gray levels). Before adding the camera to the list of input devices, set the "Display format" to the desired bit density.

TO INSTALL THE CAMERA AS A NON-INTEGRATING DEVICE:

1. Open the *Settings* menu and select *Display format*. Set the *Image Type* to **8 bit mono** or **10 bit mono**.
2. Open the *Settings* menu again and select *Input select*. The *Input Device Selection* dialog box appears, which lists every camera that you have already installed in **MCID Elite**.
3. Click the **[New]** button.
4. If another camera has been installed already, a *Create Input Device* dialog box will appear (Figure 2). Select the **New input device** option and click **[OK]**. If no other cameras have been installed, the *Input Device Definition* dialog box appears (Figure 3).
5. Select "RS170-HI" as the **Input sync** ("CCIR-HI" for European models).
6. Select "Line 0" as the **Input line** (or whichever line the camera is connected).
7. Enter a unique **Name** and **Description** in the entry fields (e.g., "Mono1", "Non-integrating Dage").
8. Press **[OK]** to exit.
9. A *Customize* dialog box appears next (Figure 4), which allows you to assign various input device operations to this camera (e.g., frame averaging controls). You can select them now or assign them later (see *Chapter 2: Acquiring Camera Images* for details). Click **[OK]** to exit the dialog.

10. The camera is now installed in the list of input devices. Select this camera whenever you wish to acquire images without using frame integration.

Figure 3: *The Input Device Definition Dialog box is used to define a camera's video signal and to indicate the input line to which it is connected.*

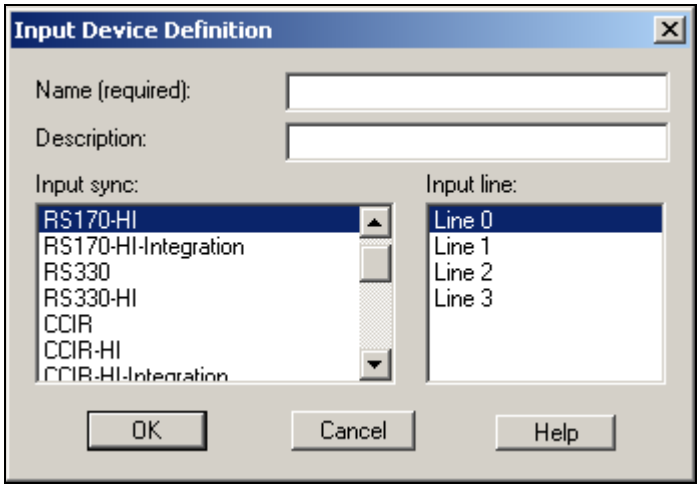
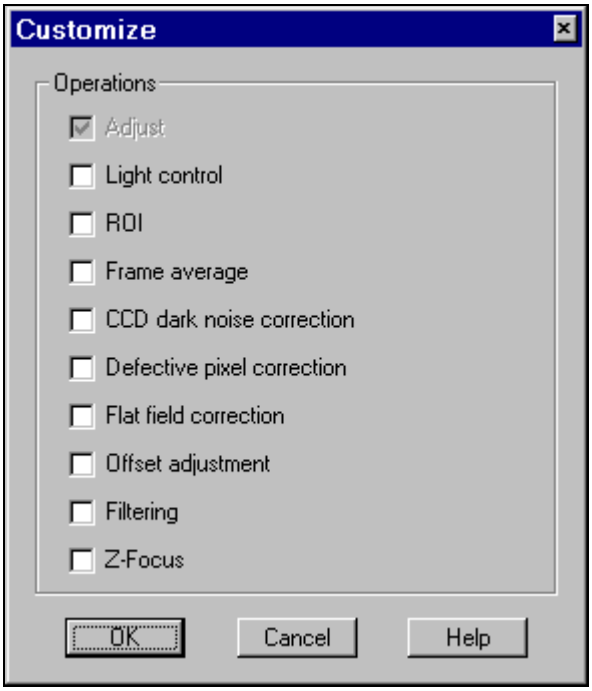


Figure 4: *The Customize dialog box is used to link controls for various camera operations to specific cameras.*



TO INSTALL THE CAMERA AS AN INTEGRATING DEVICE:

1. Repeat steps 1 – 4, above.
2. Select **RS170-HI Integrating** as the *Input sync* (**CCIR-HI Integrating** for European models).
3. Select **Line 0** as the ***Input line*** (or whichever line the camera is connected to).
4. Enter a unique **Name** and **Description** in the entry fields (e.g., "Mono2", "Integrating Dage").
5. Repeat steps 8 – 9, above.
6. The camera is now installed as two separate devices. Select this camera whenever you wish to acquire images using frame integration.

Whichever camera is selected when **MCID Elite** is shut down becomes the default input device.

Acquiring Images

If you have installed the camera as both an integrating and non-integrating device, you will have to select the camera that best suits your application. If it is not the default camera, open the *Settings* menu and select *Input select*. Select the appropriate camera from the list of input devices. Be certain that the current *Settings* > *Display format* is set to the appropriate bit density.

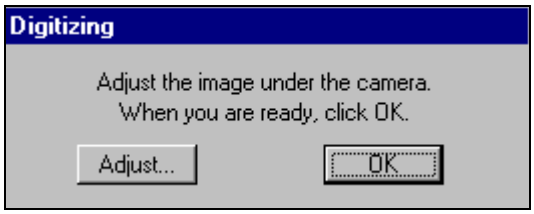
Digitizing

Click the **Digitize** icon to initiate digitization or press **<Ctrl - D>**. A dialog box appears to indicate that **MCID Elite** is digitizing continuously and a live image appears on the image monitor.

Basic (Non-Integrating) Mode

If you have selected a camera that does not integrate, **MCID Elite** will display a dialog box like the one shown in Figure 5. Video digitization occurs at 30 frames/sec (25/sec in Europe), so the digital image appears live. Position the specimen, focus the lens and adjust for optimal lighting, all while digitization continues. Note that, while **MCID Elite** is actively digitizing, no other operations are available. Press **<Enter>** to terminate digitization. The image is now frozen, and any of **MCID Elite**'s functions may be applied to it.

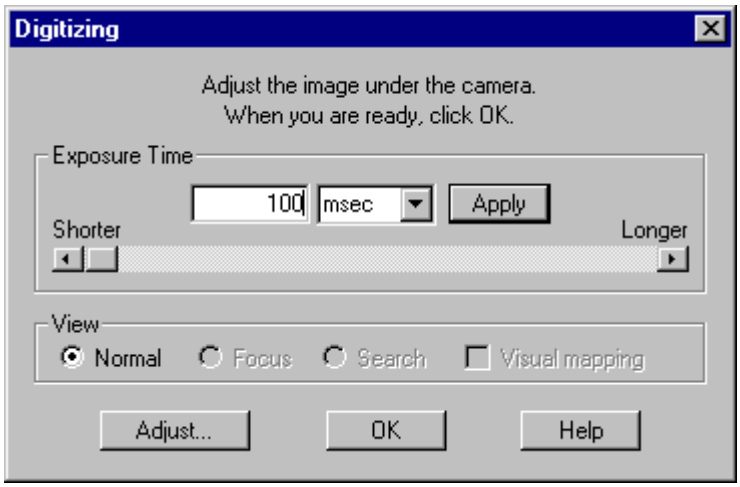
Figure 5: *Clicking the Digitize icon initiates continuous digitization and displays a dialog box. This dialog box appears only when using a non-integrating video camera.*



Integrating Mode

If you are using an integrating camera a dialog box like the one shown in Figure 6 will appear. Adjust the integration time using the **Exposure Time** control. Do not integrate if the image is bright. Just use a single frame. If the image is less bright, you will have to adjust the integration time. Once everything looks fine, click on **[OK]** (or press the <**Enter**> key) to freeze the image.

Figure 6: *Clicking the Digitize icon initiates the digitization procedure and displays a dialog box. Move the slider along the Exposure Time bar to integrate over a number of frames. This dialog box appears only when using an integrating video camera.*

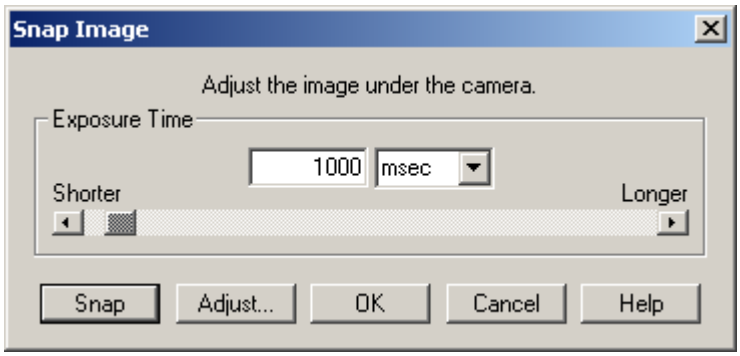


Snap Shots

Press the **Snap Shot** button to capture an image using a single exposure (i.e., without displaying a continuously 'live' image). If the camera does not integrate, **MCID Elite** will capture a single video frame. If the camera integrates, the image is automatically captured at the end of the specified exposure period. This function can be very useful if you are working with dim specimens and you have already chosen the correct exposure time. Clicking the **Snap Shot** icon will automatically capture a fresh image.

To adjust the exposure time, Ctrl-click on the **Snap Shot** icon to display the *Snap Image* dialog box. Move the slider control to increase or decrease the exposure time. Press the **[Snap]** button to test the exposure.

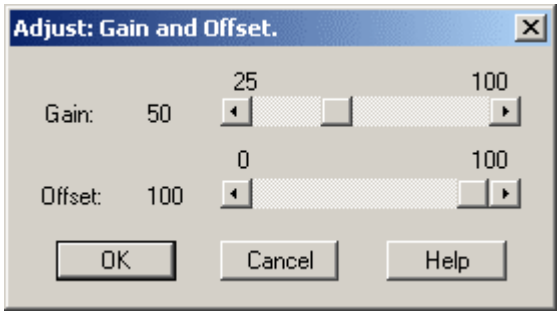
Figure 7: *The Snap Image dialog box is used to control the Snap Shot exposure time.*



Adjusting the Camera Response

MCID Elite allows digital control over camera gain (the amount of light amplification) and offset (the size of the no-light signal). To access these controls, press the **[Adjust]** button on any of the *Digitizing* or *Snap Image* dialog boxes. **MCID Elite** will display a dialog box for camera adjustment (Figure 8).

Figure 8: *The MCID Elite digital gain and offset controls.*



Gain and offset should be adjusted to yield optimal camera response with your specimens (i.e., the best image contrast), which is typically arrived at by experimentation. By default, the **MCID Elite** sets gain at 50 and offset at 100.

The Dage MTI CCD72 and 300-series cameras offer control over gain and offset via analog adjustment of camera response. It is best to use these analog controls rather than the **MCID Elite** controls.

See the Advanced Details section for more information about gain and offset.

Dage MTI CCD72 Controls

The Dage MTI CCD72 external control unit allows flexible control over analog image formation. We supply the camera set for typical specimens. Use the controls to optimize camera response.

Bandwidth

The bandwidth control is like the treble control on a stereo set. Camera bandwidth affects high frequency response, which contains much of the noise and the highest resolution image details. If possible, this control should be set to maximum.

Gain and Offset

The gain and offset controls can be used to adjust response for your specimens. By default, the gain switch is set to *Manual (MAN)* and about 300 on the potentiometer. The offset switches are on *Variable (VAR)* and *Manual (MAN)*. See the Advanced Details section for more information.

Enhance

This control enhances high frequency information and yields increased visibility of sharp detail. This can be useful in grain counting and in other applications dealing with small targets. For general imaging, this control is set to minimum.

Gamma

Gamma may be varied between 0.45 and 1. At the unity setting, the camera responds linearly to incoming illumination. This yields the most accurate representation of the image but also limits the ability of the camera to respond to a broad range of illumination. As gamma is decreased, the camera compresses high light levels. That is, sensitivity to higher light levels is less than sensitivity to lower light levels. This allows the camera to image a broader range of specimen intensities. For densitometry, gamma should be set to 1.

Advanced Details

Adjusting Camera Gain and Offset

Output from analog cameras varies from a small voltage value (under no-light conditions) to a larger value as incident light increases. Gain is the amount of light amplification provided by the camera. The higher the gain, the more amplification will be provided by the camera electronics. With high gain, even a standard video camera could be used under fairly low light conditions. High levels of gain, however, amplify both noise and the specimen. The practical usefulness of increasing gain is limited by noise.

The offset control (referred to as the "pedestal" on some cameras) adjusts the size of the no-light signal (called the black level). You can adjust the camera offset so that it drives the imaging system to only one or two gray levels. On the other hand, if you are trying to see a very dim specimen, you may want to adjust the offset so that even very dim image components yield higher gray level values.

Gain and offset should be adjusted to yield optimal camera response with your specimens. The general rule for gain and offset adjustment is:

Action	Effect on black image	Effect on real image	Effect on contrast
Increase offset	darker	brighter	decrease
Increase gain	small increase	brighter, noisier	increase

The Dage MTI CCD72 and 300-series cameras offer control over gain and offset by analog adjustment of camera response. This provides the most effective (best signal to noise ratio) means of adjusting camera response characteristics. Optimal adjustment of the camera controls varies from camera to camera. A typical optimal setting on the CCD72 camera control unit would have a gain of about 300 and an offset of about 900. For these analog settings on the camera control unit, digital (**MCID Elite**) gain is set to 50 and offset is set to about 100. These **MCID Elite** settings are a good starting point for adjusting the analog controls on any camera.

Optimal settings for specific specimen and video camera characteristics can be determined by experimentation with a density step wedge (see below). If a Dage camera was shipped with your imaging system, its gain and offset have already been adjusted by our technical staff prior to shipment. These optimal gain and offset settings appear on a sticker on the bottom of the camera control unit.

Optimal adjustment of gain and offset yields the best image contrast. For example, if you find that your film standards span only the range from 100 -200 gray levels, you are not using the full dynamic range of the camera. Decrease the black level (preferably on the camera control unit) until the darkest standards are closer to black (e.g., 20 gray levels). Then, increase gain to once again yield saturation with high incident light levels. A narrower range of incident light intensities will then drive the system from black to saturation. This allows your specimens to fill more of the system response range and can

increase sensitivity to subtle changes in image density. Be careful with this, however, because enhancing contrast decreases the dynamic range of the system (i.e., the ability to respond to a broad range of densities).

Optimal Gain and Offset Adjustment

Your imaging board and the Dage camera (CCD72, 300RC, 300TRC) both have controls for adjusting the gain and offset of your video signal. The best strategy for arriving at optimal settings is to adjust the board first and then use the optical density step wedge (supplied with the optional Macro Accessory Package) to adjust the camera. The procedure is outlined below. The instructions assume that you are familiar with some basic **MCID Elite** functions, namely, how to sample, how to make a flat field correction, and how to calibrate the system to a set of density standards. If you are unfamiliar with any of these procedures, please read the corresponding sections in the online *Reference Manual* before you begin.

Use the following instructions to adjust the camera's contrast:

1. Select a pseudocolor LUT in the **Visuals** operation window (i.e., SPECTRAL.VIS or SPECT2.VIS).
2. In the *Measures Selections* option of the *Sample* menu, select **Levels** as the density measurement.
3. Access the software camera controls in the *Input select* option of the *Settings* menu. Click on the **[Adjust]** button.
4. Set the **Gain** adjustment to 50 and the **Offset** to 100 respectively.
5. If you are using the the Dage MTI CCD72, make sure the camera controls are set as follows:

ENHANCE:	MIN
BANDWIDTH:	MAX
GAMMA:	1.0
STRETCH:	OFF
POLARITY:	POS
BLACK LEVEL:	VAR, MAN
GAIN:	MAN
GAIN HI/LO (Rear Panel)	LO

6. Perform the following Black Level setup: Cover the lens of the camera and capture an image. Sample the entire image using the "Full image scan" tool.
    a) If the sampled value (displayed in the **Dens - Levels** column) is 0, rotate the Black Level dial in a clockwise direction. Repeat step 6.
    b) If the sampled value is greater than 1, rotate the Black Level dial in a counter-clockwise direction. Repeat step 6.
    c) If the sampled value is between 0 and 1, the Black Level is set.

7. Remove the lens cap and digitize the density step wedge. Adjust the camera height and focus so that the 10 to 12 steps are visible including the clear portion.
8. Adjust the illuminator intensity to approximately 700 and the lens aperture so that the background of the image is a light green.
9. Remove the tablet from the field of view and perform a flat field correction.
10. Replace the step tablet and digitize it again. Adjust the illuminator level only so that the background appears pink with no white spots. Once set, do not adjust the lens and illuminator any further.
11. Select the **Calibration** operation window. Open the *Establish* menu and select *Density*.
12. Click on the **Cal Std** button in the **Calibration** window.
13. An *Open Density Standards File* dialog box will display the available files to load. If you have already created a file for the specific step wedge, then select the file and click on the **[OK]** button. If a file has not been previously created, then click on the **[Create]** button.
    a) In the "Standards File:" field, type "DD" in the "Standard Units" box. Enter the Diffuse Density values from the table included with the density step wedge.
    b) Save the file created. Click on the **[Done]** button to exit.
    c) In the *Open Density Standards File* window, select the newly created file and click on the **[OK]** button.
14. Digitize and sample all the visible steps in the tablet. Please note that the transparent portion of the tablet (film background) corresponds with the first DD value.
15. The idea is to now adjust the GAIN and BLACK LEVEL controls until the "Value Read" values are within about 0.03 of the DD values.
    a) To do this, adjust the controls on the Dage MTI controller while the image is digitizing ("live") and then re-sample the step tablet after the adjustment has been made.
    b) If the sampled values are higher than the DD values, then decrease the Gain dial value. Then, increase the Black Level dial value so that the film background returns to pink.
    c) If the sampled values are lower than the DD values, then increase the Gain dial value and decrease the Black Level dial value so that the film background returns to pink.
    d) The above steps may have to be repeated a number of times. After some trial and error you'll eventually get the sampled values close to the DD values.

16. After completing the adjustments, lock the dials as described in the Dage manual.
17. To check for "gain riding" perform this last test:
    a) Select a Sample tool.
    b) Select one of the steps on the film. Place it near the left side of the image monitor and take a sample, then move it to the right side of the image monitor and take a another sample.
18. Compare the two values. A 3% error is normal. If the % error is much greater than this, please let us know.

After completing the adjustments, the Gain and Offset values should be recorded on a label and attached to the camera controller for future reference.

The Thermoelectric Cooler

CCD72S and CCD72

The CCD72S and CCD72 may both be equipped with a factory-installed thermoelectric cooler (TEC). The TEC is a two stage peltier cooler directly attached to the CCD sensor. This cooling reduces the CCD sensor dark current, thus allowing extended sensor integration times while improving signal-to-noise and dynamic range.

The large, finned assembly at the front of the camera head is a heat sink that uses convection cooling to radiate heat generated by the TEC. In most cases, the convection heat sink provides adequate radiation of heat. However, efficiency will be impaired if the camera is used with restricted air circulation. The better the airflow around the camera head, the more efficient the cooling.

The TEC receives current from a fully regulated power supply, which also includes an indicator for CCD temperature. The supply monitors the current delivered to the cooler and keeps it constant. During initial turn-on, the supply ramps the current to the TEC in order to prevent thermal shock to the CCD. After approximately 5 minutes, the TEC will stabilize and the READY LED will light.

Lighting of the READY LED is an indicator of proper operation. If the TEC is not plugged into the power supply or the TEC either opens or shorts, the READY LED will turn off. In the case of a short in the system, the power supply must be turned off for at least 30 seconds so that the current sense circuitry can reset.

If cooling is not required, the TEC power supply can be turned off. The CCD camera will continue to run normally (but without cooling) with the TEC off. However, there is no reason to operate the camera in this way. It will always function better when cooled.

300TRC

The cooling unit on the Dage MTI 300TRC is fully integrated into the camera head and requires no external controls. The cooling unit automatically engages whenever the camera is turned on, and cools to about 37 degrees (C) below ambient temperature.

The large, finned assembly on the camera head is a heat sink that uses convection cooling to radiate heat generated by the cooling unit. In most cases, the heat sink provides adequate radiation of heat. However, efficiency will be impaired if the camera is used with restricted air circulation. The better the airflow around the camera head, the more efficient the cooling.

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