COMPIX® PC2000 Series Thermal Imaging Systems

Installation and Operating Instructions

(PC2000, PC2000/e, 2000/usb, PC2100, PC2100/e, 2100/usb)

Version 1.6
04/23/02

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NOTICE

This manual is intended solely to provide instructions for operation of the Compix® PC2000, PC2000/e, 2000/usb, PC2100, PC2100/e, and 2100/usb Thermal Imaging Systems and their accompanying Thermal Evaluation Software, **WinTES.** Compix reserves the right to change the information contained in this manual without notice. No warranty, expressed or implied, is made regarding the accuracy of the information in this manual at any time following its release or for any purpose other than as a guide to operation of Compix® Systems.

WinTES, the Thermal Evaluation Software for Windows95/98/2000/NT/Me/XP, may be distributed to others provided the following requirements are met:

1. No fee, charge, or compensation may be accepted or requested.

2. The **WinTES** distribution disk must be copied in unmodified form, complete with this copyright notice and other files listed in the "FILES.TXT".

3. The sole purpose of such distribution is to operate, demonstrate, analyze, or distribute images produced with equipment manufactured by Compix.

Other use or distribution of this software without consent of Compix Incorporated is prohibited.

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1. INTRODUCTION

The Compix® PC2000 family of thermal imagers work with any Windows 95/98/2000/NT/Me/XP based computer. They are designed for non-contact mapping and measuring of surface temperatures. The heart of the systems is a sophisticated camera that is sensitive to infrared (IR) radiation. These cameras are reliable, cost-effective tools that provide fast, comprehensive evaluations of thermal performance.

Since elevated temperatures are often cited as a cause of failure in electronic products, thermal phenomena are of particular interest to design and reliability engineers.

An example of their application is the study of temperature distribution and heat flow on electronic circuit boards. In an energized electronic circuit, power is dissipated as heat that produces radiant infrared (IR) energy. The PC2000 captures this radiation and produces a two-dimensional map, or thermal image, of the object's surface temperatures.

All configurations of the Compix® PC2000 family of thermal imagers require a computer for camera control, image storage and display. WinTES software provides the graphical user interface (GUI) as well as the interface that permits the computer to communicate with the Compix IR Camera. WinTES requires Windows 95/98/2000/NT/Me/XP and at least a VGA display.

WinTES lets the operator adjust the display, compare images, change colormaps, compensate for different emissivities, read temperatures at specific locations, compute area statistics, and show thermal profiles. An important feature of WinTES is the use of the industry standard TIFF image file format for storing thermal images. This makes it easy to use the images with other software programs. A second format for image storage is the Compix format (cpx). This format stores the full 32-bit range of temperature data. It is larger than the TIFF file format (192k vs 95k) and is readable only with Compix software such as WinTES or Reporter.

The rest of this manual describes the Compix PC2000, PC2000/e, 2000/usb, PC2100, PC2100/e, 2100/usb and their operation in more detail.

Note

BEFORE ATTEMPTING TO OPERATE THE SYSTEM YOU SHOULD READ SECTIONS 2. SYSTEM DESCRIPTION AND OPERATING REQUIREMENTS, 3. INSTALLATION AND SET-UP, and 5. MAKING THERMAL IMAGES.

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2. SYSTEM DESCRIPTION and OPERATING REQUIREMENTS

The Compix® PC2000 has three principal components: the **camera head,** the **computer to camera interface,** and the **Thermal Evaluation Software, WinTES** (see fig. 1). The camera head contains the infrared sensor, mirrors, motors, and circuitry required to scan, capture and digitize the image data. The interface card contains the camera control electronics, and digital circuitry required for communicating with the PC. Calibration parameters are stored in the camera head allowing cameras to be interchanged between interface types (ISA, USB, LPT) without compromising calibration. **Other than the personal computer, no other accessories or supplies are required.**

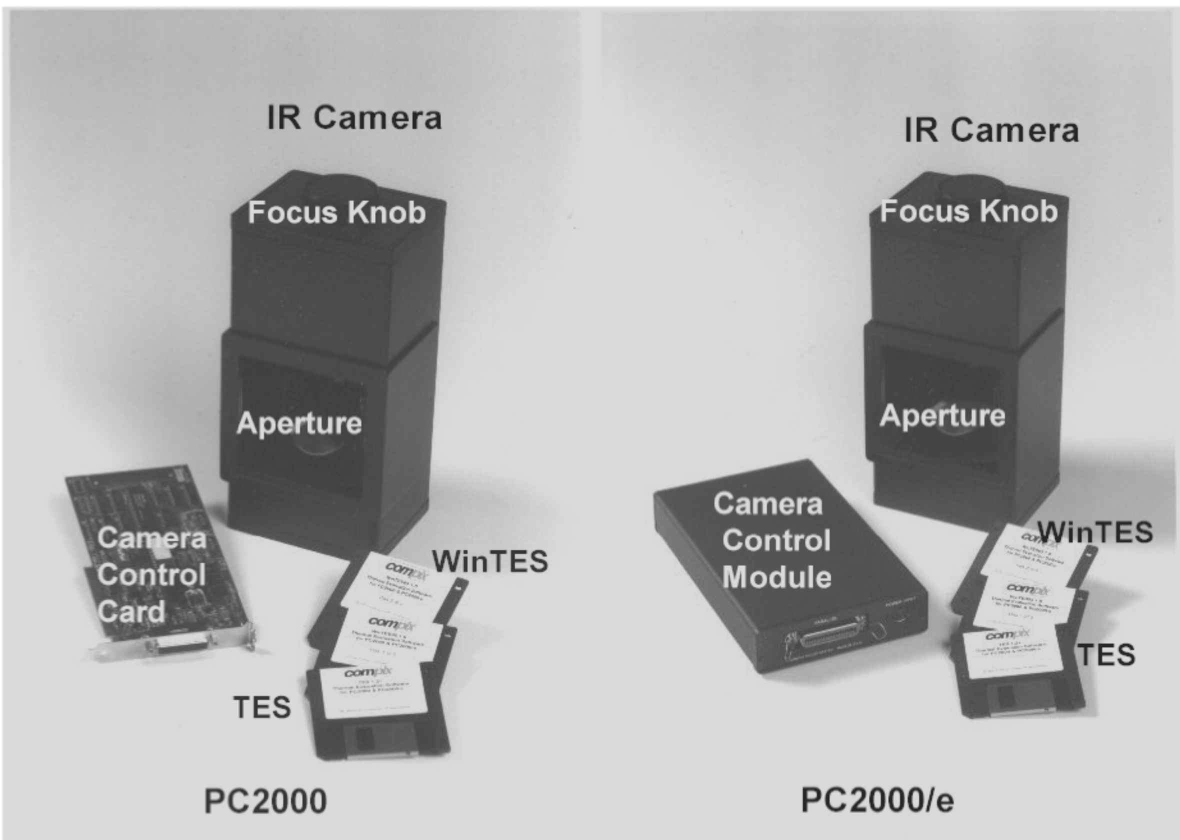


Fig. 1

The PC2000 system has been designed to operate in a typical engineering, factory or sheltered field environment. The system requires a stable surface and well-ventilated workspace at normal room temperatures. The camera head must be mounted on a tripod or other stable fixture. The standard fittings are for a 1/4 "- 20 threaded male connector, the type normally found on photographic equipment.

The PC2000/e and 2000/usb require AC power and will work with line voltages from 90 VAC 50 Hz to 240 VAC 60 Hz.

The camera head should be located within ten feet (three meters) of the imaging computer, PC2000/e module, or 2000/usb module. An interface cable of this length is provided. Cable extensions are not recommended. The **/e** interface module is connected to the computer's parallel interface via a standard printer cable. This second cable is included with the PC2000/e. The 2000/usb interface module is connected to the Universal Serial Bus (USB) via a standard USB Type A/B M/M cable.

The camera should be treated with the same care given a good visible light camera or other optical instrument. Minor vibration can reduce image quality; major vibration or shock may result in damage. And while the longer wavelength IR energy makes it less sensitive to dirt, care should be taken to keep the mirrors and detector window clean. (See Section 8, Maintenance.)

NOTE

There are no components on the PC-circuit-board interface, in the PC2000/e or 2000/usb interface module, or inside the camera head designed for user service. Removing the cover of the camera or interface unit may void the warranty. UNDER NO CIRCUMSTANCES SHOULD THE SYSTEM BE OPERATED WITHOUT THE COVERS IN PLACE.

WinTES for Windows 95/98/2000/NT/Me/XP Computers

The WinTES software is distributed on a CD-ROM. The software has been designed to work with personal computers running Windows 95/98/2000/NT/Me/XP. The display system must be capable of supporting at least the VGA standard.

3. INSTALLATION AND SET UP

Unpack the system. **Lift off the aperture cover** on the camera and carefully remove the foam strip from behind the mirror. Inspect the system for physical damage. If you find shipping damage, stop, inform the carrier and call Compix Customer Service. If possible, store the shipping carton and packing materials for future use.

There are **three distinct steps in the installation procedure:** software installation; interface board (PC2000) or module (PC2000/e, or 2000/usb) installation; camera connection and set-up. You should **perform all of these steps before proceeding** to the verification phase.

NOTE

> You may install WinTES on additional computers to allow others to view images. WinTES will run without a camera thus letting you load, display and manipulate previously stored images. If camera initialization parameters are specified in a configuration file, a warning message relating to those parameters may appear.

WinTES Software Installation

WinTES, allows an operator to control the camera, acquire, store, analyze and display current or previously acquired images.

Install WinTES on your hard disk. To do this, **run the setup.exe program in the root directory of the WinTES CD-ROM.** Follow the prompts. Programs will be installed in the folder stipulated by the user. After completing the installation, store the WinTES CD-ROM in a safe place as a back up.

Hardware Installation

PC2000 Card

The PC2000 interface board may be installed in any 8- or 16-bit ISA slot. To ensure proper cooling, leave an empty slot on the component side of the card, or install as the top card in tower or mini-tower configurations. The PC2000 is shipped with the **dipswitch preset for address 360-hex.** Any address from 300-hex to 3FC-hex in multiples of four is acceptable (e.g. 300, 304, 340, 360).

⚠ **CAUTION**

> To prevent damage to the components on the PC2000 interface board, WEAR A PROPERLY GROUNDED WRIST STRAP OR TOUCH A GROUNDED METAL OBJECT BEFORE HANDLING THE BOARD.

CAUTION

To prevent damage to the computer and interface board, REMOVE THE COMPUTER COVER ONLY AFTER ASSURING THAT THE COMPUTER IS TURNED OFF.

To install the interface board, remove the rear cover of the expansion slot. Insert the PC2000 board in an ISA expansion slot pressing it firmly into place. Secure the board to the chassis with the appropriate size screw.

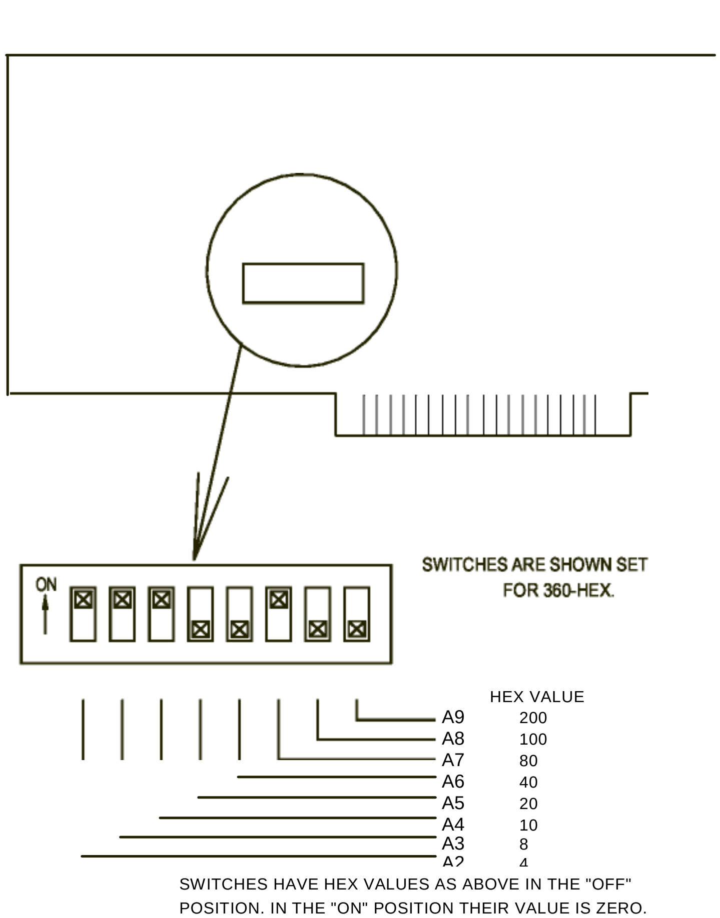


Fig. 2
I/O Port Selection DIP Switches

The PC2000 comes preset to 360-hex and lists other addresses of 300, 304, 340 and 360. If all these addresses are in use you will need to select new addresses. To find unused addresses, click the **Start** button on the Task Bar.

Select **Settings** then click on **Control Panel.** Double click on **System;** choose the **Device Manager** and double click on **Computer.** Select **input/output;** scroll through the list looking for a block of four addresses not in use.

PC2000/e

⚠

CAUTION

To prevent damage to the computer and interface module, BE SURE THE PC POWER SWITCH IS TURNED OFF AND THAT THE I/F MODULE POWER CORD IS DISCONNECTED BEFORE CONNECTING THE INTERFACE MODULE TO THE COMPUTER.

Connect the PC2000/e interface cable to an available parallel printer port on your PC. Connect the other end of the cable to Centronix® 36-pin connector on the interface module.

Connect the low-voltage connector of the PC2000/e power converter to the interface module's mating connector. Plug the converter into an available 110-250 50-60 Hz VAC power source. You may leave the power module unplugged if you are going to be using the PC for operations not involving the thermal imager, but it needs to be plugged in for the following verification.

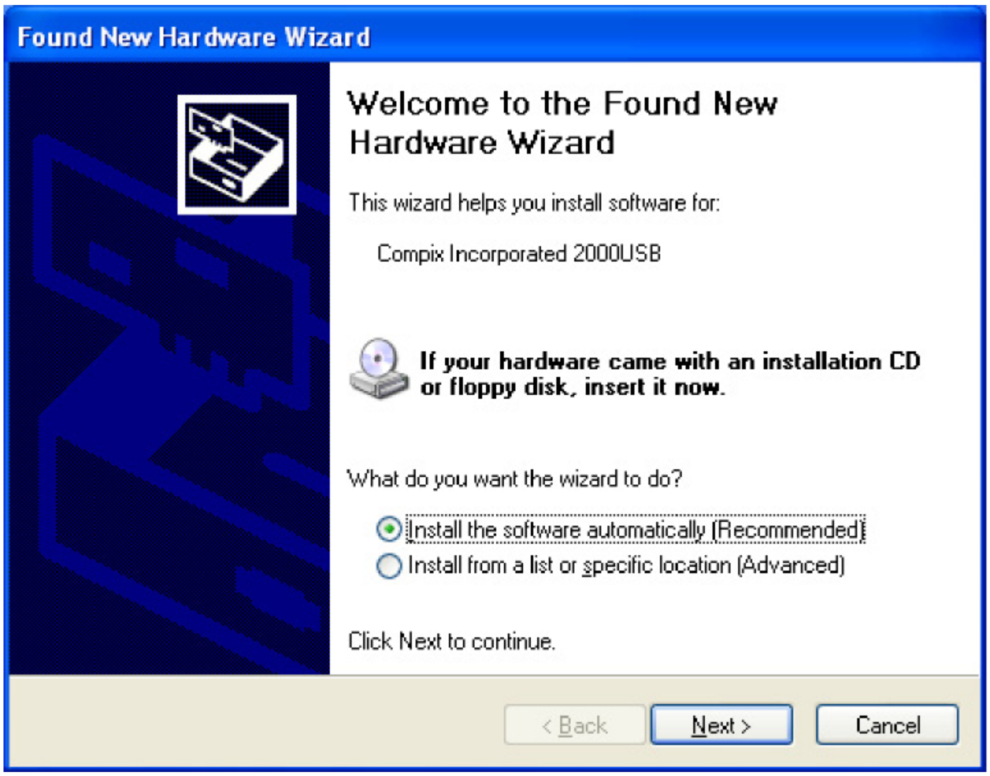
2000/usb

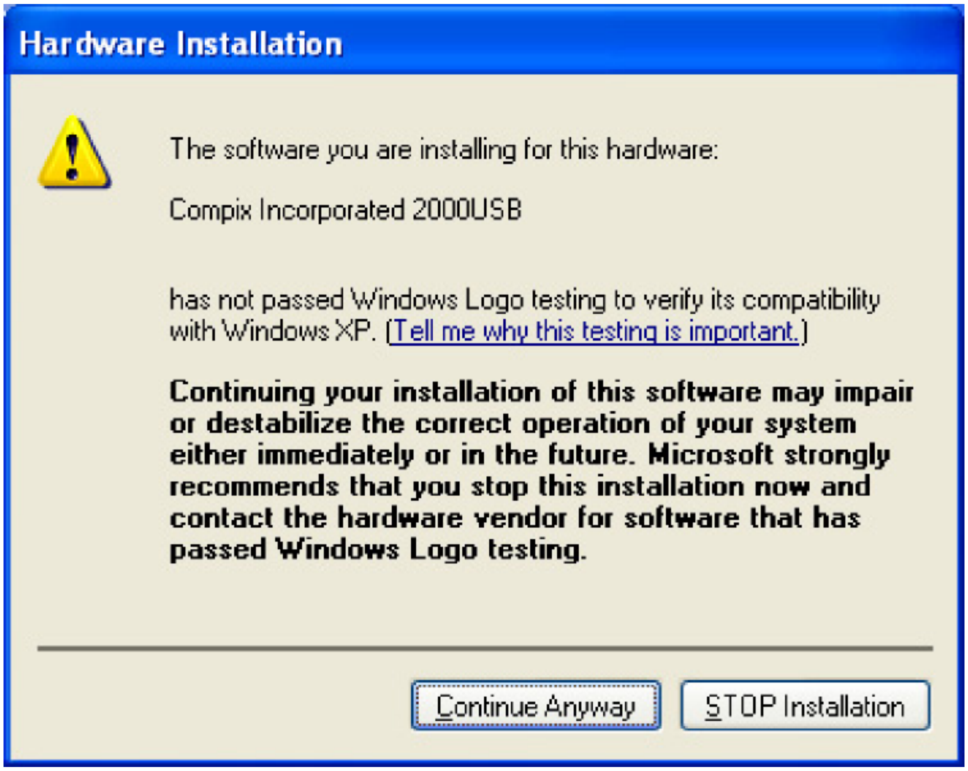
Connect the “A” plug (the wider of the two) of the USB cable to an available “A” receptacle on your PC. Connect the “B” plug of the USB cable to the camera to computer interface.

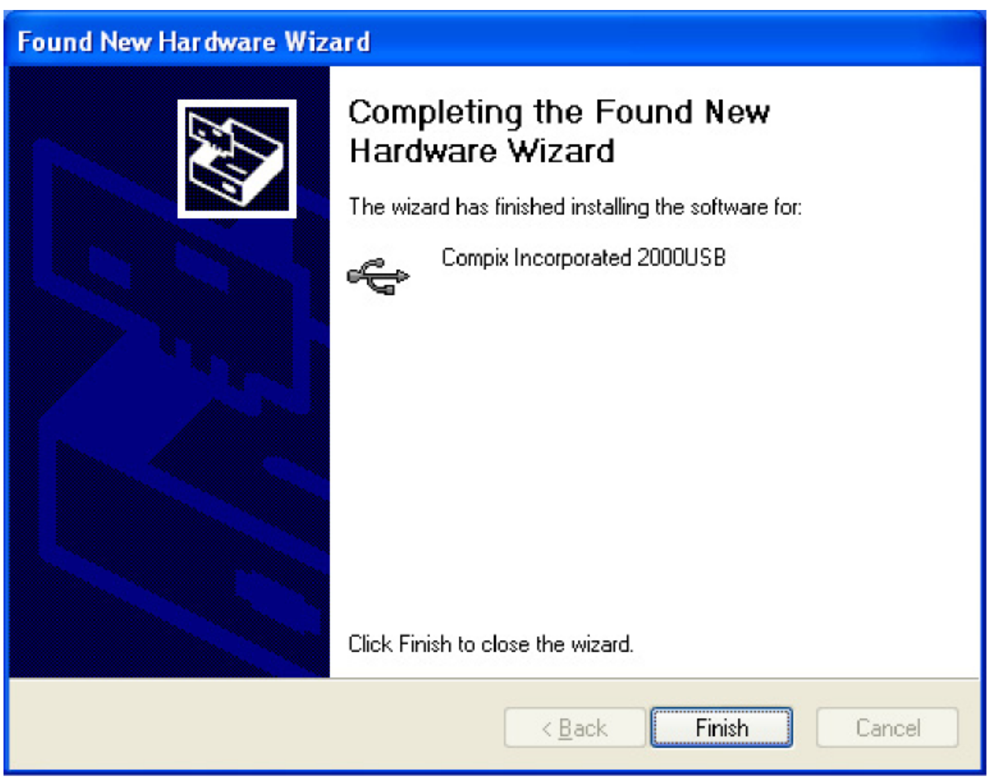
Connect the low-voltage connector of the power converter to the interface module's mating connector. Plug the converter into an available 110-250 50-60 Hz VAC power source. You may leave the power module unplugged if you are going to be using the PC for operations not involving the thermal imager, but it needs to be plugged in for the following verification. N**OTE** WinTES version 1.05.0014 or newer is required for proper functionality of the 2000/usb.

NOTE
for Windows XP users

If the host computer operating system is Windows XP the following screens will appear once the interface module has power, and a connection to the host's USB for the first time. As the screens are presented, you will need to respond as depicted by the highlighted button on each of the screen.




Hardware Installation
The software you are installing for this hardware:
Compix Incorporated 2000USB
has not passed Windows Logo testing to verify its compatibility with Windows XP. (Tell me why this testing is important.)
Continuing your installation of this software may impair or destabilize the correct operation of your system either immediately or in the future. Microsoft strongly recommends that you stop this installation now and contact the hardware vendor for software that has passed Windows Logo testing.
Continue Anyway
STOP Installation


Found New Hardware Wizard
Completing the Found New Hardware Wizard
The wizard has finished installing the software for:
Compix Incorporated 2000USB
Click Finish to close the wizard.
< Back
Finish
Cancel

Mounting the Camera to its Stand or Tripod

Place the PC with the computer to camera interface on a table or other suitable surface near the camera.

Mount the camera head firmly on its tripod or tabletop stand. Threaded mounting nuts (1/4 -20) are provided on both the back and bottom of the camera. See Section 10 for proper tripod setup.

Connecting the Camera

NOTE

POWER TO THE PC AND PC2000/E MODULE SHOULD BE OFF ANYTIME THE CAMERA IS BEING DISCONNECTED OR CONNECTED.

The camera is connected to the computer to camera interface through a 3-meter cable. Connect one end of the cable to the DB44 connector on the back of the camera, then:

- For the **PC2000 installation,** connect the cable to the DB44 connector on the PC2000 interface card.
- For the **PC2000/e installation,** connect the cable to the DB44 connector on the PC2000/e interface module.
- For the **2000/usb installation,** connect the camera cable to the DB44 connector on the 2000usb interface module.

Turn on the computer's power (or connect the power module to a suitable source of 110-250VAC 50-60 Hz power in the case of the PC2000/e or 2000usb). As the computer boots up, there may be a brief flutter of the camera mirror if everything is working properly.

Starting WinTES

Click on the Windows **Start** button. In **Programs** find WinTES and click on it. If this is the first time the system has been operated it will report that the camera is not installed (see figure below). Selecting Install Camera will launch **WinTESCheck.**

Fig 3
WinTES Start Screen

- Selecting **Exit** will terminate WinTES and return to the Windows desktop.

- Selecting **Install Camera** will launch the diagnostic program WinTESCheck and open the window shown in fig. 4.

- Selecting **Continue** will allow the user to run WinTES to view previously saved images.

If no address was previously saved, the **Select Camera Address** window will contain the message **Select.** A valid address is required for the camera to function.

- **For the PC2000 the addresses will be in hex format, e.g. &H360, etc.** You may select any address from 300-hex to 3FC-hex, however you will need to change the dipswitch settings on the interface card to correspond to the desired address. See fig 2 for examples of switch settings.
- **For the PC2000/e** the address will either be **PRN1, PRN2** or **PRN3.**
- **For the 2000/usb** the address will be **USB.**

WinTESCheck, a diagnostic program, checks that the computer has the necessary resources to run the WinTES and that the imaging system is properly connected and functioning. The **first step** in the testing **is to select a port address** for the computer.

The **Select Camera Address** window allows the operator to set the system's I/O port address. The PC2000 will have hex addresses, the PC2000/e will have PRN addresses, and the 2000/usb will have an address of USB. Click on the **Select Camera Address** window's down arrow and select a port address. WinTESCheck will test the computer for sufficient memory and processor speed and then go on to test the camera interface, interface communications, detector response, mirror motion and, finally, initialization.

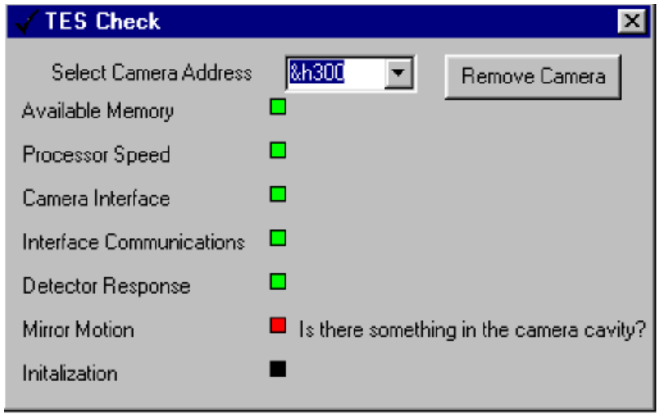


Fig. 4
WinTESCheck Diagnostics Window

A green or red light will show up next to each function as it is tested. Red will terminate the test and indicate a possible cause of failure. If the wrong port is selected the system will fail the camera interface test. This doesn't mean the system isn't working just that a wrong port address was selected. Try another address until all the lights are green. If no address works a problem exists. Check for proper seating of the PC2000 board and that all connections are properly made. In the case of the PC2000/e or 2000/usb, check that the module has been turned on. If these steps don't allow the system to initialize then it is necessary to call Compix Customer Support.

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4. WinTES MENUS

When the Compix® PC2000 takes a thermal image or when a TIFF (.TIF) or Compix (.CPX) image file is opened, the user is relieved from having to deal with many details associated with handling tens of thousands of temperature measurements. This section explains how the control and display functions may be used in combinations that get the most out of the thermal images. **Please read this section before attempting to use the system.** Take time to familiarize yourself with the functions and controls of WinTES and the PC2000, PC2000/e, or 2000/usb system.

WinTES menus are largely self-explanatory and the system permits risk-free exploration. Once an image has been saved no combination of menu functions will change the saved temperature data. The exception to this is when another image is saved under the same file name. Therefore, if you try something and don't get the desired result, you can always reload the saved image and try again.

Camera Control Introduction

When opened, WinTES will display three windows: **Camera Control, WinTES, Thermal Image-** Clicking the cursor on any of these windows will make it the active window.

Camera Control Window- This window (fig. 5) controls the camera scan. It also provides for auto scaling of images and/or automatic saving of images.

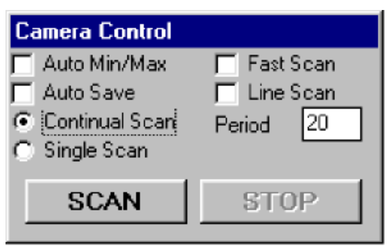

Fig 5
WinTES Camera Control Window

Two modes of scanning are available with WinTES. These are **Continual Scan** and **Single Scan.** Continual Scan causes the camera to scan, reset and scan until told to STOP or until Single Scan is selected. Single Scan causes the camera to take one scan and then stop. The **Scan** button initiates a scan.

With Continual Scan the operator can control the time from the start of one scan to the start of the next by using the **Period** feature. This is accomplished by typing the desired time (in seconds) in the period window. A normal scan takes approximately 14 seconds thus a period of 20(default setting) would have a scan starting every 20 seconds. Switching from **Continual Scan** to **Single Scan** will cause the camera to complete the current scan then wait for the next scan command. The **Stop** button causes the camera to immediately stop scanning.

Auto Min/Max provides automatic scaling. The minimum and maximum temperatures for the displayed image are updated after each scan.

Auto Save automatically saves each image to a file after each scan.

Fast Scan causes the PC2000, PC2000/e, or 2000/usb to scan in approximately 8 seconds. In this mode the image resolution is half that achieved at the normal scan rate.

Line Scan allows the operator to "park" the scanner over a point or line on a sample. The pan motion is disabled and the camera is allowed to line scan over a two-pixel wide area. The display is converted from a x-y thermal map to a display of temperature Vs time. Fast changes can be detected using this mode.

WinTES Window

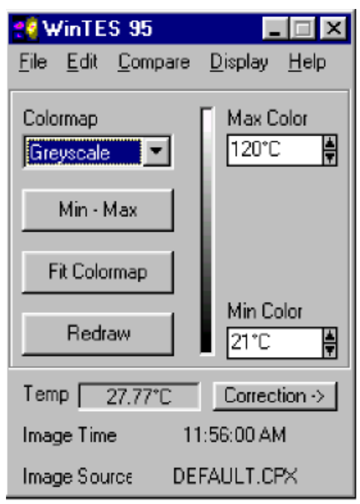

Fig. 6 WinTES Control Window

Menus: File, Edit, Compare, Display and Help.

File- Sub-menu items: **Open File, Save File, Exit.**

> **Open File-** Allows operator to open a previously saved image, configuration, or colormap. **Save File-** Allows operator to save an image as a TIFF or as a Compix Image File that retains the full resolution temperature data. **Exit**-terminates the program.

Edit- Sub-menu: **Copy, ColorMap.**

Copy- Copies the displayed image to the Windows clipboard where it can be accessed by other programs. **ColorMap-** Provides a **ColorMap Editor** for setting under and overrange colors.

Compare- Permits the operator to compare images with a reference or previously stored images. Differences between an “unknown" and “golden” board can quickly be determined.

Compare- Sub Menus: **Use for Reference Image, Display Reference Image, Revert to Scanned Image, Compare to Reference Image, Compare ALL to Reference.**

Use For Reference Image- Current image is saved as the reference to which others may be compared.

Display Reference Image- Shows the image currently saved as the reference image.

Revert to Scanned Image- Displays the scanned image.

Compare to Reference Image- the current image is compared against the previously saved reference image. Each pixel, or temperature data point, of the reference image is “subtracted” from the second image.

(compared image = current image - reference image)

Compare ALL to reference Image- Every scan is immediately compared with the reference image.

Display- Sub Menus: **Cursor, Degree Units, Camera Control Window, Thermal Image Window, and Heat Flow Window. Cursor- Spot Cursor, Profile Cursor**

Spot Cursor- The cursor reads out the temperature of the selected point of the image. This is indicated in the TEMP window of the WinTES window.

Profile Cursor- Selecting profile cursor brings up two additional windows at the bottom and side of the image window. Temperature ranges are displayed along with a graph of temperature along vertical and horizontal extensions of the cursor. The crosshair may be moved using the mouse or the cursor keys. The temperature at the intersection of the horizontal and vertical lines is displayed in the temperature window.

Degree Units- Allows for Selecting Celsius or Fahrenheit thermal scale.

Camera Control Window, Thermal Image Window- Activates window selected.

Heat Flow Window- Selecting this item opens a window with a movable slide bar. This feature allows the operator to "move" the scale up and down over the displayed image. The minimum and maximum temperatures of the scale define the range of temperatures displayed. The movable window allows subtle temperature differences to be accentuated.

Sub-Window- Color Edit contains image display controls.

ColorMap- The color scale has six " built-in" display palettes; Default, Rainbow, Blue to Red, Blue-Green-Red, Grayscale and Medical. Image files may be displayed in any of these six "colormaps" or palettes. Each is useful for displaying images and personal preferences may dictate the operator's choice.

The palettes contain 234 shades of color or grayscale. Changing color palettes doesn't affect temperatures in the image.

The **Max Color** value is the highest temperature displayed in the color palette. The **Min Color** value is the lowest value displayed in the color palette.

The values above and below the MIN and MAX are useful for setting and displaying "over-range and under-range values". To set upper or lower control or "over-range" values, double click on the color bar. A secondary window will appear and the operator can select a color to signify "over and under range" values. Select the color and tell the program to apply the chosen colors. The top and bottom portions of the colorbar will now display those colors. Subsequent display of images having values outside the colorbar will show the overrange colors.

Min-Max- Auto range reads the minimum and maximum temperatures in the image and sets the min and Max so they encompass the display range. The system automatically redraws the image with the new scale.

Fit ColorMap- Auto scale fits the scale so that one cycle of the colormap is used to display the image data.

Redraw- Refreshes the image. This is done automatically when Color Scale is changed. It is not automatically updated when thermal correction factors are changed.

Thermal Correction- This is an auxiliary window, which is opened when **Correction** is clicked. A series of controls are made accessible.

Ambient, Emissivity, Lens factor, Field of view (FOV), Focus (in).

Ambient- the Emissivity is calculated about this value. Set the value to the temperature of the ambient in which the instrument is operating.

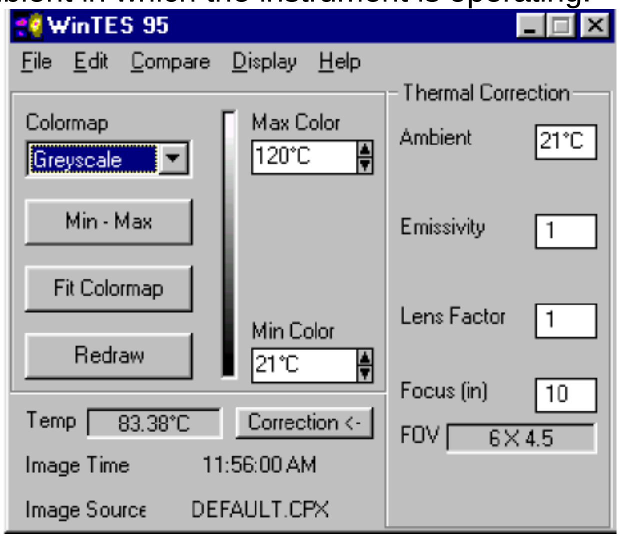

Fig. 7
WinTES Control Window with Thermal Correction Open

Emissivity- All materials have characteristic emissivities, which are, less than 1.0. This means that non-black bodies radiate IR at a lower rate than does the ideal source. Practically speaking this means that an object with a lower emissivity will appear to be closer to ambient than a black body having the same temperature. The Emissivity setting corrects for this effect and provides the user with the correct temperature reading for that object. Values can be selected from 1.00 to 0.01.

Lens factor- This correction compensates for the attenuation introduced when the system is operated with the 7.5x lens. Without the correction, temperatures read by the system would appear lower than their true temperatures. Each lens comes with its lens factor specified on its serial number label. Nominally this is around 65%.

Focus (in)- Temperature readings can be affected by the distance of the camera from the object being measured. This setting represents the distance in inches from the front of the camera to the object and corrects for any distance-related errors.

FOV (Field of View)- This is an indication of the approximate size of the area being scanned.

ColorMap editor- The three color scales display colors that represent temperatures between the indicated minimum and maximum values. There are two bands of colors, one above the Max temp and one below the Min temp called **Over Range** and **Under Range.** The operator in a way, which emphasizes different aspects of the thermal data, may change their colors. To edit the colors, place the cursor on the color scale and double click. A window called ColorMap editor will appear. Double clicking on either the **Over Range** or **Under Range** colors will open another window entitled **Color.** The operator can select the color to represent these extremes. Clicking **OK** will bring back the ColorMap editor window. Clicking **Apply** will change the value to that color. Repeat the process for the other range.

Thermal Image Window

Stats (Statistics)- Stats provides the ability for the operator to define an area of the image and have the system report out the temperature min, max, avg. and standard deviation for the area. To define a measurement area, hold down the left mouse button and move the cursor across the image. A "box" will open within the displayed image. Releasing the mouse button will cause a window labeled **Stats** to appear.

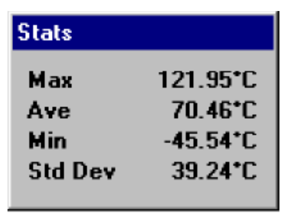

Fig. 8
Statistics Window

Within the window are displayed the maximum, minimum, average and standard deviation of the temperatures. Repeating the process anywhere on the image will yield the data for the newly defined "box".

The "box" can be moved across the image by using the Shift key and Arrow keys. Horizontal movement is accomplished by moving one side and then the other through use of the Left/Right arrows and Shift (or no-Shift) keys. Vertical movement is accomplished in similar use of the Shift key and Up and Down arrows instead of Left or Right arrows.

Cursor as Profile: This function constructs line graphs of the temperature variation along a horizontal and vertical line.

5. MAKING THERMAL IMAGES

Once you have completed the set-up steps of section 3, the system is ready for operation.

Definitions: The **top** of the camera is the end with the focusing knob. The side with the large opening (aperture) is the **face** or **front.** The opposite side, with the cable connector, is the **back.**

Preparing to take images

With its face toward the subject, position the camera head so it is approximately centered over the area to be scanned. The top edge will correspond with the top of the display. The face of the camera head should be parallel to the surface of the subject.

The area scanned by the camera depends on the distance from the camera to the subject. As with a “box” camera, the greater the distance the larger the field of view. WinTES displays the field of view when the distance from the camera to the object (focus) is entered in the correction menu. Set the camera head at a distance appropriate for the size of the subject. It should be no closer than 2.0 inches. The focusing knob has a scale showing focal length in inches and mm. For an initial focus, turn the knob to where the distance indicated by the index mark matches the distance from the camera to the surface of the subject.

Start WinTES by double clicking on the WinTES icon. If the camera has been set-up previously the system will configure itself automatically. To begin scanning select **Single Scan** or **Continual Scan** and click on the **Start** “button”. The default value for **Delay** is 20 seconds. This is the time from the start of one scan to the start of the next scan. The user can select values to best suit their application.

While the system is scanning you may improve the focus by making small adjustments of the focusing knob until edges appear sharp. Remember that heat will flow from one object to another thus thermal images may appear “smeared” when compared to photographic images. (See Section 6 for suggestions on focusing and framing.)

Single scan will take one image, then stop. **Continual scan** will periodically scan, depending upon delay, until commanded to **Stop.** You can stop either process at any time by selecting STOP. Selecting single scan while in the middle of a multi scan will cause the scanning to stop at the end of the current scan.

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6. OPERATING SUGGESTIONS

Focusing

The optical system of the Compix® PC2000 camera operates in the same way as a photographic camera. One implication of this is that the system's large aperture results in a short depth of field. Near the middle of its focal range (12”-15”), a depth of field around 1/2” would be typical. At two inches, the depth of field may be less than 1/4”. In any case, focusing is important to image quality as well as temperature accuracy.

Generally, items seen in a thermal image are not as crisp as when viewed in a video image. As a result, when first viewing an image it may be hard to determine whether the camera is well focused or not. This will become easier with practice.

The PC2000 camera utilizes a manual focusing mechanism. The first step in focusing is to measure or estimate the distance from the forward edge of the aperture bezel to the subject. If the subject isn't flat, use the average distance, or use the distance to the area of greatest interest. With the focus index set to match the camera to object distance take a **Single Scan.** After the scan is completed, click **Min-Max.** This will set the Min and Max temperatures so that the range displayed encompasses the temperatures in the scanned area. You should now see an image from which you can begin to fine tune the Focus. In the Camera Control window set the scan for **Continual** and start scanning. While the system is scanning make a series of small focusing adjustments and observe the changes. Look for improvements in the definition of the outlines of components such as crystal cans, IC legs or board mounting hardware and mounting holes. Straight edges of larger components are also good guides. Entering this focus distance in the **Correction** window will indicate the camera's field-of-view (FOV) as well as provide a correction factor to compensate for variations introduced when the camera is moved away from the 10 inch focal length used in calibrating the instrument.

Many users find this process easier with the Grayscale colormap, since black and white images tend to appear more natural. A technique, which gives excellent results, involves indirectly shining a 40 to 60 W incandescent light on the unpowered target. To the PC2000 this is the functional equivalent of an infrared flashbulb. The lamp illuminates the target and the camera displays the reflected IR energy. The resulting image will look much like a visible light picture. Edges will be sharply defined, components will stand out in sharp relief and fine focusing will be easier.

To use this technique, place the lamp about two feet above, and at an angle of about 45° to an unpowered target. Don't shine the light directly into the aperture of the camera. Use Grayscale colormap and take an image. You may have to experiment with the position of the lamp to get the best result. **When finished focusing, turn off the lamp** as high levels of reflected infrared will distort the temperature readings.

Framing or Determining What is Being Viewed

Framing involves two things: first, the aiming of the camera so the target is centered in the image; second, being able to relate specific points in the thermal image to the corresponding locations on the target. The same factors that make it more difficult to focus a thermal image can also make it harder to frame properly. Many users find their first thermal images are ambiguous and confusing. But image interpretation is quickly learned if the user has a working knowledge of the object being scanned.

Remember, *it is important to have a well-focused image.*

Operating hint: Look for obvious reference points. Typical hot spots are power resistors, power transistors, and power IC's. Cold or low emissivity components would normally include mounting brackets, metal capacitors or crystal cans and bare copper runs. Surface mount devices, hybrids, etc. are often framed by the contrasting colors of surrounding heat sinks or substrates. Packaged IC's may be identified by the rows of legs or leads on the sides.

Edges of circuit boards are usually easy to find. In an energized board, conduction through the substrate and ground plane normally creates some visible differential heating to the edge of the board. Providing a good background can make the edges easier to see. A dark, matte finish material such as cardboard or black paper behind the board can improve contrast.

Simple markers can be used as pointers. Any small non-conductive (for safety reasons) object at room temperature will work. Plastic tools, non-metallic rulers are also useful. Put the marker on the target as a pointer or an edge indicator, and then take an image. The marker should show up as a distinct dark area against the warmer background of the board and its components. Objects you take out of your pocket will already be warm and may not show up in the image. Some users have reported good success with active (hot) markers. The wire will appear as a distinct hot pattern in the thermal image. The focusing technique described above of using an incandescent lamp or other infrared source is also useful for framing. Make a reflected IR image using that technique. Then, with the lamp off, make a normal thermal image. Watch the display as the thermal image overlays the reflected IR image and you will see which points correspond.

Temperature Measurement

The Compix PC2000 is a sensitive instrument that has the capability to detect small temperature differences within the range typically encountered by engineers. However, non-contact temperature measurements are affected by a number of variables that can change the accuracy of temperature measurements. The following techniques will help improve the accuracy of measurements made with the PC2000 system.

Be Consistent

Often all that's needed are good relative measurements. The engineer wants to know how one temperature compares with another. Consistency is the key.

- Maintain the same environmental conditions, e.g., ambient temperatures, ventilation and the presence of other heat sources in the room.

- Maintain the same physical set-up for the system. Put the boards in the same orientation -- flat or upright, the same distance from the camera and the same relative position on the display.

- Maintain the same electrical set-up: same power inputs, same program to exercise it. While a circuit board may take several minutes to reach thermal stability, it is not necessary to wait for the board to stabilize, but comparative readings between boards will be more accurate if both circuits are at approximately the same point in their warm-up cycles.

- Use the same scan rate in both cases.

Minimize external sources of infrared energy.

The Compix PC2000 measures temperature using emitted infrared energy, i.e. the infrared energy generated by the target. Objects also reflect infrared energy from their surroundings.

The PC2000 system (or any other infrared system) can't tell the difference between reflected and emitted energy. Therefore, reflected energy is a potential source of error. Some reflected infrared (IR) energy is unavoidable and the PC2000 will automatically compensate for typical levels of external IR energy, which are uniformly distributed over the target. Nevertheless, it will be helpful to minimize significant sources of external IR, particularly those that may not be uniformly distributed.

Other sources to avoid are direct sunlight coming through a window and shining on the target, or heat from nearby electronic devices. A general rule of thumb is that if you can feel heat from a source near the target, then it will affect the accuracy of the image.

Minimize the reflectivity of the target.

Another aspect of the problem described above is that some objects naturally reflect more infrared energy than others do. Unfortunately, due to the laws of physics, good reflectors are poor emitters of infrared (emissivity<<1.00). As a result, these objects produce a high ratio of reflected (undesirable) to radiate (desirable) infrared, thus yielding less accurate temperature readings.

The solution is to reduce the reflectivity of these objects. Fortunately, surfaces that are reflective to infrared are usually reflective to visible light. So look for bright, shiny or metallic surfaces, as they will be the problem.

There are several easy ways to reduce reflectivity while minimally effecting the component's thermal performance. A strip of electrical or masking tape on the top surface is one. Anything with a matte surface is a good choice. Or a quick, light buffing with fine emery paper -- just enough to break the surface sheen -- will also help. Most conformal coatings and solder masks provide a low reflectivity surface for thermal images.

Adjust the Emissivity setting

The default Emissivity setting of the PC2000 system is 1.00. This is appropriate for the highly emissive (low reflectivity) materials that are most common on circuit boards. For components with lower emissivity, temperature accuracy will be improved if the PC2000 system's Emissivity setting is adjusted to match the component's emissivity. Emissivity tables are available for many of the materials commonly used on printed circuit boards.

7. PRINTING AND EXPORTING IMAGES

WinTES produces TIFF (Tag Image File Format) images that adhere strictly to the TIFF standard Revision 5.0 for Class-P (Palette Color) Images. Some software applications, which claim to be TIFF compatible use a limited subset of the TIFF specification and may not import Compix TIFF files, so universal compatibility is not assured.

The most reliable way to export a color image is to use the **Copy** command from the menu. This puts the image into the clipboard from where it can be pasted into the appropriate document. Alternatively, **Print Screen** may be used to copy a full Windows screen to the Clipboard or **Alt Print Screen** will copy only the active window to the clipboard. These objects may be pasted into a Word, WordPerfect or other word-processing document.

Additionally, the TIFF thermal image files may be opened in any of a number of applications programs. Finally, images may be captured and saved using any of a number of commercially available screen capture programs.

From these word processing or screen capture programs it is a simple matter to print to a file or printer.

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8. MAINTENANCE

Calibration

It is recommended that instrument performance be verified once a year. The instrument should be compared against a calibrated blackbody source. It is recommended the instrument be returned to the factory for repair and recalibration.

General

The exterior of the camera, PC2000/e module, and 2000/usb module can be dusted with clean, low-pressure air or a clean, soft cloth. For more persistent dirt, scrub gently with a damp cloth.

Mirrors

Inspect the camera's mirrors periodically. If used in a relatively dust-free environment and if the aperture is covered while the system is not in use the mirrors shouldn't require frequent cleaning. When the mirrors are visibly dusty, clean them as follows:

Remove the plastic bezel surrounding the camera's aperture. With the camera firmly supported and facing you, carefully reach inside with your thumbs and press outward on the sides of the bezel while pulling forward. When the bezel is off, set it aside.

Turning the focusing knob to the high end of its scale will move the focusing mirror to where it is accessible for cleaning.

The cleaning techniques for the mirrors are the same as for a high quality camera lens. Usually dust can be removed with a blast of clean, low-pressure air or a soft, gentle brush. For more thorough cleaning, use a non-abrasive, lint-free cloth with a photographic wetting agent or alcohol.

Replace the bezel by reversing the steps to remove it.

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9. Installation and Operating Instructions For the 100 Lens

Introduction

The **100** is a collection of accessories for the PC2000, PC2000/e, or 2000/usb which together form the PC2100, PC2100/e, or 2000/usb respectively, and which consists of the following:

Alternate bezel, which holds the magnification lens. The magnification lens itself consists of three precision optical elements made of silicon and coated for optimum performance in the 3 to 5 micron wavelength band. These elements are housed in a black anodized aluminum holder mounted in the front panel of the alternate bezel. Two lens dust covers are included, one for each side of the lens. The two lens dust covers are identical.

A sturdy bench top stand to support the camera with lens attached securely over the object to be imaged and which provides a means for making minute adjustments in the height (or Z-axis) position of the camera.

A large hex wrench for tightening/loosening the clamp arm that holds the camera/lens combination.

Optional Accessories:

A micrometer-style X-Y positioner mounted to the base of the bench top stand on which the object to be imaged is mounted.

Set-up & Installation

Assembling the Heavy-duty Stand

1. Attach the post to the base plate using the long-shaft socket driver.

2. Install the safety clamp

3. Install the camera support arm and pinion assembly onto the vertical shaft. Make sure the arm support is oriented to the top of the pinion assembly. Gradually lower the assembly until the pinion engages the rack. Do not force.

Installing the camera on the bench top stand

1. Position the safety ring four inches (100mm) or more above the base. Tighten it securely in this position. Later you will adjust the height of this ring so that the lens cannot possibly touch or crash into the object being imaged.

2. Remove the standard bezel from the camera: Lay the camera on its back with camera cable disconnected. Carefully reach inside both sides of the bezel and push out as you pull the bezel away from the camera. Avoid touching the mirror. It may be easier to cross you arms and slip your thumbs inside so that you can push outward controllably with enough force to remove the bezel easily.

3. Remove the internal lens cover from the magnification lens. It is not necessary to twist the lens cover to remove or install it, but if you do, always turn it clockwise so as not to have a tendency to loosen the lens-retaining ring. Inspect the lens surface and clean it if necessary (see section 4-2). Note the value to be used for the Lens Factor as indicated on the label inside the lens-bezel assembly. Note which end should be up. Slide the lens-bezel assembly into position. Use your fingers to pull the sides apart as the assembly is pushed all the way into place. Make sure the protruding setscrews engage the holes in the camera sides.

4. Make sure the clamp bolt of the camera support arm is fully loosened. Remove the external lens cover. After assuring that the lens-bezel assembly is properly installed, turn the camera over and carefully insert the lens housing into the large hole in the camera support arm. The focus knob of the camera may be oriented away from the post or to either side. Tighten the arm clamp using the hex wrench just enough to hold the camera securely and prevent it from twisting. Do not over tighten!

5. Replace the external lens cover until you are ready to actually start imaging. The external lens cover may be twisted, if desired, in either direction. Store the internal lens cover in a safe place where you can find it later if you want to remove the lens

and use the camera for imaging larger objects. The lens covers are interchangeable.

6. Re-position the safety ring so that the camera cannot come down too close to the object being imaged. Tighten the safety ring. Always keep the safety ring positioned and tightened to insure that the lens cannot fall onto, or come in contact with the object being imaged.

Mounting the positioner (if applicable)

The optional positioner, if ordered, is shipped separately to prevent damage to the micrometer adjustment mechanisms. It is to be installed on the base of the bench top stand using the four threaded holes.

1. Remove the four #6-32 socket-head cap screws from their holes in the base plate.

2. Position the X-Y positioner over these four holes. The positioner may be mounted in any of four orientations. The most common is to have one adjustment in front and the other to the right. However, on a crowded bench, better protection against damage and accidental change may be worth the inconvenience of mounting one adjustment to the back and the other to either side as dictated by the environment or by the preference of the operator.

3. Install all four cap screws finger tight. It may be necessary to move the stage of the positioner to get satisfactory access. Avoid manually moving the stage against the force of the return springs, and, especially, DO NOT LET THE STAGE RETURN OUT OF CONTROL TO ITS REST POSITION. (Repeatedly letting the stage slam against its stops under force of the return springs could damage the micrometer mechanisms.)

4. Finally, tighten all four screws uniformly. Do not over tighten. Tighten them just enough to keep them from vibrating loose or allowing the positioner to wiggle when operating the micrometers. Use a torque screwdriver, if possible, and tighten the screws to 40 in-oz.

Removal/Disassembly

To remove the lens assembly in order to use the camera for imaging larger objects, or for shipment, simply reverse the above steps.

Operation

Set up the object to be imaged on a stable surface. (If the grid of #6-32 threaded holes of the optional X-Y positioner are used, be careful that the screws never engage beyond 0.2 inches (0.5mm) and protrude through the stage. Nylon screws are recommended. Alternatively, a sample can often be installed satisfactorily using masking tape or equivalent.)

Adjust the safety ring so that, with the lens cover in place, the camera cannot come down any further than to have the lens cover almost touching the sample.

To raise or lower the camera, adjust the tension as needed, tight and slowly rotate the height adjustment knob. The tension will automatically increase as you lower the camera, or decrease as you raise it. To maintain constant tension, turn both knobs together.

Connect the camera cable, apply power, and proceed to operate in the normal manner (see PC2000 manual).

Raise the camera several inches above the object being imaged and remove the lens cover.

⚠ **CAUTION:** Never touch the lens or allow any object to touch or strike the lens.

Set the focus distance knob on the camera to 15 inches (375mm). Carefully lower the camera to within 0.3 inches (7.5mm) of the object to be imaged. This distance is measured from the forward most (lowest) surface of the lens housing to the plane of the object.

Set the **Lens Factor** according to value printed on the label on the inside of the lens-bezel assembly. To set the lens factor in **WinTES,** click on the **Image Data** button. This will expand the WinTES window and add a **Thermal Correction** section in which Lens Factor and Emissivity can be set. Focus distance should be set to 15 inches (375mm). The FOV (Field of View) is not valid when using the magnification lens. In the case of the DOS-base **TES** software, the Lens Factor is entered using the corresponding item in the TES **Display** menu. The use of the Lens Factor is necessary to compensate for the attenuation introduced by the lens. See Appendix A for further discussion of the Lens Factor.

If the device is powered (or illuminated from a small nearby incandescent source) an image should be obtained. To adjust the focus, adjust the height of the camera. When reasonably good focus is achieved, further refinement may be made adjusting either the height or the focus knob. Overall performance will be best if the camera focus setting is kept between 12 and 18 inches (between 300 and 450mm).

Maintenance

Storage

Use the lens cover to protect the exposed lens whenever the **100** is not in use. If for any reason the magnification lens is removed from the camera, be sure to protect both internal and external lenses with the lens covers.

Cleaning

Small amounts of dust or lint on the lens surface will have little or no effect on the performance or calibration of the lens. It is possible to degrade the lens surface by improper or excessive cleaning techniques. Use the following cleaning techniques carefully and not too frequently.

To remove loose dust or debris, use a gentle stream of dry air. Aerosol-type cans of clean dry air available at camera and electronic stores are suitable for this purpose. For more persistent loose dust or debris you may use a camelhair brush or soft cotton swab ("Q-tip"). **Do not use lens tissues: Lens tissues intended for eye glasses contain chemical additives and lens tissues available in camera stores are often not soft enough.**

Avoid touching the lens surface with your fingers. If you do need to clean off fingerprints or other more resistant material, use clean alcohol or acetone to dampen a soft cotton swab, gently dab, and swipe the spot or fingerprint. If you look at the lens surface under magnification you will probably notice a few tiny defects in the coating that have no measurable effect on the performance of the lens; But if you mistake such a defect for debris and try to remove it you can make the defect larger.

Preventative Maintenance

Whenever you remove or install the lens assembly onto the camera check to make sure the inner lens retainer hasn't turned and that the beveled portion of the retaining ring is exactly aligned along the bottom. Newer lenses have no beveled portion in which case this check may be ignored.

Occasionally inspect all parts of the lens assembly, bench top stand, and X-Y positioner for damage and for accumulation of dust and debris. Clean and lubricate (using a light oil) all moving parts as needed.

Repackaging for Shipment

DO NOT SHIP THE CAMERA WITH THE LENS INSTALLED. Use the lens covers and provide plenty of packing material. Refer to the PC2000 manual for camera packing instructions.

To ship the bench top stand it is recommended that the X-Y positioner be removed and packed separately. Make sure the support arm and safety clamp are tight, and use plenty of packing material.

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10. USER SUPPORT

User support is available by phone, mail, e-mail or in person at Compix' offices in Lake Oswego, Oregon. Support will normally be available from 8:00 A.M. to 5:30 P.M. Pacific Coast Time, Monday through Friday, excluding national holidays.

User support is generally free of charge on issues relating to interpretation of this manual, the proper operation of the system, routine maintenance and warranty service. Consultation is generally not available on image interpretation problems, fault diagnosis, system modifications or application specific issues, particularly those outside the field of electronic test.

Compix reserves the right to determine, at its sole discretion, the extent of user support made available to any user. A user may be asked to furnish proof of ownership of a Compix PC2000 system before receiving support.

For phone support call **(503) 639-8496,** identify yourself as a user of the Compix PC2000 system and ask for User Support. It may be helpful for you to have the serial number of your PC2000 system and the version number of WinTES available when you call.

Visit **www.compix.com** for technical articles, price lists, product photos, and other information on current products.

For support by mail write to:

Compix Incorporated
Attn.: User Support/PC2000
P.O. Box 885
Tualatin, OR 97062-0885

If you want to visit us in person, please call us at the number above for directions and to make sure the person best equipped to help you will be available when you arrive.

Our office location/ shipping address is:

Compix Incorporated
15824 SW Upper Boones Ferry Rd
Lake Oswego, OR 97035-4066

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APPENDIX A. Efficiency, Emissivity, Lens Factor, and Noise

Both **emissivity** and **lens factor** work alike to express the efficiency with which radiation from that object reaches the sensor of the camera. Use what you already know about emissivity effects to understand the effect of the Lens Factor.

The overall value for efficiency may be determined by multiplying the emissivity and lens factor. In the following examples, the first three lines represent mathematically equivalent situations:

Emissivity	Lens Factor	Efficiency
.49	1.00	.49
1.00	.49	.49
.70	.70	.49
1.00	1.00	1.00

Background noise is exaggerated by non-unity lens factor or emissivity settings. To fully understand this it may be helpful to view the top two lines of the **Apparent Temperature table** are reproduced below. The first entry of the second row simply indicates that for a 100% emissivity object, 30^{o}C would be reported; the second entry indicates that a real surface of 0.9 (90%) emissivity would appear the same as a blackbody of only 29.1 ^{o}C.

Another way of looking at the information contained in this table is to realize that if the emissivity were set to 90%, then a black body of only 29.1 ^{o}C would be converted to read out as 30^o C. Similarly, the third entry from the end in the first row indicates that a blackbody of only 22.9^o C would be converted to read 30^o C if the emissivity setting were 20%.

Apparent Temperature as a function of
Actual Surface Temperature º C (down) and Emissivity % (Across)

100	90	80	70	60	50	40	30	20	10	0
30	29.1	28.3	27.4	26.5	25.6	24.7	23.8	22.9	21.9	21.0

The background noise reported with a 100% efficiency setting (100 emissivity and 100 lens factor) will typically span two to three degrees. Suppose a particular instrument reports background noise of 21^o C to 22.9^o C. Suppose these values were converted with a lens factor of 20%. By definition, 21 ^{o}C is converted to the same value, 21 ^{o}C. But 22.9^o C, as shown in the table fragment above, would be reported as 30.0^o C, resulting in a 9-degree span for the temperature-equivalent background noise.