XR 4000 Real-Time
X-Ray Inspection System
Operation Manual

Rev A-3-2001-PRM

P/N 5050-0516

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1. XR 4000 Safety Information

IMPORTANT: READ THIS FIRST

It is essential that the operator of the XR 4000 read and understand the following safety warnings **PRIOR** to operation.

The XR 4000 is designed to provide safe and efficient operation. However, any equipment producing ionizing radiation (x-rays) must be considered hazardous and should be treated accordingly. When operating this equipment, observe the following:

- PACE strongly recommends that all maintenance be performed by a qualified service technician.

- The XR 4000 x-ray tube produces high voltages of up to 70,000 volts. Under no circumstances should the case be disassembled or modified as severe electrical shock may occur.

- The XR 4000 is designed to ensure adequate radiation shielding. Even so, always be aware that the ionizing radiation (x-rays) can constitute a distinct hazard if not employed in strict accordance with instructions provided in this manual for maximum operator safety.

- Exposure to excessive quantities of radiation can be dangerous to your health. Avoid not only direct radiation exposure, but also to secondary or scattered radiation which occurs when an x-ray beam strikes or has passed through any material.

- Do not insert any part of the body into the inspection chamber while x-rays are on. Although the XR 4000 operates at an extremely low x-ray dose, unnecessary radiation exposure should be avoided. If an item becomes jammed or lodged in the inspection area, the XR 4000 should be turned off before any attempt is made to clear the inspection chamber.

- PACE strongly recommends that all personnel operating the XR 4000 wear a radiation film dosimeter badge. See Section 15. This badge records an exposure history for the operator and acts as a constant reminder to the operator to use caution and safe work practices when operating the XR 4000.

- The radiation exposure dosage received by personnel working with x-ray inspection equipment should not exceed those limits set by local regulations relating to ionizing radiation.

- Adequate warning signs and symbols should be displayed in the vicinity of the XR 4000 warning of possible x-ray exposure. Any warning lamps and signals should be checked prior to operating the XR 4000.

- The electrical circuits of the XR 4000, although enclosed for operator protection, must be considered as a potential hazard. Strict observance of safety practices pertaining to operation and maintenance is essential. Proper electrical grounding must always be used.

- Before operating the XR 4000, all personnel designated or authorized to operate the unit, as well as those supervising its operation, should have a full understanding of how it works. Additionally, they should be familiar with established radiation safety exposure practices sanctioned by the National Bureau of Standards Handbook, "X-ray Protection" HB93, pertaining to x-ray protection.

- Service personnel should read this manual and be familiar with its contents before attempting to adjust or repair this equipment.

2. Radiation Safety Information

Federal, State and Local Radiation Regulations (US ONLY)

This cabinet x-ray system was designed to conform to U.S. and Food and Drug Administration (FDA) requirements as stated in the Code of Federal Regulations, Title 21 (21CFR). These requirements (often referred to as the CDRH or BRH regulations) govern the design and manufacture of all equipment that produces ionizing radiation. Such equipment includes television sets and microwave ovens, as well as cabinet x-ray systems. In fact, the maximum allowable radiation emission for cabinet x-ray systems is the same as that set for television sets and microwave ovens. Therefore, respect to radiation emission, a properly maintained and operated cabinet x-ray system is a safe as a television or microwave oven.

<u>Warning:</u> Failure to adhere to the following warnings may result in exposure to radiation:

- Do not operate the x-ray system unless all system components and features are in good repair.
- Never attempt to remove any system component or bypass any system function.

Several features are included in the system design to provide for radiation safety. The controls (including key switches), control circuitry, leaded components (including the leaded acrylic windows), physical barriers, interlocks, and status and warning indicators each contribute to overall radiation safety.

The Federal Aviation Administration (FAA), Occupational Safety and Health Administration (OSHA), most state and some local government agencies typically have specific standards regarding operational safety and constraints regarding the modification of x-ray systems conforming to 21CFR (mentioned above).

Typically, an x-ray system must be registered with the appropriate state agency, by the physical possessor of the system, regardless of the legal owner. Frequently, registration must occur prior to the x-ray system being placed into service. Regulations may require initial and periodic inspections by a government agency or a qualified vendor. In addition, the regulations may require the implementation of standardized operating procedures, specialized training, the distribution and use of exposure monitoring badges and posting of radiation exposure warnings and other special notices. Radiation safety requirements may differ slightly from one jurisdiction to another. **It is the users responsibility to ensure that the x-ray system is installed and operated in compliance with all applicable governmental regulations.** Failure to comply may result in substantial penalties.

3. Radiation Safety Guidelines

To ensure the health and safety of the operator and all others in the vicinity of operating x-ray inspection equipment, the following guidelines are recommended for establishing a basic radiation safety program.

Note: Federal, State, and some local government agencies may have more stringent regulations concerning the operation and use of equipment that produces ionizing radiation (x-rays). The requirements of these governing agencies supersede the recommendations made by the manufacturer.

1. A copy of the operating instructions should be kept at the machine at all times.

2. Personnel operating the equipment should be trained in the proper and safe operation of the machine.

3. Radiation surveys should be performed periodically to ensure that the amount of radiation being emitted by the machine is less than 0.5mR/hour. We recommend performing a radiation survey:

    - Following initial installation – before placing the x-ray system into service.
    - Whenever the x-ray system is relocated.
    - Whenever the x-ray system receives a strong jolt (e.g., being dropped more than one inch or struck sufficiently hard to dent or deform the exterior cabinet).
    - Whenever a leaded component (such as the x-ray generator, shielding, inspection tunnel curtains, LXDA or collimator cover) is removed for any reason or period of time.
    - Annually – from the date of the most recent radiation survey

4. All controls and indicators should be checked daily to ensure proper operation.

5. Do not operate the x-ray system if it is not in good repair. Do not attempt to remove or bypass any controls (e.g. foot pedals and key-switches), interlocks, status indicators, leaded components (including the inspection tunnel curtains) or physical barriers. In the event of failure or breakage, these items should only be replaced by a qualified service technician using factory-approved parts.

6. Service of the equipment should only be performed by or under the instruction of trained PACE personnel.

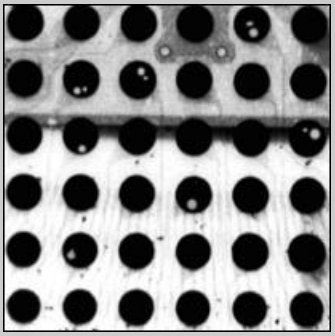
Many users choose to issue periodic radiation film badges to assure employees that they are not being exposed to significant levels of radiation and to provide added assurance that radiation emissions are well within regulatory limits.

4. Radiation Safety Training

PACE can provide (or make referrals to those who can) operation and radiation safety training to ensure that the facility is in compliance with all state and federal radiation regulations.

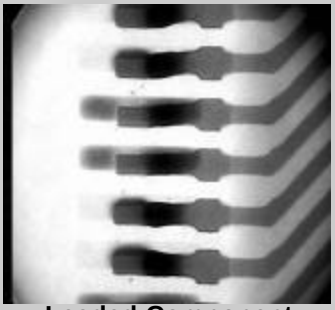
5. Operation

Bare Board
Hole/Pad Offset



BGA Voiding

Leaded Component
Non-Co planarity



Leaded Component
Opens

XR 4000

The XR 4000 Real Time Inspection System is a powerful tool in the quality control and process verification of all aspects of microelectronics manufacturing. The XR 4000 provides rapid, real-time x-ray inspection for production and rework environments. Its self-contained console design supports easy customizing for numerous applications, including multi-layer PCBs, small hole drilling, large back-planes and assemblies with advanced components, such as BGAs and chip-scale packages.

In bare board applications, it can be used to check for interlayer shift and drilled hole-to-pad offset. Inspection is performed following lamination, to determine the presence and degree of interlayer shifts. At the onset of either conventional or small hole drilling, inspection is used to qualify hole-to-pad alignment. In addition to enhancing product quality, x-ray inspection enables users to control costs by eliminating defective boards early in the production process. It can also be used to quality control incoming boards from vendors or customers so that defects can be detected before problems occur.

For surface mount components, it is used to verify lead/pad co-planarity, shorts, opens, and solder bond quality. It can be used to check resistors and capacitors as well as IC's for internal damage and verify adjustments throughout the placement and reflow processes.

For BGA's, the XR 4000 can be used to check for all potential defects including: shorts, opens, mis-registration, non-wetting, solder ball voids, and delamination. X-ray is used to verify proper reflow profiles for advanced packages, and to control rework process.

6. Set Up

A. XR 4000 as a stand-alone inspection station

Place the XR 4000 in a location where it will not be in the way and will not be damaged. Images can be displayed on either a monitor, the XR 4000 PC, or one of PACE's BGA rework systems, depending on the option purchased.

Familiarize yourself with the back of the XR 4000. Note that the 115 V system has a multi strip mounted on the back to plug in the PC, video monitor, or other accessories.

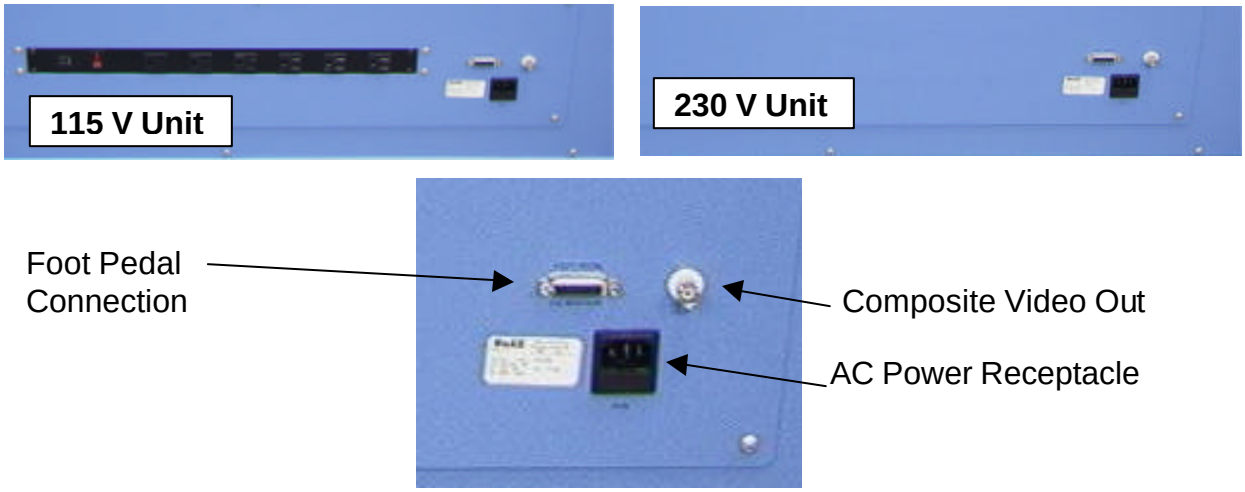
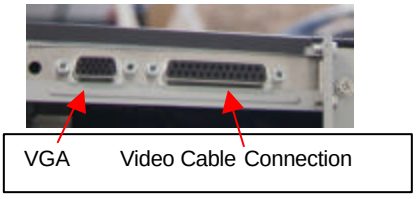


Figure 1. The back of the XR 4000

Locate the foot pedal, composite video cable, and power cord. These should be connected as shown in Figure 1. The power cord should be connected to a properly grounded 120 VAC power supply.

A-1. **If the PC package was purchased**, first, install the PC mounting brackets on the side of the XR 4000 as shown. Next, mount the PC on the side of the XR 4000 as shown in the figures to the right.

On the back of the computer, locate the video acquisition card and connect the included video input cable. One of the B/C connectors should then be connected to the video out on the back of the XR 4000. The BGA cable should be installed from the VGA connector on the video acquisition card to the



LCD monitor.

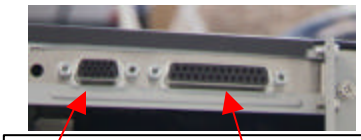
A-2. **If the non-PC model was purchased**, the video out on the back of the unit needs to be connected to video input on the side of the LCD monitor. using the adapter provided.

The monitor used to view the images can be placed on the work surface next to the XR 4000 or can be mounted on top of the XR 4000 using the monitor bracket provided. **ALWAYS REMOVE THE LCD MONITOR BEFORE OPENING THE XR 4000**, otherwise the monitor may be damaged.

B. XR 4000 used with the TF 3000 BGA/CSP Rework Center

Place the XR 4000 near the TF 3000 to allow for the connection of the composite video cable to the PC. Locate the foot pedal, composite video cable, and power cord. These should be connected as shown in Figure 1.

The other end of the composite video cable should be connected to one of the available composite video inputs on the connector that is installed on the video input port on the video acquisition card.



7. XR 4000 Initial Power-up and Operational Test

A. The XR 4000 can be used as a closed cabinet system with PCB manipulator or very long PCBs can be slid through the openings that are protected with leaded vinyl. In either case, the lid on the **XR 4000 MUST BE CLOSED AND LOCKED** before trying to operate the unit. An interlock is installed on the machine that will prevent its use unless the lid is closed and the interlock is engaged. Additionally, the access panel on the front of the system that can be raised to get access to the cabinet when placing a PCB into the PCB manipulator MUST BE CLOSED before the unit will operate. An interlock is installed on the access panel that will prevent its use unless the access panel is closed and the interlock is engaged.

Latch in closed position

B. The control panel on the XR 4000 is a retractable panel on the right hand side of the system. Make sure the control panel is open before attempting to use the system. For a detailed explanation of the XR 4000 control panel, see Section 8.

C. The system should be fully set up according to the System Setup Section before starting these procedures.

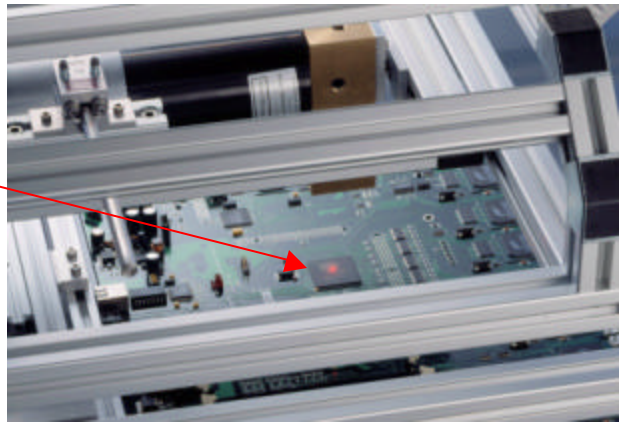
1. To turn on the power, turn the key to the ON position. The key is required to turn on the power and cannot be removed unless the key has been returned to the off position. The green system light should also turn on when the key is engaged.

2. Make sure that there is nothing inside the inspection chamber and depress and hold the foot pedal. The image on the PC or video monitor should change to a bright, slightly grainy image. This is the blank x-ray image.

3. Release the foot pedal and the image will disappear.

4. Depress the foot pedal again and now look at the front panel. The red “x-ray on” light should illuminate and remain on for as long as you hold down the foot switch. Release the foot pedal.

5. Place a component (such as a circuit board) inside the inspection chamber directly underneath the x-ray tube. A Red LED indicator will assist in locating the component under the X-Ray head.



6. Depress and hold the foot switch. The x-ray image of the component should now be visible.

7. Using the PCB manipulator, move the PCB so the component you are inspecting is directly under the X-Ray head, while the foot switch is depressed. The image should move with the component. The image will display a trail behind the component, which will disappear when the component has stopped moving. This is a normal occurrence and is a function of the image processor. The video processor included with this system is preset to 8 frame averaging. Averaging makes the x-ray image less grainy and can be adjusted to improve image quality but with an increase in motion lag. Refer to the section on the image processor for further information.

8. Images may be captured electronically when the XR 4000 is used with the XR 4000 PC or TF1500 PC or TF 3000 PC.

Your system is now ready for use. Please refer to the individual component sections found later in this manual for further adjustment.

8. XR 4000 Adjustment Features

A. Introduction

The XR 4000 is fitted with an XRTV Zoom X-Ray camera. The zoom camera magnification can be varied from 7x to 40x. The memory button can be used to store a magnification setting and to quickly return to that setting.

The XRTV Zoom X-Ray camera utilizes the latest servo-control and microprocessor technologies to produce sharp, high resolution images at any magnification. The camera automatically monitors and adjusts the focus and exposure parameters.

B. Control Panel

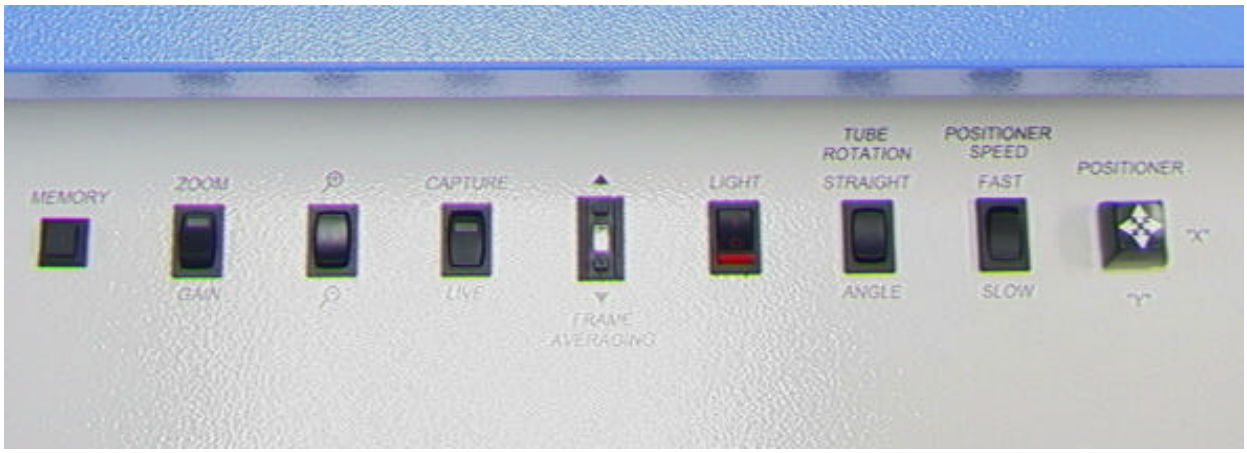


Figure 3: XR 4000 Control Panel

1. The camera is controlled through the button and two switches mounted on the XR 4000 control panel. See Figure 3.

   When the power is turned on, the camera automatically sets itself to 14X magnification. This is the magnification setting that is stored in memory when the unit leaves the factory.

   The camera operates in either the ZOOM control mode or the GAIN control mode; set by the rocker switch on the control box panel. See Figure 3. To adjust the image magnification, place the control switch in the ZOOM setting. The camera magnification is controlled by the +/- rocker switch. Press the rocker in the + direction to increase the magnification. Press the rocker in the - direction to decrease the magnification.

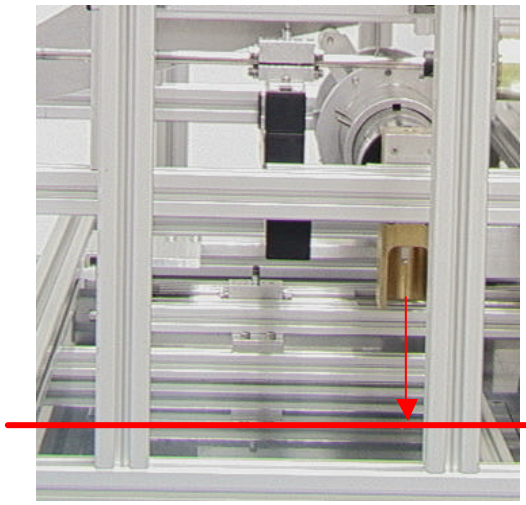
As shipped from the factory, the startup setting stored in memory is 14x magnification and auto focus mode.

2. The memory button can be used to store and quickly return to a preset magnification and focus setting. This function is useful if a video measurement system is used. To store the current magnification and gain setting, press and hold the MEMORY button for three seconds. The camera will beep to indicate that the current setting has been stored in memory. To restore the magnification and gain setting from memory, press and release the MEMORY button. The camera magnification will quickly return to the setting stored in memory.

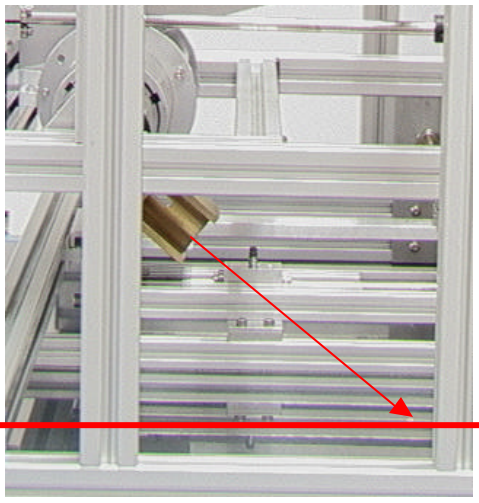
3. Manual gain control is enabled by placing the mode switch in the “GAIN” position. Press the rocker in the + direction to increase the gain. Press the rocker in the - direction to decrease the gain. Press the rocker once for each step on gain. After setting the gain, the rocker can be switched to the ZOOM mode without losing the manual gain setting. Automatic Gain Control is enabled if the mode switch is set to GAIN and then back to ZOOM without using the +/- rocker switch.

4. The PCB manipulator is controlled by the joystick on the control panel. It can be moved in the X and Y directions. The movement speed can be set to either slow or fast by the speed switch next to the joy stick.

5. The X-Ray head on the XR 4000 is usually used in a position that is 90 degrees (perpendicular) to the PCB. It can be rotated to an angle of 45 degrees to check for “open” joints. Please Section 9. To move the X-Ray head, use the switch on the control panel labeled “Tube Rotation”

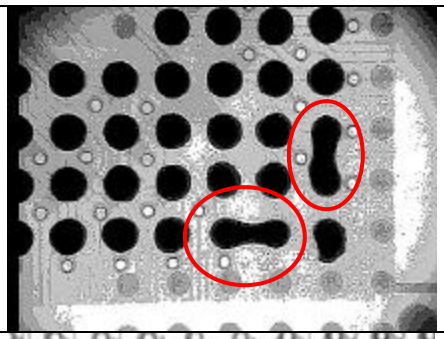
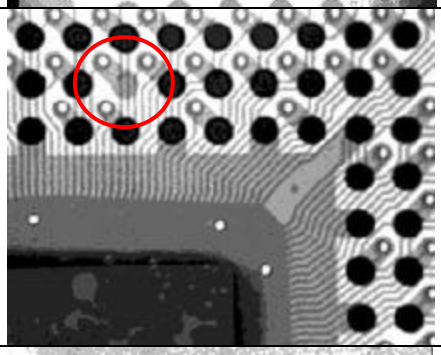
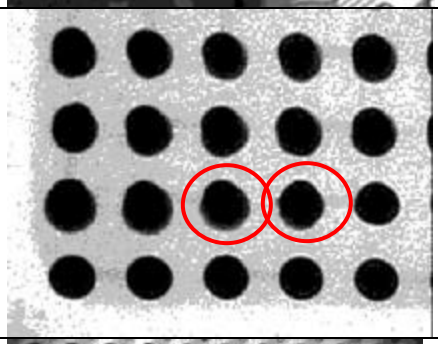
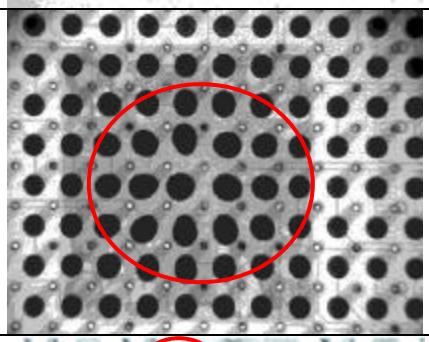
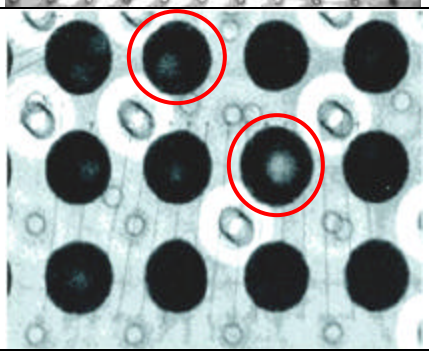


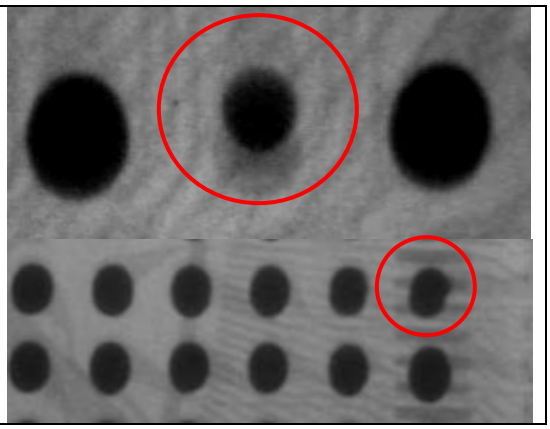
X-Ray Head at 90 Degrees



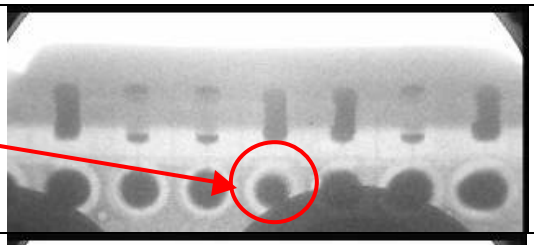
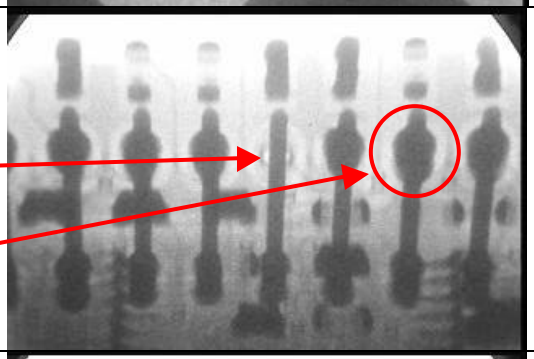
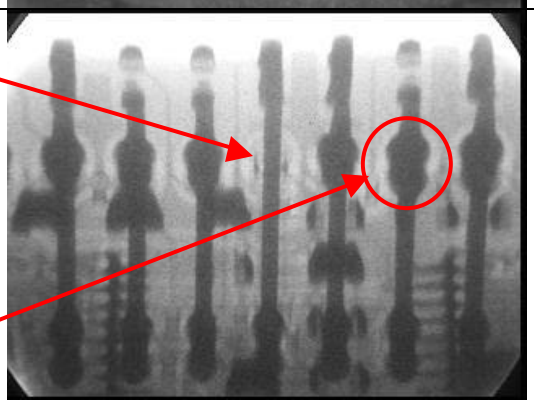
X-Ray Head at 45 Degrees

9. Examples of Common Defects

Bridging between solder joints is easily identified.	
Missing solder ball is easily identified.	
Cold solder is signified by a jagged, irregular edge around the perimeter of the solder ball. Note that in this image only some of the solder balls show this signature.	
Solder balls in the center of the package are oversized due to the delamination and compression under the die area.	
Voids in Solder Ball	

Solder ball is smaller than adjacent balls and pad shadow can be seen below indicating no contact between ball and pad. Note figure 8 shape indicating 2 unattached spherical shapes unlike oval shapes adjacent to it indicating contact between pad and solder ball.	

X-Ray and Thru Hole

Straight down view, no angle. Joints appear solid due to lead filling thru-hole. Desoldered joint also appears to be OK.	
50% angle, desoldered joint is clearly visible. Solder in other joints looks fairly consistent. Desoldered joint is clearly visible Beginning of figure 8 shape indicating good fillet on both sodes of the PCB.	
100% angle, desoldered joint is clearly visible. Solder in other joints looks fairly consistent. Some are a little light on top, but OK as solder is present all the way through the thru-hole. Figure 8 shape indicating good fillet on both sides of the PCB is very clear on most joints.	

10. Troubleshooting

A. Self-Diagnostics

The XRTV zoom camera is equipped with self-diagnostic features that help to debug certain problems that may hinder system performance. This self-diagnostic feature will help to identify if the x-ray source is emitting x-rays, and if the camera control microprocessor and the camera itself are functioning normally.

To use the self-diagnostic feature, power off the entire x-ray system at the main power switch. Turn the system back on with the main power switch. Go to the camera controls. The camera controls should be making an audible beep and, if equipped with a lighted Zoom/Gain switch, the LED should also be flashing. As soon as the beeping starts (about 4 seconds after start-up) hold down the memory button until the beeping stops. You will notice that the image processor will not boot up and that there will be no image on the monitor. Depress and hold the footswitch. After about 3 seconds, the camera control box should let out a continuous beep and the AGC LED (if so equipped) should turn on. Now release the foot switch and the LED should turn off and the beeping should stop. The beeping and lighting of the AGC LED signifies that the x-ray source is emitting x-rays and that the x-ray converter inside of the camera is functioning properly. Now, press and release the memory button. The camera control box should begin its start-up beeping. This is testing the camera and microprocessor communications. After about 5-7 seconds, the beeping should stop and a video signal will now be present. Note that the image processor should now boot up properly and an x-ray image should now appear on the monitor. If there is ever a problem with your x-ray system, you may be asked to perform this test if you call PACE for technical support.

B. Blurry Image

The XRTV Zoom camera employs an advanced focus system, which keeps the image in constant focus. On occasion, the focus system will drift. This problem occurs most often if the magnification is changed while the x-ray source is not on. In most cases, the camera control system will refocus the camera within 1-2 seconds. If the image appears out of focus for longer than a few seconds, change the magnification setting while the x-ray source is on. This should give the camera enough information to let it lock onto the proper focus. In general, it is best to change the magnification only when the x-ray source is on. Changing the magnification when the x-ray source is off will not cause any damage; it will just take a few extra seconds for the camera to lock into focus.

C. General Problems

If the camera does not appear to operate properly, switch off the power, wait a few minutes and switch the power back on. If the camera is still not operating properly, call PACE.

11. Specifications

- Operating voltage: 120V, 50/60 Hz or 230V, 50Hz
- Energy sensitivity: less than 15kV to greater than 160 kV
- X-Ray Tube – 70 kVA
- Resolution: greater than 20 line pairs per millimeter; can easily resolve a 1 mil bond wire
- Magnification: 7 - 40x
- Maximum field of view: 1 inch diameter circle
- Maximum PCB size: 27” x 27” (685mm x 685mm) with PCB manipulator
  27 x Unlimited (685mm x Unlimited) without manipulator

12. RTVA Image Processor

The RTVA (Real-Time Video Averager) is an image processor used in the XR 4000 X-ray system. It uses video frame averaging to smooth the inherently grainy image coming from the X-ray camera. It is located inside of the XR 4000 housing.

The RTVA is adjustable by using the front mounted switch marked “FRAME AVERAGING”. See Figure 3. This adjusts the amount of frames that the RTVA averages before sending the video out to the monitor. When using the switch, please note the following frame averaging settings:

(Note that image trailing will occur at higher settings.)

Setting	Effect
0	BYPASS. There is no averaging in this setting
1	2-frame averaging
2	4-frame averaging
3	8-frame averaging
4	16-frame averaging

The RTVA image processor also has a “CAPTURE” ability that is designed to hold the current image. To use this option, just switch the front-mounted CAPTURE/LIVE switch to the “Capture” position. See Figure 3. To return to normal operating mode, return the switch to the “LIVE” position.

Please note that there are no user serviceable components inside. If the component is suspected of being faulty, please call PACE.

13. XR 4000 Maintenance

The XR 4000 system has been designed for simple maintenance. The only suggested maintenance is to keep the unit visibly clean and to keep the system's calibration up to date. Any mild surface cleaner, like Windex, may be used to clean the system. If you find that your system is coming close to its calibration date, please contact PACE to schedule a calibration.

It is very important that you contact PACE early so that we may schedule service at a convenient time.

Warning: The acrylic and vinyl around the opening of the XR 4000 contain lead. Always wash your hands immediately after use. Eating and drinking without washing your hands may cause you to ingest lead.

14. Troubleshooting

In the event that your system exhibits problems, this section will familiarize you with the basic steps to troubleshoot the problem as well as what information PACE will require in order to give you the best possible service.

Quick Tips

The first thing to do is to simply try and re-start the system. This can solve most problems right away.

1. The first step in troubleshooting is that the system must be completely shut down and re-started. You can do this by turning the keyed power switch, located on the front of the system, to the "Off" position.

2. Turn the power back on.

3. There are three categories that are used to troubleshoot the system:

   Power: The power category covers all problems that include lack of power to a component or to the full system. Power problems would include:

   - The system not powering up.
   - The x-ray controller's red light does not turn on.
   - The system's green light does not function.

   - **Do all components power up when the main power switch is turned on?**
   - **Do all power-indicating lamps turn on?**
   - **Do all power outputs show the proper voltage?**
   - **Is the foot pedal connected?**

   Video: The video category covers the problems that affect the presence of a video signal from the x-ray camera. Video problems would include:

   - No x-ray image on the monitor, but x-rays are present.
   - The image processor on the system does not boot up.
   - The x-ray image is fuzzy or out of focus.

   - **Is the video cable attached properly?**
   - **Does an X-ray image appear on the monitor when the foot switch is depressed?**
   - **Does the systems image processor boot up?**
   - **Does the X-ray monitor have a light gray screen or flicker?**

X-Ray: The x-ray category covers the problems that affect the tube's emission of x-rays. The x-ray category includes:

- The red "X-Ray On" light is not turning on.
- There is no image on the monitor, but video signal is present.
- There are no x-rays being emitted from the x-ray source.

- **Does an X-ray image appear on the monitor when the foot pedal is depressed?**
- **Does the red "X-ray on" light turn on when the footswitch is depressed?**

15. Replacement Parts

Description	Part Number	Image
Leaded Vinyl 4’ x 2’ sheet	1335-0248-P1	
Replacement X-Ray Tube	4018-0110-P1	
Replacement X-Ray Zoom Camera	4018-0111-P1	
RTV Image Averager	6020-0161-P1	
Control Box Assembly	4018-0113-P1	

16. Model XR-4000 Design Safety Standards and Safe Operating Practices

Because of the low operating anode power of the XR 4000, real time x-ray inspection system, it has been registered with the Center for Devices and Radiological Health Branch of the FDA as an "Analytical X-ray System". As registered, the system has a number of safety features provided to minimize any x-ray scatter reaching the operator.

A. Safety:

The X-Ray tube assembly is lead shielded with at least a ¾ inch space between collimator and image plane to minimize any x-ray scatter. The collimator insures that the x-ray beam size at the image plane is no more than a one-inch diameter circle. The table assembly employs a lead acrylic view panel and additional lead shielding. The highly sensitive x-ray camera permits the x-ray tube to operate at low power (anode voltage of 70 kV and anode current of 25 microamps) resulting in minimal x-ray scatter. All these safety features result in a structure with radiation scatter at 5 cm from any exposed surface less than 0.5 milliRoentgens per hour. (Radiation exposure in an airplane at 30,000 feet during the day is greater than 0.4 milliRoentgens per hour.)

B. Radiation safety precautions for the use of XR 4000 Real Time X-ray Inspection System:

It is imperative that the XR 4000 be operated only by trained personnel who are familiar with the basic safety precautions to be taken when working with x-ray producing equipment.

1. The key to actuate the x-rays should not be left in the equipment when the equipment is not being used and is unattended.

2. Operators should not place hands under the leaded acrylic panel in the front.

3. The equipment should not be operated with any panels removed.

4. Operators should be familiar with the use of the Monitor-4 radiation survey meter.

5. Service of the equipment must be performed by or under the instruction of trained PACE personnel.

C. Radiation monitoring:

Specific regulations regarding the monitoring of possible radiation leakage of industrial x-ray cabinets are determined by the individual state or country. There are a number of measures, which can be taken to provide a means of cursory monitoring.

D. Dosimeter badges:

Dosimeter badges can be obtained from:

1) Siemens Dosimetry
   Barrington Road
   Hoffman Estates, IL 60195

   (800) 666-4552 2501

2) R.S. Landauer & Co
   2 Science Road
   Glenwood, IL 60425

   (708) 755-7000

Dosimeter badges can be placed by the equipment or worn by the individual to constantly record any x-ray exposure. At the end of the month a replacement dosimeter is sent and the present months dosimeter is returned to the dosimeter service company. A report is issued monthly tabulating any x-ray exposure received. A dosimeter service is most useful in that documented records are established for the corporation showing that no radiation leakage has occurred.

E. Radiation survey meters:

Radiation survey meters detect the presence of ionizing radiation and display a value in units of mR/hr (milli Roentgens per hour). It is generally a good idea to have, as part of a radiation safety program, a radiation survey meter. The monitor –4EC survey meter is available from PACE. The Monitor-4EX employs an energy compensated G-M tube to measure the presence of radiation. It is calibrated to Cs-137. The Monitor-4EX can be used to detect any radiation leakage from x-ray systems.

F. Radiation safety training:

PACE can provide or recommend providers of operation and radiation safety training to ensure that the facility is in compliance with all state and federal radiation regulations.

17. Warranty

PACE USA
9030 Junction Drive
Annapolis Junction, MD 20701
USA

Tel: (301) 490-9860

Fax: (301) 490-0193

PACE Europe
Sherbourne House,
Sherbourne Drive
Tilbrook, Milton Keynes
MK7 8HX
United Kingdom

Tel: (44) 1908 277666

Fax: (44) 1908 277777

Equipment Warranties

All warranties are against manufacturing defects only. Warranties exclude consequential damage or damage resulting from normal wear, accident, mishandling or modification. (Customer will be advised of charges for such repairs). Liability is limited to repair or replacement of any parts, which prove to be defective. Parts proving defective will be replaced free of charge FOB Laurel, Maryland, USA if defective equipment is returned to PACE for inspection. Freight charges prepaid.

X-Ray Inspection Systems: Parts only. 12 months from date of delivery. Part will be repaired or replaced at our option provided it is returned to us, or a location designated by us, by prepaid transportation and that inspection indicates defective part. Shipments from us will be on a freight collect basis. Labor charges for on site work will include travel, expenses and hourly rate. These prices will be quoted separately as they are subject to change. The guarantee applies only if the equipment has been operated in accordance with the instruction manual. It does not apply to defects resulting from accidents, alterations abuse, or misuse.

Do not return your instrument without return authorization from the factory or authorized service center. Always include the serial number, which is located at the rear of the instrument.