AXC-800
Operators Manual

High-Performance, High Resolution X-Ray Test System

Preface

Thank you for choosing products of SCIENSCOPE.

SCIENSCOPE has been engaged in the R&D and production of X-Ray machines and providing all kinds of X-Ray machines with high quality and low price for clients. We hope that this product can well address your problems.

This X-Ray machine is characterized by high resolution, large amplification factor, compact structure, small weight and convenience for maintenance. It is widely applied for the following fields.

1. Electronic and electric appliances: IC, capacitor, battery, multilayer PCB, diode, etc..
2. Auto related parts: aluminum castings, rubber products, resin products, etc.
3. Chemical products: FRP, resin products, ceramics, etc.
4. Universe, aviation related parts: machine body and wings, etc.
5. Pharmaceuticals: lozenge, ampule (small vial to contain injection agent), etc.
6. Sports goods: golf stick, golf ball, bicycle parts, fishing rod, etc.
7. Others: aluminum cans, etc.

This machine adopts the most advanced modular control system and is subject to centralized control and management by the computer through software so as to ensure convenient repair and maintenance work. Besides, the HR camera adopted also ensures faster and clearer image production.

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For service support, do not hesitate to contact us by calling or mail.

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CONTENT

Section 1 Safety

1.1 User Responsibility

The following general safety precautions must be observed. Failure to comply with these precautions or with specific warnings elsewhere in this manual so as to violate safety standards of design, manufacture and intended use of the system, SCIENSCOPE assumes no liability for the customer's failure to comply with these guidelines.

1.2 Safety Information

Specific notations are used in this manual to call attention to conditions that could potentially result in personnel injury, damage to equipment, or a condition which if not strictly observed, could result in injury or loss of life.

※**WARNING:** A WARNING notation is used to describe an operating or maintenance procedure, practice, or condition which if not strictly observed could result in injury or loss of life.

※**CAUTION: A CAUTION** notation is used to describe an operating or maintenance procedure, practice, or condition which if not strictly observed could result damage or destruction of equipment.

※ **NOTE: A NOTE:** notation is used to describe a general rule for a procedure or an exception that requires the attention of the operator.

To ensure personal safety, it is necessary that a radiation meter be used to check for radiation leakage during installation and periodically thereafter (not to exceed six months). The radiation survey instrument shall be calibrated at intervals specified by the State or Local Authority. This instrument should be sufficient and suitable for detecting and measuring the types and levels of radiation involved.

NOTE:

Geiger-Muller and certain other scintillator type radiation meters may not be acceptable when checking radiation from SCIENSCOPE x-ray systems. Pressurized Ion Chamber type radiation meters should be used for radiation emission compliance.

NOTE:

SCIENSCOPE employees perform a radiation leakage survey at the time of manufacture of your SCIENSCOPE AXC 800 system. These persons are competent, but may not be considered qualified experts by your state. Check with your state radiation control authority to determine what the survey requirements are in your state. It may be possible that a state qualified expert must survey the installation before the equipment is operated.

Each operator shall keep ALL radiation exposures **AS LOW AS REASONABLY ACHIEVABLE**. This means the operator is to keep his fingers and hands out of the radiation beam while x-rays are engaged. The protection of personnel and the public depends entirely on strict adherence to safe operating procedures.

1.3 Principle

How X-ray works, on a vacuum sealed tube the wire filament (cathode electron) creates a high voltage and send the cathode electron at very high speed by accelerating via electric field force to the anode target (W) (A1)(Mo) and then X-ray shall be . X-ray may penetrate samples and form an X-ray image. Different material density shall generate different attenuation. X-ray camera obtains corresponding images by means of computer processing.

- ☆ On the occasion of the same density, thick material is difficult to penetrate
- ☆ On the occasion of the same thickness, material with high density is difficult to penetrate (material with large atomic number is difficult to penetrate)

X-ray imaging utilizes its penetration function while its protection utilizes its function of being absorbed.

1.4 Government regulations

Most states in the United States have radiation control regulations that require registration of radiation sources with cognizant state and / or local jurisdiction public health agencies. Registration normally must be made immediately or within 30 days of acquiring such a source. Please contact your local public health agency for registration information pertinent to this installation. Scienscope will be glad to assist you with system registration, please call Scienscope 909-590-7273 for details.

1.5 Operation safety

The AXC 800 should be operated only by personnel who have been instructed in radiation safety and the operating instructions set forth in this manual. Most x-ray installations and portable x-ray systems are subject to Federal, State and Local regulations which may involve registration, licensing or compliance with specific rules. For example to meet federal requirements (USNRC & FDA) the radiation levels in a non-controlled area must not result in an exposure to an individual continuously present in the area in excess of 2 mR in any 1 hour or 100 mR in any consecutive days.

1.5.1 Radiation

The equipment uses a primary radiation barrier and other shielding material to protect the operator from the radiation beam. The AXC 800 x-ray system is listed as a cabinet x-ray system and regulated to comply with applicable DHHS Standards under the radiation control for health and safety act of 1968 (21 CFR 1020.40 subchapter J) PN 10042**.** The user should perform a radiation survey on the AXC 800 before the first use, this survey should be repeated in six month intervals. The radiation leakage is specified at less than 0.5 mR/hr at 5 cm (2 in.) from exterior surface at maximum kV setting. For all other countries including Mexico, UK and Canada the measurement is Less than 1 μSv. For values more exact to the coinciding machine please review radiation survey supplied by the manufacture. In addition, SCIENSCOPE INTERNATIONAL recommends the use of a radiation film badge program for cumulative individual monitoring. For information pertaining to Film Badge Programs please visit http://www.chpdosimetry.com/

1.5.2 Safety interlock

Two interlock switches of front door are concatenated with safe locks of left side door, right side door and head cover. So please don't tamper or modify the interlock switch which may cause absence of equipment safety protection.

1.5.3 Don't replace parts or modify system

Upon delivery of machines our company produced, sufficient inspections have been carried out with regard to X-ray leakage to ensure user safety. In view of the introduced hazard, upon receiving X-ray equipment, user should not install replacement parts into X-ray equipment or perform unauthorized modification. Or else our company cannot confirm its safety. For any help please contact with SCIENSCOPE. In case that parts or certain part of the X-ray equipment are modified, environmental protection agency shall require re-registration for recertification in accordance with DHHS standard, namely Basic Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (GB18871-2002, 1968).

1.5.4 Don't operate in humid environment

Don't operate the equipment in environment with inflammable gas, smoke or dust suspended particle. Fire and/or explosion may occur when high-voltage tube generates electric arcs.

1.5.5 Don't open safety window when X-ray is turned on

When X-ray is turned off, please confirm that X-ray voltage completely dropped to 0 and then open the inspection window to take inspected sample.

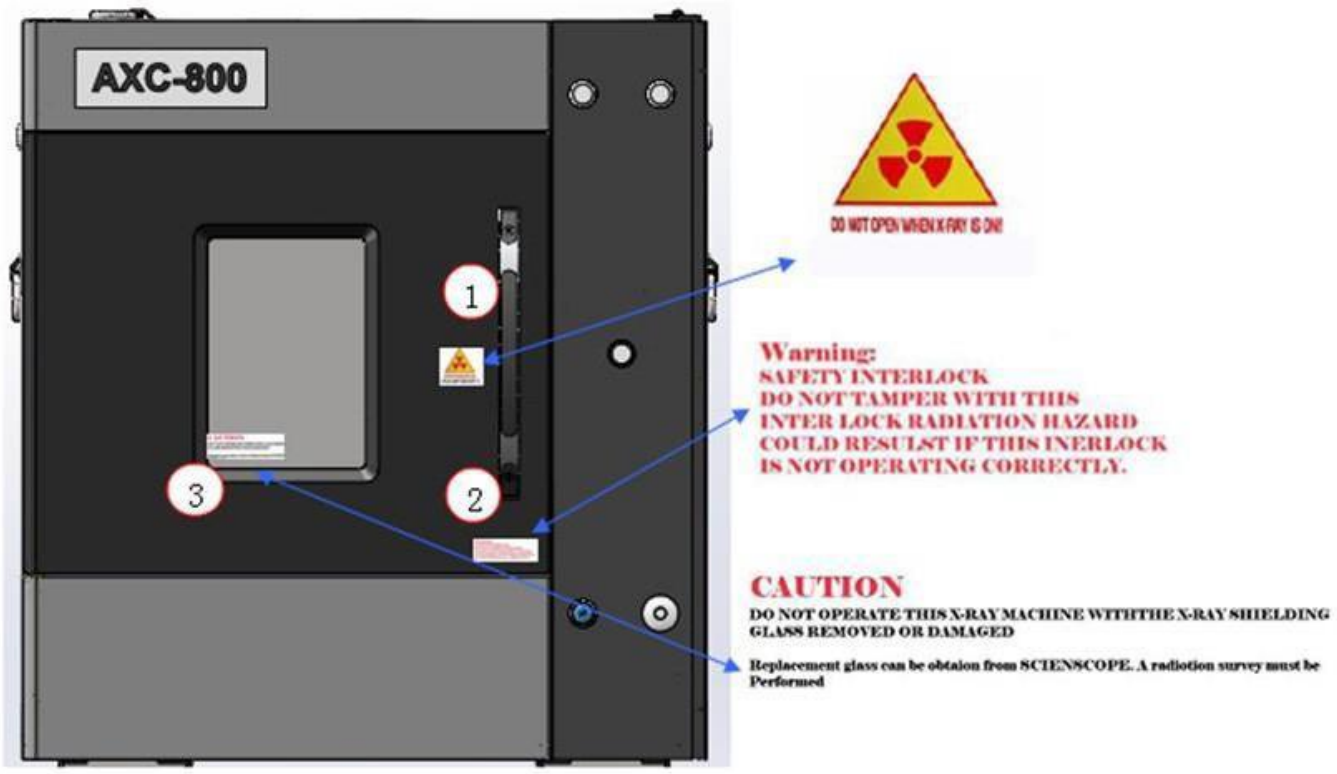
1.5.6 Please use with caution in case that light tube voltage is unstable or arc phenomenon occurs

If light tube voltage is unstable or arc phenomenon occurs (abnormal noise) during operation, reduce the voltage by 50% at once. It is strongly recommended to carry out preheat and till completion, add to the original voltage level gradually. In case of no abnormalities, maintain this voltage level for 10 minutes and then perform normal inspection. If abnormity persists, please stop using immediately and notify SCIENSCOPE engineer for inspection and confirmation.

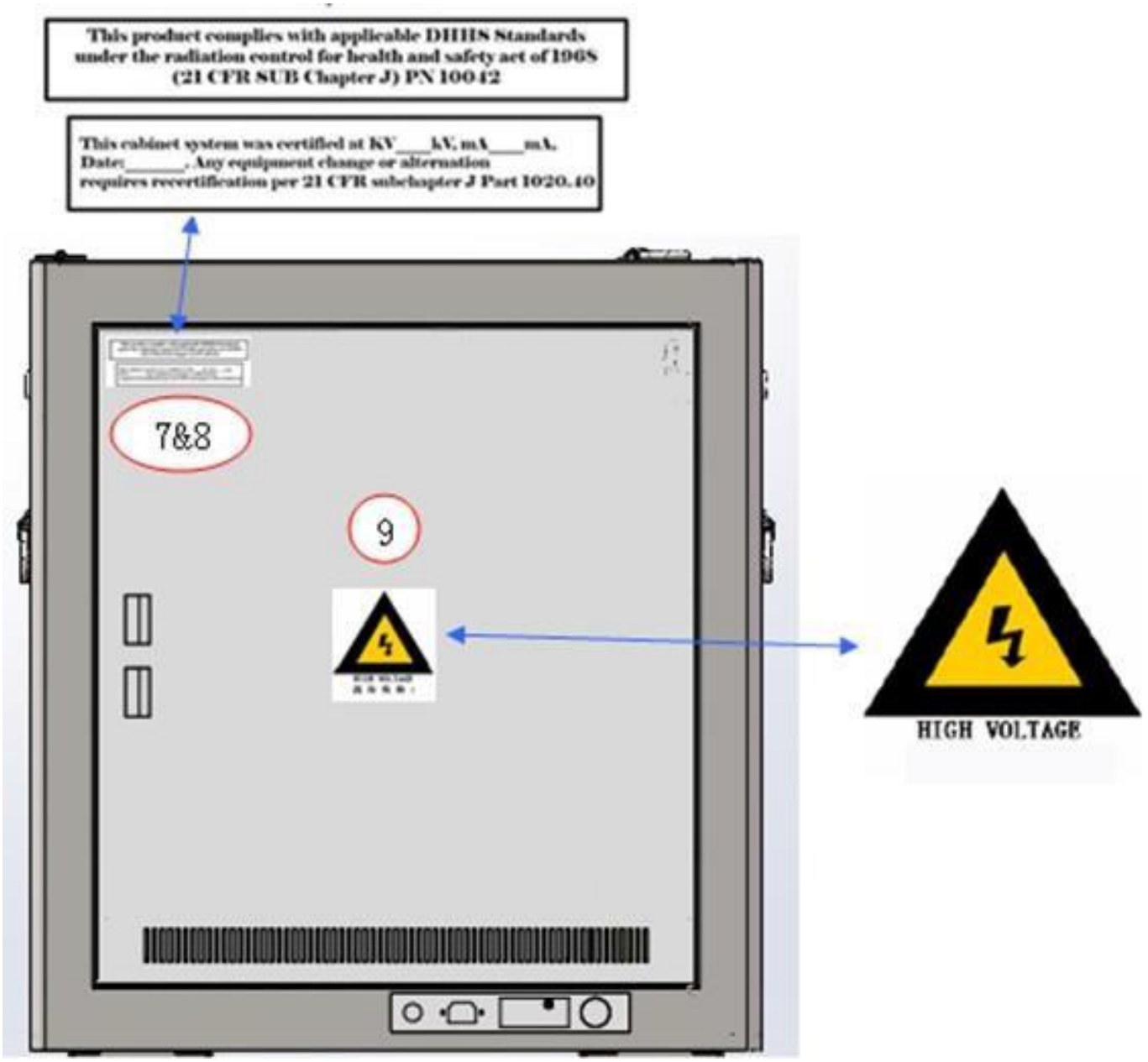
1.6 Warning label of X-ray

At the time of machine delivery, our company had already picked and placed various instructions and warning labels. Please do guarantee its integrity and in case of wearout or loss, replace new one in a timely manner.

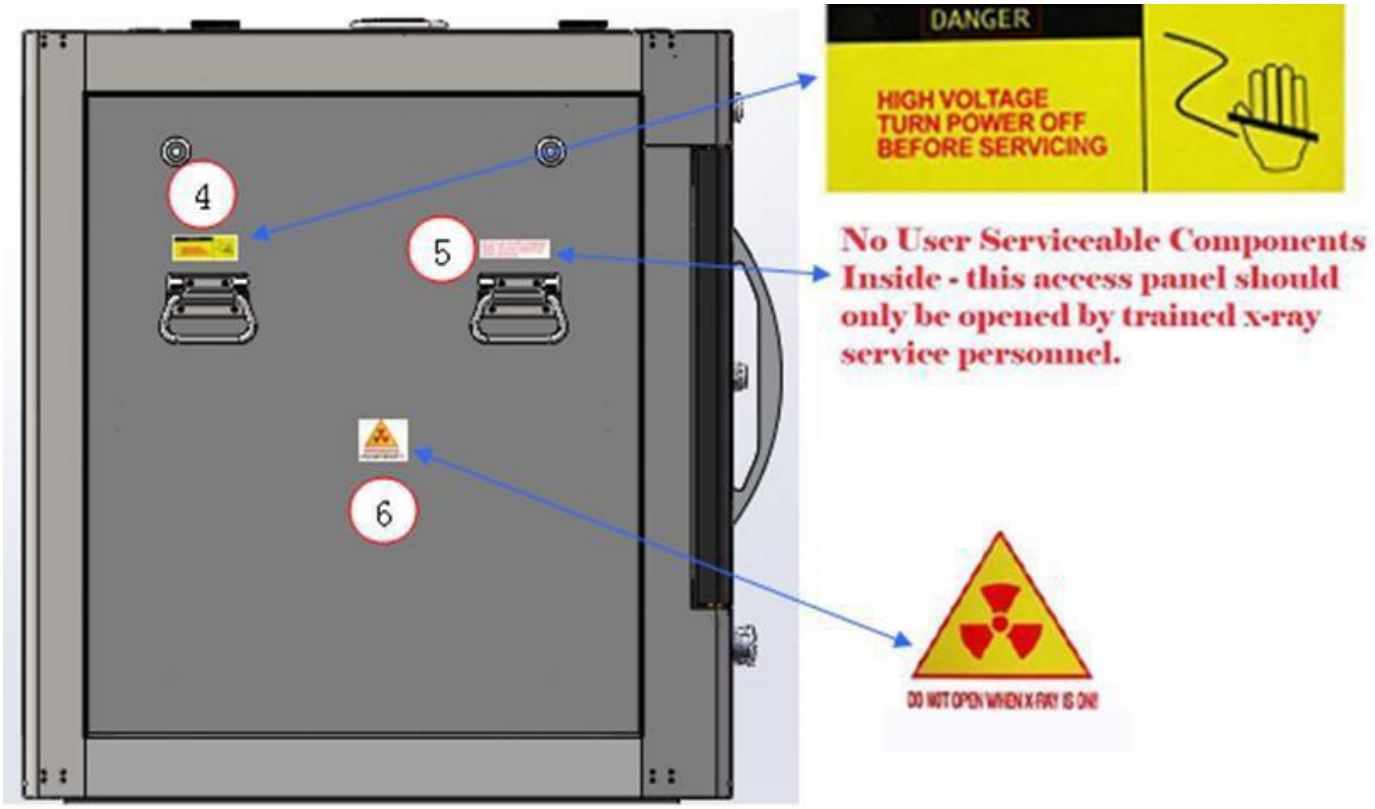
1.6.1 Front Warning Labels



1.6.2 Back side Warning Labels



1.6.3 Left and Right side Warning Labels



Section 2 Site Preparation and Installation

2.1 Preparation before installation

Before installation, the installation department should ask for the product site prep manual for a brief introduction of our company to learn about its weight, volume and working environment, etc.

2.1.1 Forklift

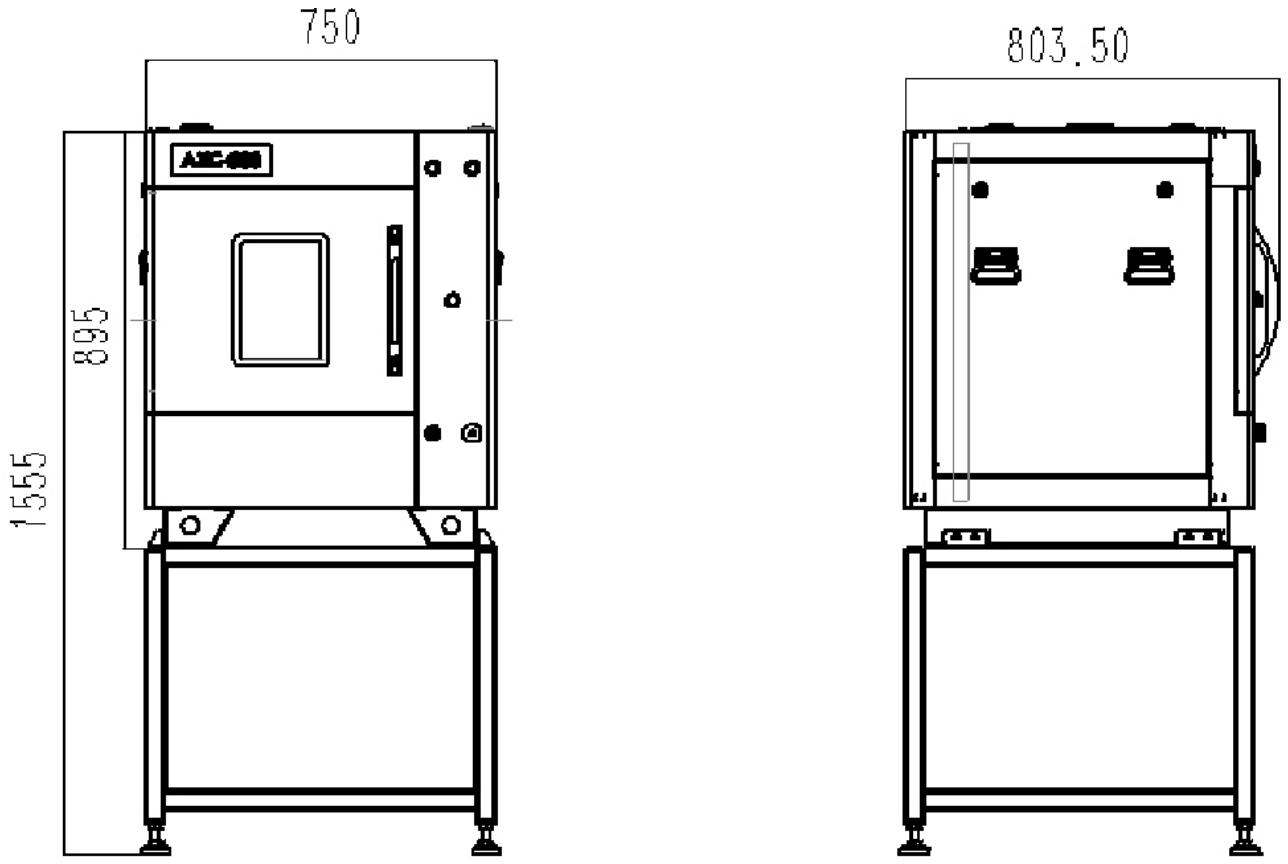
Before installation, forklift and hand fork lifter of at least 3 tons shall be prepared to facilitate transportation. Goods elevator with carrying capacity at least 3 tons shall be required in case of transportation upstairs.

2.1.2 Weight

Weight of complete machine is 1279 pounds (580 kg).

2.1.3 Dimension

Placement point shall be of sufficient space with space of about 1m reserved on all sides.



2.1.4 Electrical requirement

※This equipment requires single phase alternating current of 110-220V, 50/60 Hz;

※In addition, one independent and favorable geodesic line is required with resistance lower than 10Ohm or even lower (don't rely on and use ground wire of AC power socket only);

※Length of power socket is less than 1.8m;

※Three-core AC cable.

For the protection of operating personnel, requires that the x-ray power supply and the system cabinet be grounded. AXC 800 is equipped with three conductor AC power cables that, when connected to an appropriate receptacle, grounds the x-ray system through the offset pin. Further, check to make certain the wall outlet is properly wired. The X-Scope is shipped from the factory with a switching power supply that automatically accepts any AC voltage 100 to 240 VAC, 47 to 63 Hz.

2.2 Initial Inspection

Each x-ray system is carefully inspected both mechanically and electrically before shipment. The equipment should be free of defects, scratches, and in perfect working order upon receipt. To confirm this, the equipment should be inspected for physical damage that may have incurred in transit. If damage is found, refer to the claims paragraph in this manual. Retain the packaging material for possible future use.

Read the User Responsibility and the Safety Information in the preceding pages before installing and operating the system.

To prevent operator injury or damage to the AXC 800, verify that the line voltage setting and fuse protection are correct before connecting the line power. Also ensure that the AC line power cord is connected to a properly grounded electrical outlet.

NOTE:

Before you unpack the X-Scope, read this paragraph for your own protection.

DAMAGE - This shipment was packaged and delivered to the carrier with the utmost care to ensure safe delivery of goods. When the AXC 800 is received and signed for by the transportation company, consignor's responsibility ceases.

CONCEALED DAMAGE -A carrier is as much responsible for concealed damage as for visible damage in transit. Upon receipt of shipment, promptly unpack and check the AXC 800 for

damage.

If concealed damage is discovered, cease further unpacking and request immediate inspection by the local agent of the carrier. A written report of the agent's findings, with his signature, is necessary to support a claim.

2.2.1 Uncrating

Uncrating of AXC 800

Remove the AXC 800 from the shipping crate by using a forklift to get under the X-Ray machine.

Lift off pallet, pull pallet way & set unit down. Make sure to move the rubber stopper feet upward to be able to move the machine freely. Move X-Ray machine into designated location. Carefully remove vinyl protection, stage zip tie downs and brackets in the system. Unpack Computer, Monitor and x-ray source.

The basic AXC 800 with its shielded cabinet system are shipped fully assembled and tested at the factory.

Move X-Ray machine into designated location. Carefully remove vinyl protection, stage zip tie downs and brackets in the system. Unpack Computer, Monitor and x-ray source.

The basic AXC 800 with its shielded cabinet system are shipped fully assembled and tested at the factory.

2.3 Installation

2.3.1 Installation Instruction

VERY IMPORTANT

When installing, the factory must divide machine working area and offer independent air circuit breaker switch for this power supply system in order to separate with other electrics.

> Note: This equipment is to be operated in an area free from humidity and dust and with sufficient space to guarantee installation, debugging and maintenance around the equipment and for the convenience of operators to make inspection tours and take inspection sample. Sufficient space shall be reserved for equipment installation.

- Ensure the key control switch is in the "OFF" position.

•Ensure that AC power is 'OFF' and that the AC power Cord is **NOT CONNECTED** before connecting the remaining cables or malfunctions will occur.

•Do not touch the X-Ray source window or subject it to any mechanical Pressure or abrasion. Do not allow anything to contact the window, especially adhesives or corrosive materials.

•Connect ground cable, 12 pin cable harness and RS232 Communication cable.

•Mounting the x-ray source is accomplished on the surface parallel to the tube axis. Place the X-ray source on the bracket inside of the x-ray chamber. Tighten screws on the source into place. The mounting threads are ¼-20 UNC Hex heads. Ensure the X-Ray source is securely mounted.

• **Storage** Attach the x-ray tube window cover to protect the window from accidental damage. Wrap or box the PXS10 to prevent accumulation of dust and moisture.

•Ensure that there is adequate room for airflow around the unit so that the maximum ambient temperature is not exceeded. An internal fan provides adequate cooling as long as the ambient air temperature is < 32 degrees C. Above this ambient temperature, the unit may not be able to operate continuously at full power.

•Do not operate with restricted airflow around the unit. Although the unit has an internal fan, and an over-temperature sensor, ambient air must be less than 35°C and freely circulating for full power operation. For elevated ambient temperatures, it is recommended that an external cooling fan be directed at the tube snout or tube extension.

Note: The X-Ray source contains glass and other fragile materials. Do not drop or subject to excessive vibrations. Do not operate with restricted airflow around the unit. Although the unit has an Internal fan, and an over the temperature sensor, ambient air must be less than 35°C and freely circulating for full power operation. For elevated ambient temperatures, it is recommended that an external cooling fan be directed at the tube snout or tube extension.

•Connect the AC power input to a suitable AC power source.

• Make sure all the cables are connected correctly to the back of the PC, before hooking power & powering the PC.

- LCD Monitor, please attach the monitor with the 4 black thumb screws to the monitor mount. Install the LCD monitor and hook the power and video cable.
- Turn the AXC 800 main power key switch (cabinet control).
- Turn on the image processing computer (the computer is on a secondary power supply line to minimize loss of data if the key switch is inadvertently switched to the off position).
- Double click the X-Scope icon on the desktop.
- The AXC 800 will go into a warm-up cycle to ensure maximum x-ray tube life.
- Connect the AC power input to a suitable AC power source.
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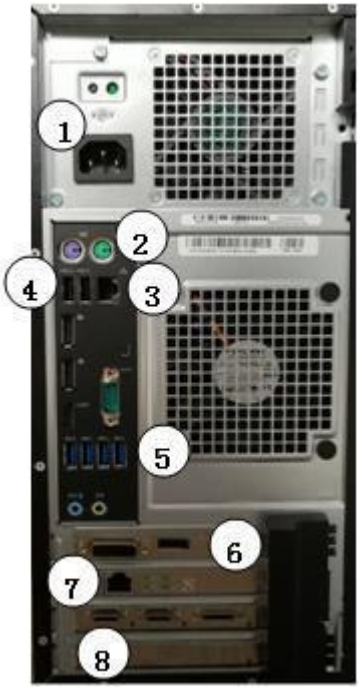
2.3.2 PC interface connection



1 、 AC power supply interface

2 、 Interfaces of mouse and keyboard

3 、 Interface of integrated network card

4、USB interface *2

5、USB interface *4

6 、 HDMI of discrete graphics (DP)

7 、 Interface of independent network card (kilomega)

8 、 Interface of USB cable of line-scan camera

2.3.3 Network

The Scienscope AXC 800 is a stand-alone x-ray inspection system. The image processing computer is capable of being networked, but has no security enabled in the factory configuration. Use caution when connecting the image processing computer to a network that has internet access, there's no factory installed virus software. The image processing computer is configured to run the required image capture board and the AXC 800 image processing software, changing the factory configuration could cause the image processing software to stop functioning. The installation of additional software programs is also discouraged and could cause the image processing software to stop functioning. Changing the factory configuration and installing third party software will void the image processing computer warranty, any repairs or service to the image processing computer will not be covered under the system warranty.

Section 3 AXC 800 System Overview

3.1 Overview

Scienscope AXC 800 is applicable to count SMT parts for comprehensive control of SMT parts number in the factory to avoid overstock of inventory and fund.

AXC 800 includes a real time digital flat panel and X-ray device while the entire machine adopts **fully enclosed radiation shielding chassis**. The cabinet door is equipped with important safety interlock. Surface radiation leakage 5cm away from arbitrary point on the chassis is less than 0.5milliroentgen/hour (or 1 μSv as stated in statement above). So extra X-ray shielding facility is not necessary in AXC 800 position.

X-scope provides real time X-ray image via flat panel detector and x-scope image processing module.

There is digital display for current voltage and current (kV & μA) in computer operation software. When X-ray is turned on, early-warning index shall show a red light.

Control button for voltage and current is of easy and convenient operation. Maximum voltage and current of AXC 800 with standard configuration may be adjusted to 70 kV and 200uA (to be governed by the contract).

Main power switch and emergency stop button on display/keyboard panel may shut down all system operation immediately.

3.2 Configuration instruction (to be governed by the contract)

3.2.1 Chassis instruction (fully enclosed radiation shielding chassis)

Input voltage	AC110V/60HZ-AC220V/50HZ
Body size	750（L）*803.5（W）*1555（H）
Body weight	580KG
Radiation leakage rate	Less than 0.1mr/hour (100% protection on safety room)

3.2.2 X-ray tube (closed tube/microfocus/80 Kv)

Light tube type	Integrated closed tube
Maximum voltage of light tube	70KV
Maximum current of light tube	200uA
Minimum focal spot of light tube	5μm (microfocus)
Service life of modulator tube	About 5 years or 10000 hours

3.2.3 Digital flat-panel detector

Flat-panel type	4080 ultrahigh resolution line-scan camera
Pixel resolution	4080*n
Service life of camera	About 8 years
Display	24“LCD

3.2.4 Computer configuration

CPU	Intel®-core™ i7-6700 CPU @ 3.40GHz
Memory	16GB
Graphics card	Discrete graphics card
System	Windows 7® (64-bit) professional edition (Chinese/English system optional before delivery)
Hard disk	120G (SSD) +500G mechanical hard disk

3.2.5 2+1 axis motion direction

Control type	Computer control
Suitable tray size	Below 15 cun
Display	24“LCD

3.2.6 Software function

Type	Professional X-ray real time detection software
Platform	Windows 7 high performance workstation
Image sharpening	Image convolution sum filter operation (Gaussian filter template) is adopted for image sharpening
Image denoising	Adopts multi-frame image addition denoising
Measurement mode	Manual operation
Function	Count SMT parts
	Artificial intelligence automatic learning mode

3.3 Warranty

Scienscope technology provides 1-year overall machine warranty and 1 year or 5000 hours (whichever comes first) warranty for light tubes. The warranty period is subject to the warranty contract.

Being out of free warranty period is being not in the scope of free maintenance. The company will charge maintenance service fees and costs of replacement parts in accordance with the regulations.

The following items are excluded from any warranty coverage:

1. Damage to accessories due to input voltage instability or voltage exceeding the equipment standard;

2. Damage to accessories due to failure to meet the requirements of the ground wire;

3. Damage to accessories due to the failure to meet the requirements for equipment operating environment;

4. Damage due to improper operations by the user, including water immersion and collision of equipment, human-induced burning of circuit board;

5. Other damages to accessories due to purchase of replacement accessories without the after-sales service authorization by Scienscope International

6. Damage to accessories due to equipment relocation without the after-sales service authorization by Scienscope International

7. Damage due to disassembly or repair without the after-sales service authorization by Scienscope International

8. Sealants and stickers of equipment and accessories being torn or damaged;

9. Consumables, fragile accessories (such as synchronous belts and conveyor belts, etc.);

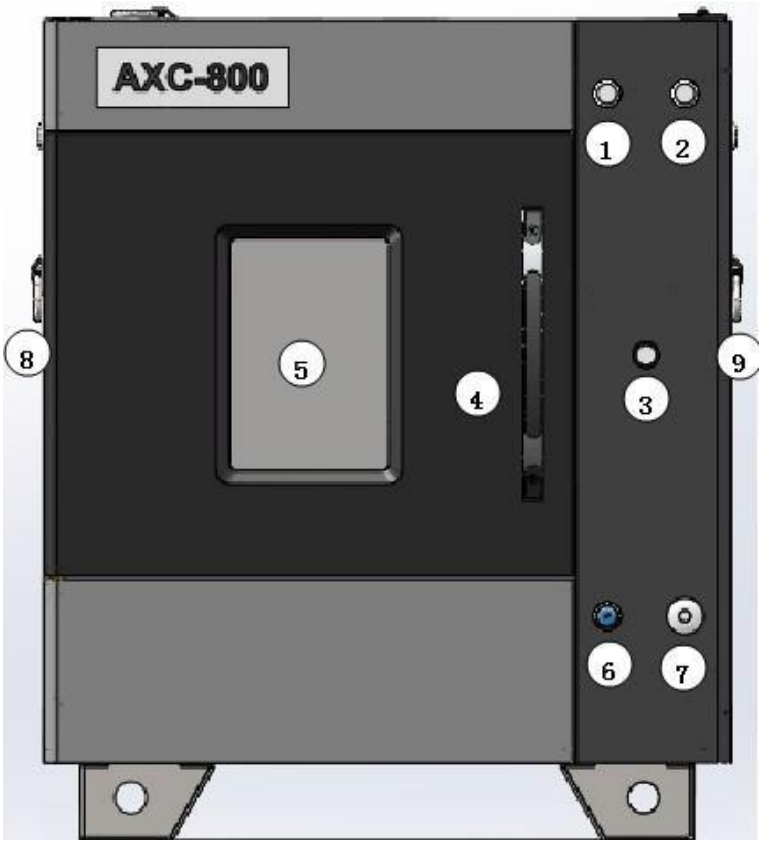
10. Accessories that expires the warranty period;

11. Damage to accessories due to force majeure;

Scienscope International reserves the final right to interpret the warranty terms.

3.4 Hardware instruction

3.4.1 Hardware instruction (external)



1、Early warning indicator light (it is red when X-ray is on)

2、 Power on indicator light

3、 Main switch

4、 Slide door (product access)

5、 Inspection window

6、 Key switch

7、 Emergency stop switch

8、 Left side door

9、 Right side door

1、X-ray ON early warning indicator light

Operator may get to know operating condition of AXC 800 quickly via early warning indicator light. The control system shall control early warning indicator light in accordance with current operating condition.

※Red indicator light on

When X-ray is turned on, red indicator light shall be on to remind operator of safe operation.

2、X-ray OFF indicator light

Operator may get to know operating condition of AXC 800 quickly via early warning indicator light. The control system shall control early warning indicator light in accordance with current operating condition.

※Green indicator light on

When the system is in standby mode, it shall send a ready signal to early warning indicator light and then the green indicator shall be turned on.

3、Main power switch

To turn on AXC 800, operator must turn on main power switch, after which the indicator light shall be on and green.

4、Slide door AXC 800 adopts slide door of safety interlock type while it is entirely fully enclosed radiation shielding chassis. Radiation shield of chassis and slide door is permanent thus cannot be replaced or modified. Operator may open the slide door and replace the product.

5、Lead glass inspection window

Lead glass inspection window is made of lead glass, featured by radiation isolation and convenient operation for observing operation condition within AXC 800.

6、Key switch

Key switch is the power switch controlling the whole AXC 800 equipment (except computer).

7、Emergency stop buttonPress this switch in case of emergency circumstances or malfunction to stop AXC 800 system which shall be in normal use after cancelling emergency stop button, returning to origin and initializing equipment.

All functions of X-scope are controlled by PC keyboard. The key switch and emergency stop button cannot be dismantled or replaced to effectively protect personal safety of staff during operation and equipment safety. Meanwhile national and industrial laws, regulations and stipulations related to electric power such as *Production Safety Law of the People's Republic of China* requires installation of this switch on electrical equipment; otherwise it cannot go through safety check.

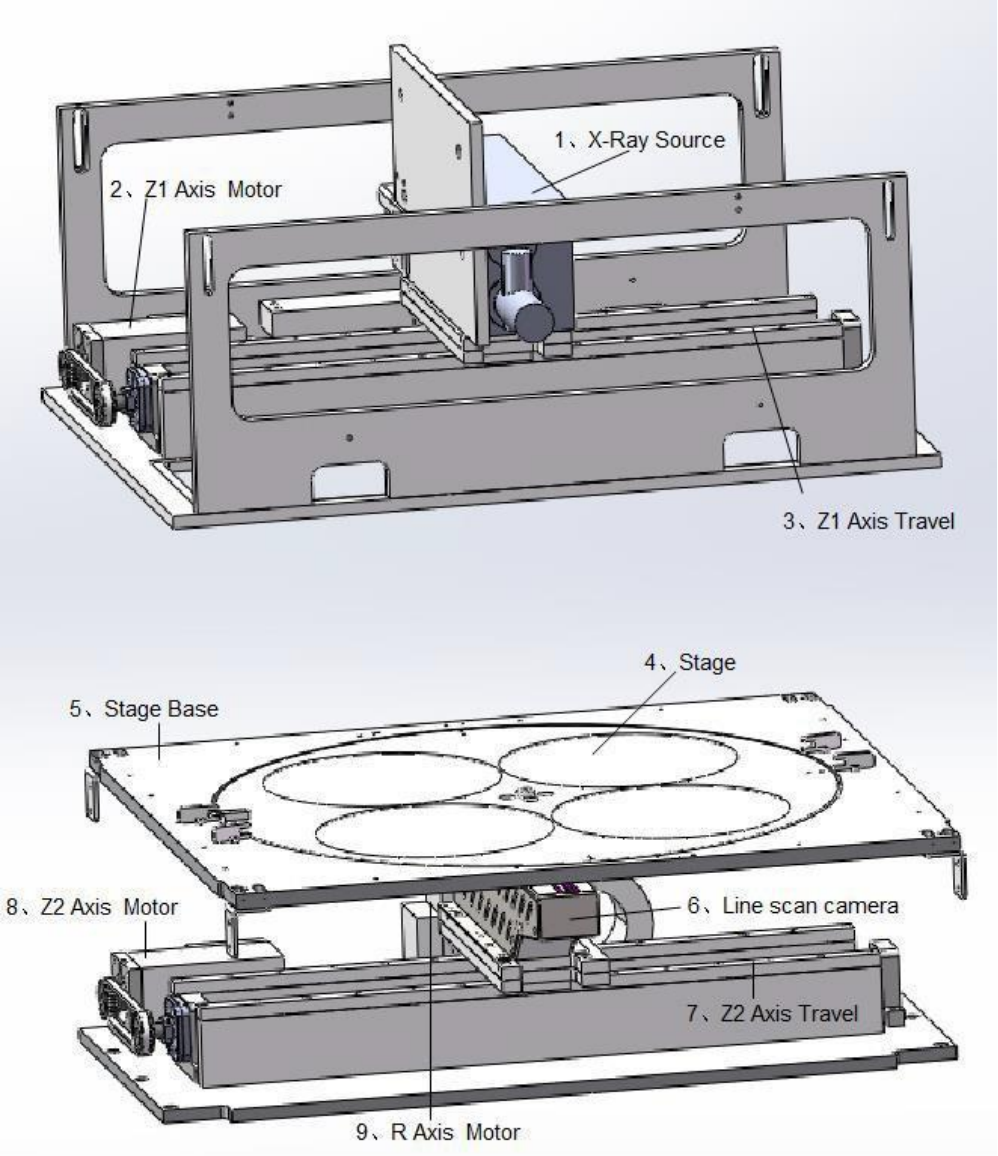
8、Left side door (normally closed)

9、Right side door (normally closed)

Back door: electric signal box (open this door and inspect high voltage power supply, motor driver,

control card and relevant electrical circuit).

3.4.2 Hardware instruction (internal)



1、X-ray source: X-ray emission device.

2、Z1 axis motor: control the light tube moving left and right.

3、Z1 axis travel: the light tube can move left and right on this direction.

4、Stage: a table to place samples (tray).

5、Stage base: fixing base of stage.

6、Line scan camera: X-ray line-scan imaging equipment.

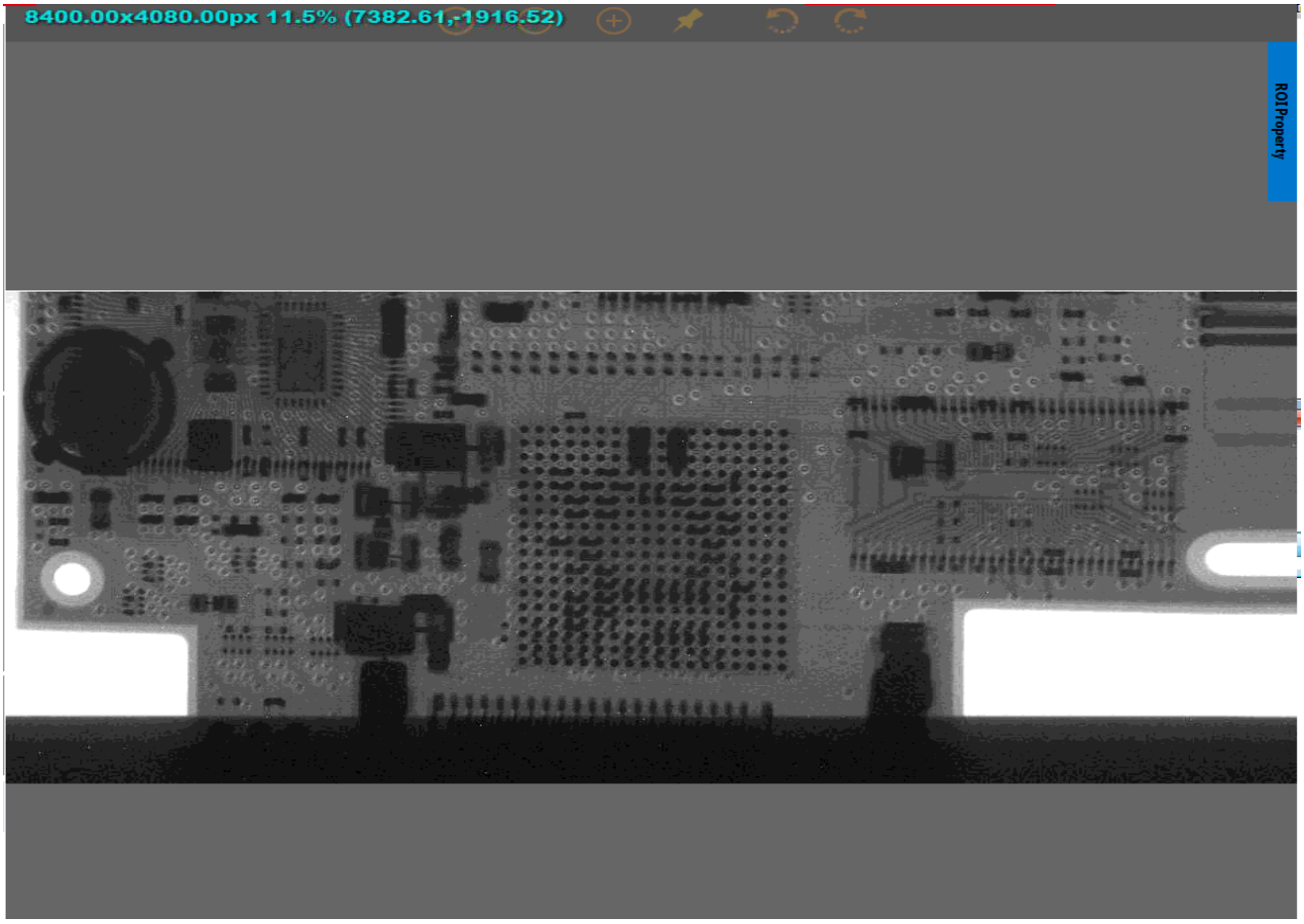
7、Z2 axis travel: the camera can move left and right on this direction.

8、Z2 axis motor: control the camera to move left and right.

9、R axis motor: control the stage to rotate.

Section 4 Software

4.1 Software interface




Start Image Capture.

Adjust Image contrast.


Home machine axis


Stop all functions


Print image

View includes Toolbar (including Status Bar, Lock dockbars, Language)

Status Bar: status bar may be removed from the operation interface by not checking it

Lock: when not checking the lock bar, the side column module can be dragged

Language: English by default; the operator may change to local language. Restart the software after the language change, and then it will take effect.

Page layout:

When the control toolbar on the right is not well arranged, choose Menu bar View=>Lock Dock Bar to unchecked. Adjust the control dialog box on the right and then check View=>Lock Dock Bar.

Language setting:

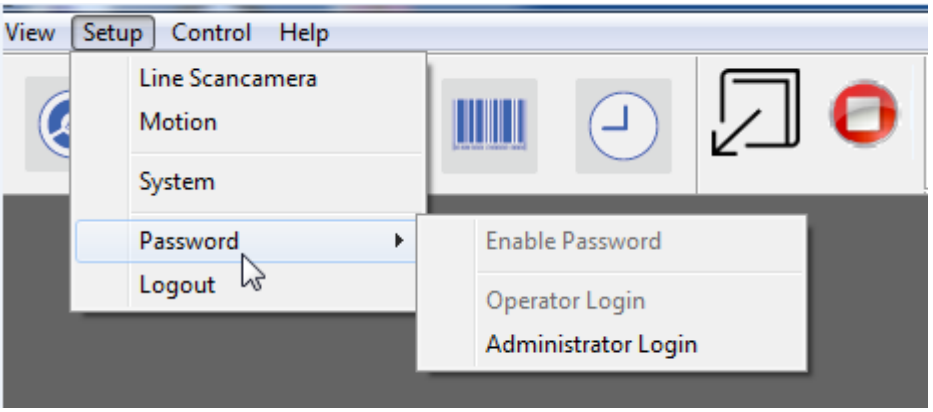
Enter senior user before language changing. Setup=>Password=>Administrator Login=> enter the password to complete senior user login. (Password: **scienscope**)

Enter View=>Language, select the appropriate language and complete language selection.

※**NOTE** Password for senior user: **scienscope;** after language setting, the software should be restarted.

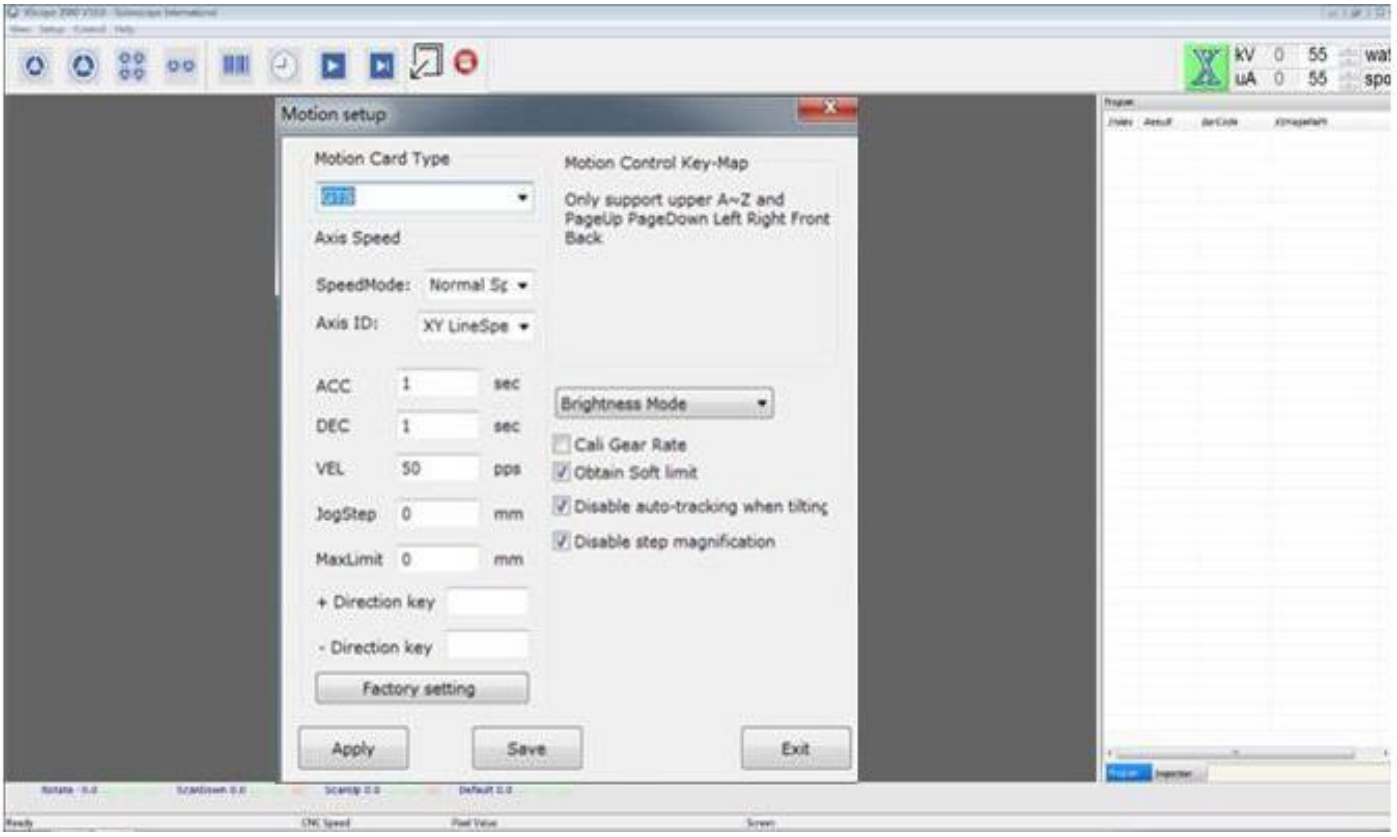
4.3.1 Setting items:

Setting items include line scan camera setting, motion control setting, system setting, password log in and log out (before delivery, parameter of this menu has been subject to strict debugging by engineer. So please don't modify at will, otherwise the equipment shall be unable to operate normally as a result).



4.3.1.1 Motion control setup

Enter into administrator user and click "Setup ➔-> Motion" to set up motion parameter.



“Motion Card Type”: choose proper type based on different motion control card in the drop down list;

“Speed Mode”: respectively low speed, normal speed, high speed, CNC. Choose in the drop down list.

“Axis ID”: setting of moving speed of various axles. Choose “XY Line speed” in normal situation. Choose X, Y, Z, R, CAM or X Ray in the drop down list and then set speed through ACC, DEC, VEl, Jog Step below; ACC means acceleration; DEC means deceleration; VEL means running speed; Jog Step means the motion journey when click the control key in jog mode.

“Cali Gear Rate”: moving axis tracking function; this function is only supported for inline machine;

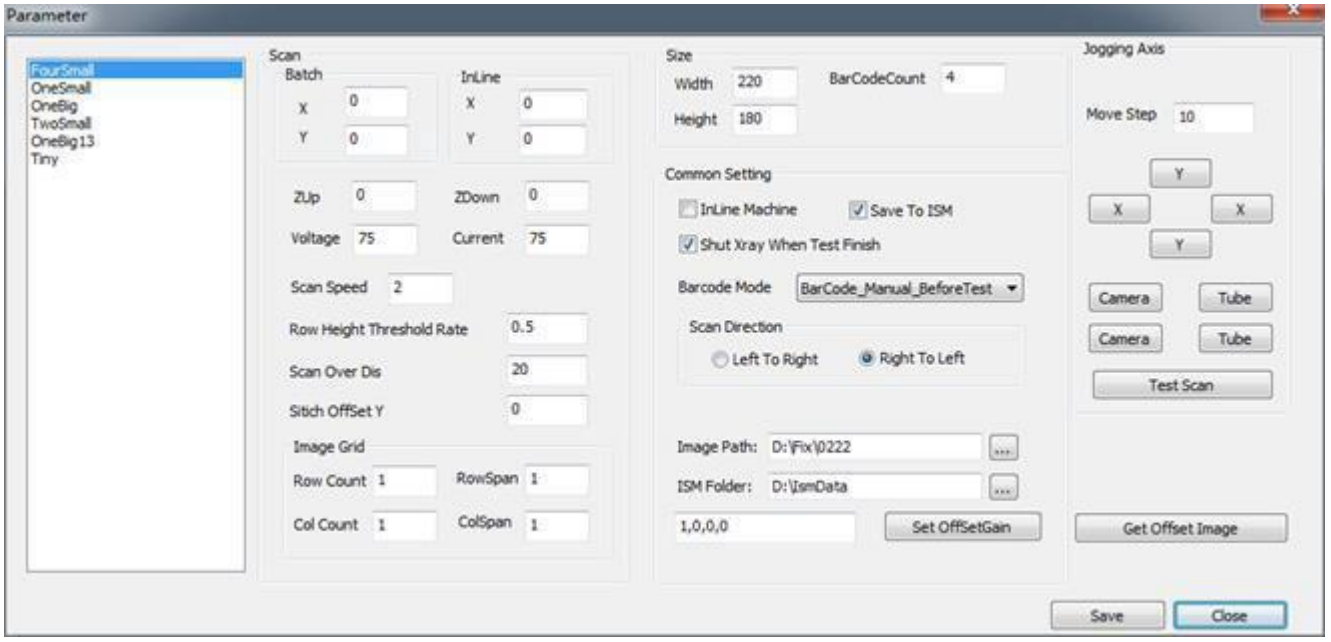
“Obtain Soft Limit”: soft space limit; this function is only supported for inline machine;

“Disable auto_tracking when tilting”: disable navigation tracking when tilting. If it is not checked, it means automatic tracking will be carried out in case of tilting.

“Disable step magnification”: disable multi-step amplification factor calibration. If it is not checked, automatic multi-step calibration of amplification factor will be supported. Besides, only multi-step staying is supported when various axles are moving. Then, the shortcut key can be operated by single click. When it is checked, the shortcut key should be operated by long press and various axles may stay at any place in moving process.

4.3.1.2 Offset setting

Enter into administrator user and click “setup ➔system” successively.



Set value of “SetOffSetGain” as 0,0,0,0. Click button “SetOffSetGain” and then button “GetOffSetImage”. The popup dialog box from procedure means succeed in capturing “offset” image. Then set value of “SetOffSetGain” as 1,0,0,0. If image effect is still unsatisfactory, value of “SetOffSetGain” may be subject to fine adjustment with minimum unit of 1. Principle of “Offset” setting is to brighten dark parts. The first parameter is corresponding to upper half of the image, the second parameter to lower half while the last two images to “Gain” setting of the image.

4.3.2 Control

4.3.3 Help: version information, etc..

Section 5 Use of Software

5.1 Precautions

1. Operators must receive professional training.
2. Ensure to complete Warm Up before operation every day.
3. Before opening X-ray, check and ensure that the safety door has been closed.
4. Don’t leave the X-Ray equipment after the opening of X-ray.
5. Don’t lean against the device in operation process.

6. When open the door for product replacement, ensure that the X-Ray opening button  is in “closed” state (green) and wait until the feedback value reducing to 0 before opening the safety door.

5.2 Operation

1. Press main power switch, insert a key into key switch and rotate to position “ON”. Then, turn on display and computer.

2. Start xScope software. The prompt “return to origin, Yes or No” appears and select “Yes” to return to origin.

4. Upon homing completion, select corresponding measurement mode (big tray, small tray, double trays and four trays).

5. Open safety door, put the sample (tray) on the stage and then input corresponding Barcode in the prompt dialog box.

6. After safety door is closed, the software shall automatically open X-ray for test. Upon test completion, test results shall be displayed on right side of the interface. Click the test results on right side and then switch the image display to main interface.

After opening X-ray, control button shall turn from green to red meanwhile red early warning indicator light shall be on. Voltage and current of light tube shall automatically rise to preset value. If this is first time to use X-ray light tube, Warm Up shall start.

For longer service life of light tube, it is recommended that the user perform Warm Up for 15 minutes per day and 30 minutes per week.

If the door is open, X-ray cannot be open. If user opens safety door forcibly after X-ray is open, the interlocking device shall automatically close X-ray to guarantee safety.

After X-ray is open, please don't attempt to open safety door.

Tube voltage and current need no manual setting. Before delivery, engineer had already set tube voltage and current as optimum value based on different trays to obtain best image effect.

After use of the X-Ray test system, please close the software and shut down the computer, turn the key switch to OFF and remove the key. The main power supply switch should also be turned to OFF. If the machine will not be used in short term, the operator should remove the keyboard to ensure safety so as to avoid it being operated by any person unauthorized or untrained when the machine is not safeguarded by special personnel.

Section 6 Fault Diagnosis and Maintenance

6.1 General electrical faults and troubleshooting

Fault	Symptoms	Troubleshooting
The machine cannot be normally powered on	Internal leakage of electricity	
	Lost and failure to maintain the main power supply button	Adjust the main power supply button
	Loosening of the key switch	Adjust the key switch
Failure to open X-Ray	The safety switch cannot be switched on	Adjust or replace
	The safety switch is damaged	Replace
	The HV power supply is damaged	Refer to HV power supply repair section
	X-ray tube cooling fan is damaged	Replace
	X-ray tube is damaged	Replace
Z1/Z2/R axis cannot move	Z1/Z2/R diver is damaged	Check whether the display lamp is on
	Driver 24V is not correctly provided	Check or replace 24V power supply
	Z1/Z2/R limit switch is damaged	Replace the damaged limit switch
The computer cannot be started	Damage of the computer switch power supply	Computer repair
	Damage of computer mother board	Computer repair
The computer can be started but it is unable to enter Win7 page	The VGA card is not well inserted	Computer repair
	The computer is seriously infected	Computer repair
	The computer hard disk is damaged	Computer repair

6.2 General hardware faults and troubleshooting

Fault	Causes	Troubleshooting
Z1/Z2/R axis cannot move	Z1/Z2/R coupler is broken	Replace
	Z1/Z2/R screw nut pairs are damaged	

6.3 General software faults and troubleshooting

Fault	Causes	Troubleshooting
Unable to start the software	System operating environment configuration failure	Install VC++2005 runtime library: Vcredist_x86.exe
	Failure appears in software ii process	Re-install
	The software activation has expired	Contact work staff of Scienscope
	Virus infection	
“No license……” pops up when start the software	Software is not inserted or is expired	Contact work staff of Scienscope
“Device setting” pops up when start the software	The capture card is not driven or the joint is not well inserted	
“The USB camera does not support the type setting” pops up when start the software	X-ray tube serial number not activated	

6.4 Precautions for use of light pipes

1 Ensure that the light pipes are securely installed.

2 Light pipes are preferably operated in a working environment of less than 30° C and free of dust and free circulation of air (equipment placed away from windows and rainproof);

3 It must be ensured that the device access voltage is stable and does not exceed the standard voltage;

4 Use a 6-square (mm) ground wire to ground separately(being not dependent, only use the ground wire of an AC power plug with a resistance of less than 10 ohms or less);

5 Make sure that the 15-minute Warm Up has been completed before the daily operation;

6 If a light pipe is not used for more than 24 hours, a 30-minute warm-up is required;

7 After the light is switched on, the current and voltage should rise slowly;

8 Do not operate light tubes for long periods of time at high power, with an optimum load of 70% (operation at 70% of maximum power);

9 Do not touch the head of a light tube and do not let anything touch the window of tube head, especially the adhesives or corrosive materials;

10 Light tubes contain fragile materials such as glass. Do not drop or suffer excessive shock or vibration. Do not relocate machines when possible. Please notify us to remove the light tube before relocating the machines;

11 Transport and storage temperature: -20 to +50°C;

12 When light tubes are stored, the 30-minute Warm Up should be completed at least once every month;

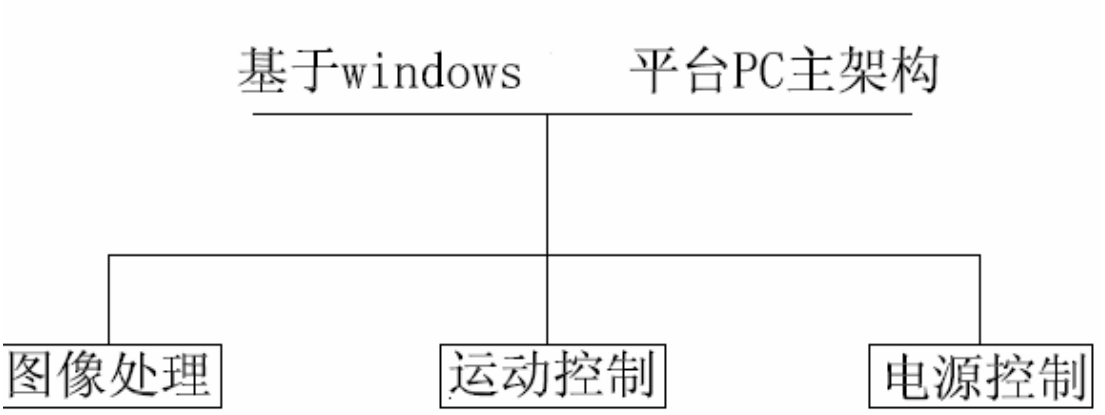
The above precautions should be strictly enforced, as these will affect the life of the light pipe.

※WARNING The damages to light pipes or other accessories due to failure to meet the requirements for equipment operating environment, the instability of input voltage, ground wire not grounded as required would not be covered in the warranty.

Section 7 Software Installation and Introduction (Attached)

Note: Software operating environment plug-in and related driver should be installed before software installation. Software installation and operation should be carried out by workers trained by our company.

7.1 Software structure



7.2 Software installation

7.2.1 Operating environment plug-in installation

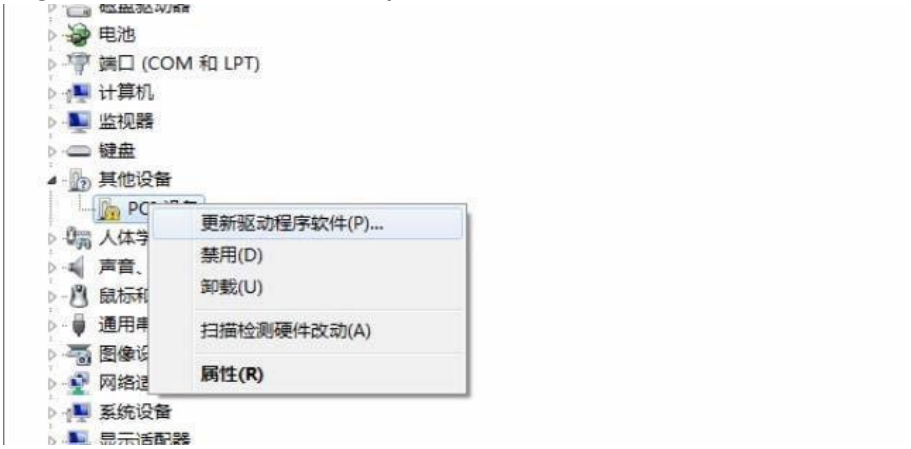
To run SCIENSCOPE and Xscope x-ray operating software on windows; VCredist_x86.exe plug-in should be installed; C:\XScope\..

7.2.2 Driver installation

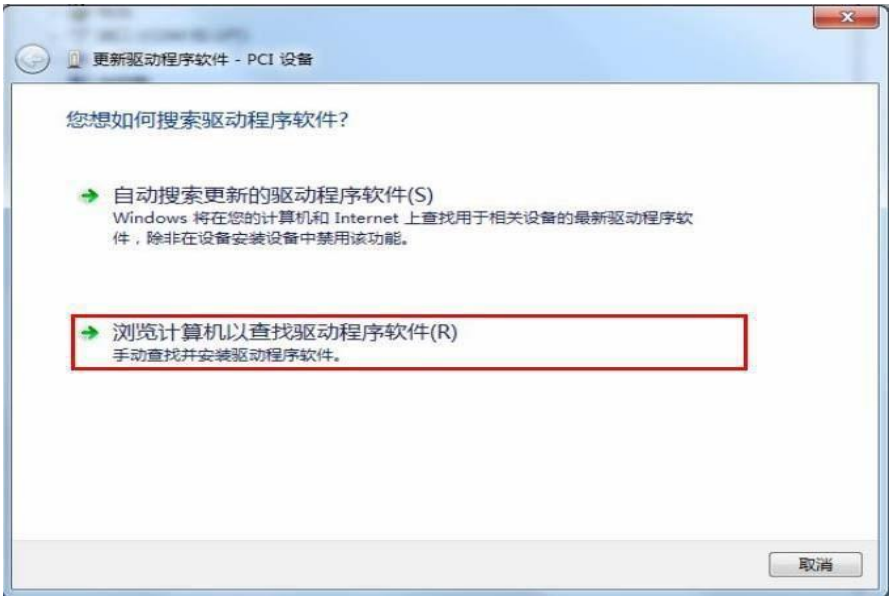
1) Motion control card driver installation

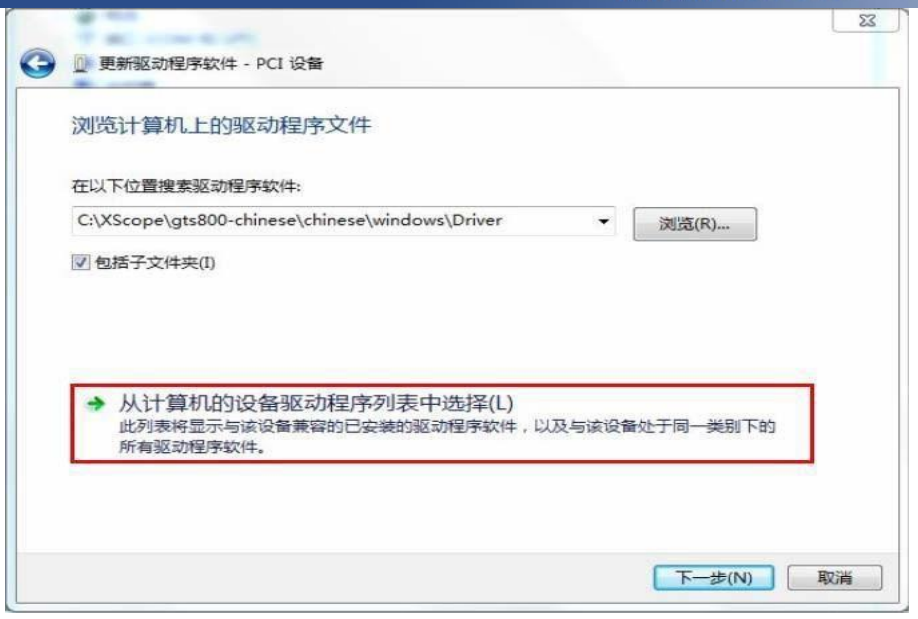
a. GTS-800 motion control card: open the computer manager and find PCI equipment

Right click and choose to update the driver software



Choose the driving directory




更新驱动程序软件 - PCI 设备
浏览计算机上的驱动程序文件
在以下位置搜索驱动程序软件:
C:\XScope\gts800-chinese\chinese\windows\Driver
浏览(R)...
包括子文件夹(I)
从计算机的设备驱动程序列表中选择(L)
此列表将显示与该设备兼容的已安装的驱动程序软件，以及与该设备处于同一类别下的所有驱动程序软件。
下一步(N)
取消

Choose “always install the driver software”

Complete installation

b. GTS-400 motion control card: double click to run C:\ XScope\GTS400\ REG_Win_VISTA32.bat to complete installation.

2) Flat detector driving:

a. Double click to run C:\XScope\camera\Programs\GigEVision_1.90.05.0062 Release.exe; click NEXT as per prompt until installation completion.

b. Double click to run C:\XScope\camera\Programs\ SaperaLT740CamExpertSetup.exe; click NEXT as per prompt until installation completion.

3) Team Viewer: to run Team Viewer on two computers at the same time for remote control and assist; a series of simple and quick solutions can be supported, including desktop sharing, file transmitting, etc.

7.2.3 X-Scope software installation

See setup flow as below:

1. Find the installation file X-Scope SetUp 9.0.exe and ensure the latest version.

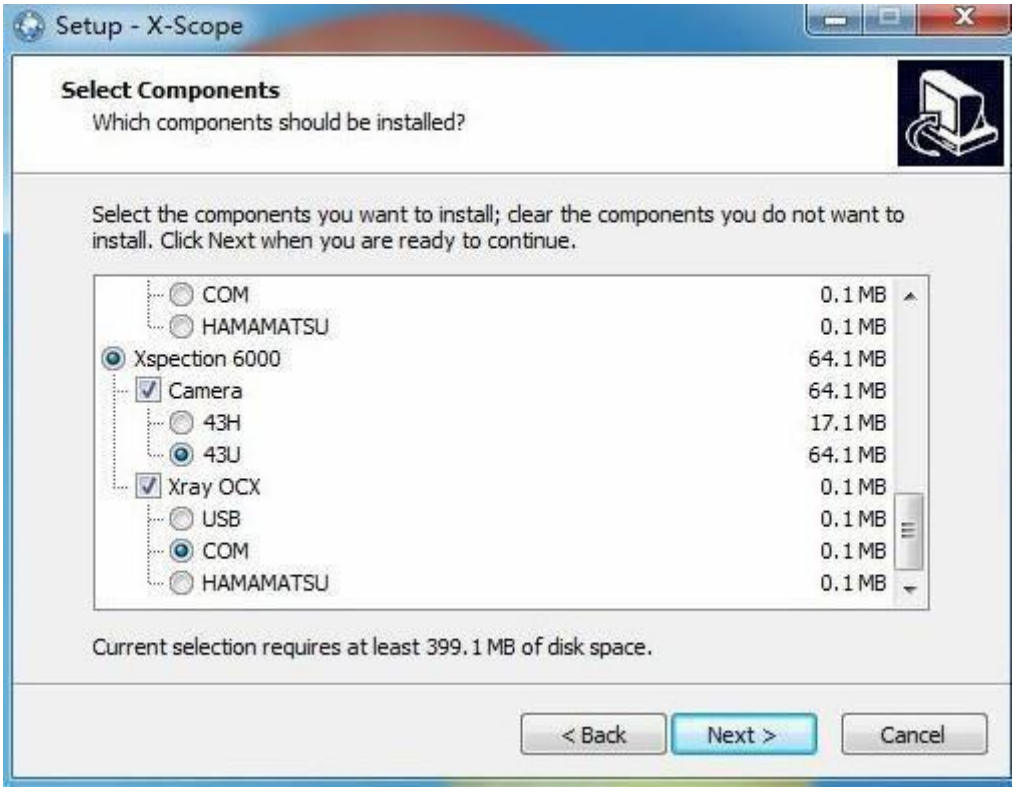
2. Select the language and click “OK”


Select Setup Language
Select the language to use during the installation:
English
OK
Cancel

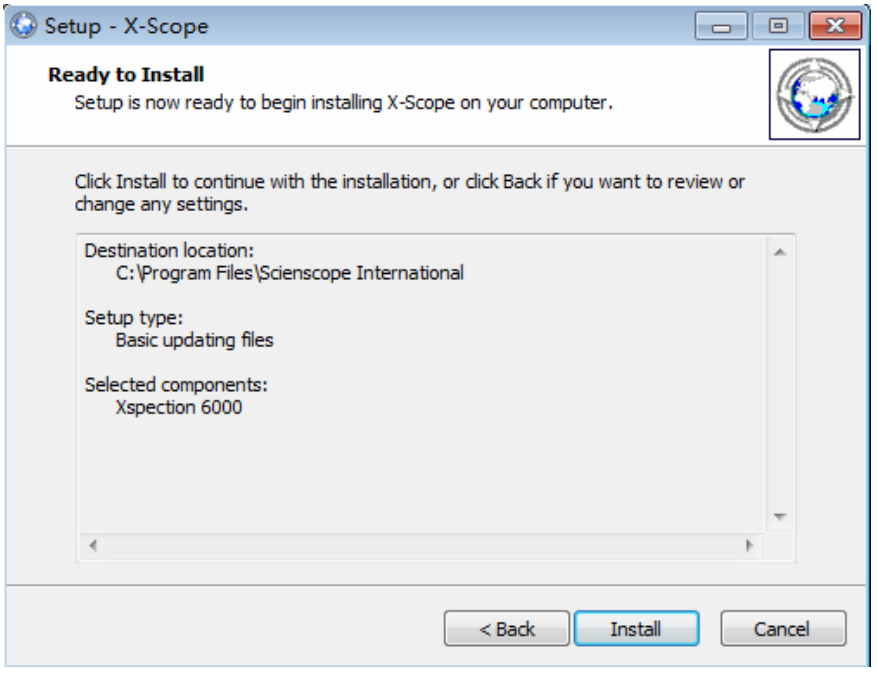
3. Click “NEXT” to execute setup procedure

4. Determine the installation path: C:\Program Files\Scienscope International which is recommended not to change

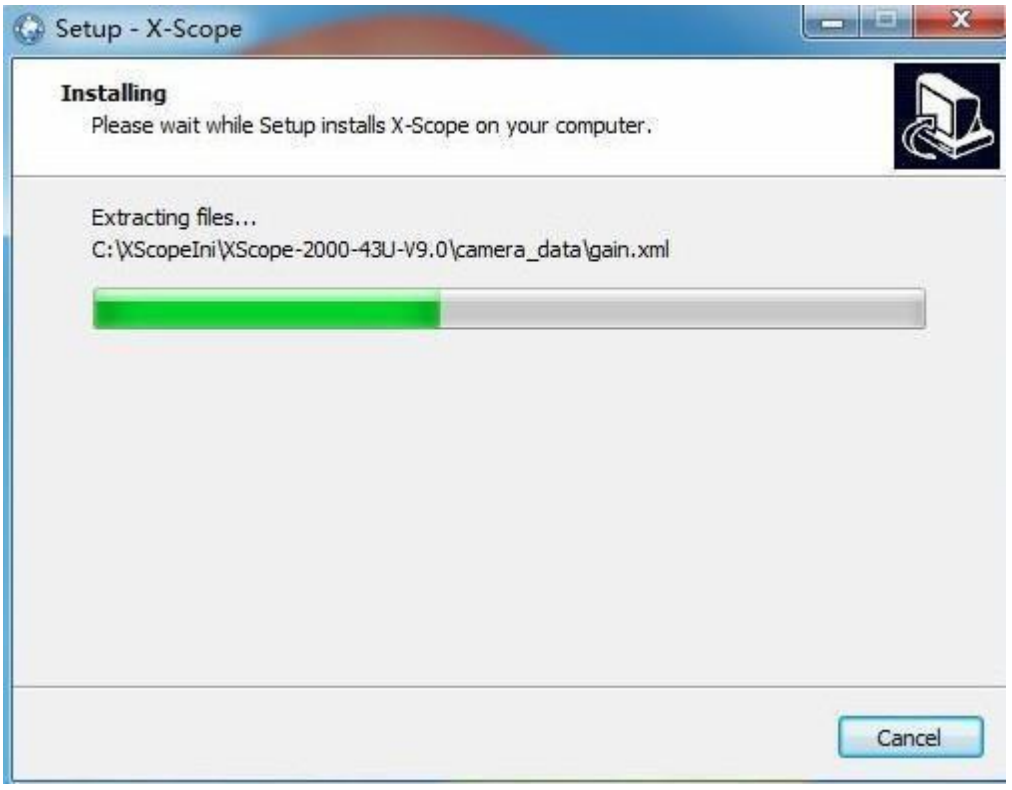
5. Select equipment type (machine model, plat detector model, X-ray tube control)



5. General information



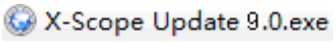
6. Installation procedure starts



7. Installation finish

Upgrade installation

1. Update.exe will be used



2. The process is quite simple. It is unnecessary to choose equipment type, but to update part of dll only. Just follow the installation process.

7.2.4 System backup

The computer system will be backed up in disk E before delivery of the machine. The directory is to store system image files (System_Back.GHO). In case any system problem unable to be solved, system restoration may be realized by ghost software. Usually, original applications, related matching and driving software and related third-party software will be stored in disk C, such as Team Viewer networked remote assistance tool, etc..

Section 8 Preventive Maintenance, Application Radiation Safety Training, X-ray Theory & Supplemental

8.1 Preventive Maintenance

X-Scope 1000	XSpection 6000
X-Scope 1800	AXC800 / CC
X-Scope 2000/2300	AXI 5100 / CC
X-Scope 3000	AXI 6100

Benefit of Scienscope X-Scope Service.

Uptime

• On-site or Remote Support
• Repair Service
• Spare Parts and Kits

Performance

• Setup and Configuration
• Preventive Maintenance
• Professional Installation
• Upgrade and Refurbishment

Compliance

• Equipment Qualification
• Performance Verification
• Test Samples and Weights

Expertise

• User Training
• Consulting and Business Support
• Documentation and Downloads

X-SCOPE X-Ray Division

SCIENSCOPE
We Sell Solutions

XSCOPE SERVICE

Preventive Maintenance

- Ensure Optimize performance
- Minimized repair time
- Reduce inventory costs
- Minimized equipment uptime

Keep Production Running

Total peace of mind

PM Services

SCIENSCOPE
We Sell Solutions

Preventive Maintenance

To maintain productivity, reliable equipment performance is key.

Our Preventive maintenance service is designed to preserve and restore your equipments reliability. Periodic inspections prevent failure or unplanned downtime, avoiding repair costs, all the while protecting your budget.

Unplanned down time can be prevented

Ensure continuous productivity with regularly scheduled preventive maintenance visits according to the frequency of the equipment use and process risks so that you can:

- Ensure reliable performance
- Maintain compliance requirements
- Avoid unexpected equipment downtime
- Protect your budget

Peak performance with proactive maintenance

Preventive maintenance is key to your equipment's accuracy and longevity. Preplanned, periodic maintenance provides you with complete trust that you equipment achieves:

- Consistent, accurate results
- Extended equipment life
- Safe and reliable operation
- The best performance possible

Equipment reliability you can depend on

Our services provides you with periodic, preventive maintenance, including activities required to ensure continuously accurate and reliable operation , such as:

- Inspection and cleaning
- Testing and adjustment
- Radiation survey and Documentation equipment condition
- Improvement recommendations

X-SCOPE X-Ray Division

PM Services

SCIENSCOPE We Sell Solutions

Preventive Maintenance Schedules Plan.

Semi Annual PM Schedule (Recommended)

Annual PM Schedule (Required)

To prolong the life of the components and up-keep of the machine.

Safety System Maintenance:
- Perform Radiation Survey at Full Rated Output of X-ray System
- Inspect and Adjust Safety Interlock, Tower Light, and Cabinet Doors
- Check kV and mA Displays, kV and mA Controls of Sealed Tube X-ray
- Focus X-ray Tube Power Supply
- Check all Electrical and X-ray Safety Labels

Real-Time X-ray Systems:
- Check and Lubricate Ball Screws, Bearings
- Clean and Lubricate Sample Stage
- Image Calibration of Offset and Gain
- Check Gear Ratio and Parcentricity
- Navigation and Mapping Camera Calibration

Maintenance Services Provided for Electrical & Mechanical:
- Check Power Recepticle and Ground Wire Connections
- Check all Power Supplies and Incoming Power Supply Voltages
- Check Sealed Tube Wiring Harness and All Cable Connections
- Check Stage Drives - Ball Screw, Coupler and Sprockets for Wear
- Check and Clean All Drive Belts

Calibration and Certificates
Our Calibration Services ensure equipment performs accurately and complies with local global regulations.

Upgrade and Refurbishment
Equipment upgrades enhance functionality beyond the original manufactured condition, while refurbishment returns functionality to a like-new state.

User Training
Increase operational knowledge and maximaze equipment and process performance with professional training.

X-SCOPE X-Ray Division

Six Month Schedule or 1000 Hours (Recommended)

- Radiation Survey
- Check All Safety Labels
- Check Power Receptacle and Ground Wire Connections
- Check Access Panel Interlocks
- Check kV and uA Displays
- Check kV and uA Meters for Operation
- Clean and Adjust Camera Lens
- Clean Exterior
- Clean and Lubricate Sample Stage
- Check Cable Connections

Annual Schedule or 2000 Hours (Required)

- Radiation Survey with documentation
- Check All Safety Labels
- Check Power Receptacle and Ground Wire Connections
- Check Access Panel Interlocks
- Check kV and uA Displays
- Check kV and uA Meters for Operation
- Clean and Adjust Camera Lens (where applicable)
- Focus X-Ray Tube Power Supply (where applicable)
- Clean Exterior
- Clean Interior
- Clean and Lubricate Sample Stage
- Lubricate The axis stage ball screws
- Check Cable Connections
- Check stage drive/ball screw for wear
- Check Stage drive couplers
- Navigation Mapping Camera Calibration
- X-ray Detector Pixel Mapping Calibration

Radiation Safety Standard

For systems delivered to all countries except the UK, Germany:

Less than 0.5 mR/hr at 5 cm (2 in.) from exterior surface at maximum kV and uA settings.

For systems delivered to the UK, Germany:

Less than 0.1 mR/hr at 10 cm (4 in.) from exterior surface at maximum kV and uA settings.

Measuring Instrument Check - Before Survey

Type of instrument:

The Victoreen 450 P or equivalent with an accurate reading at 0.5 mR/hr is recommended.

Calibration Date:

Make certain that the meter has a current calibration status.

Battery Check:

Check for proper battery condition. Replace the batteries before the survey if required.

Operational Source Check:

If the meter has a source check function, check the meter as described in the meter operating manual.

When using a meter with a beta cap, all measurements should be made with the beta cap removed .

Surveying the Cabinet System

1. Turn on the system and perform the proper warm-up procedure.

2. Perform an operational check on the survey meter.

3. Place a re-sealable plastic bag filled with 4 oz. of water in the center of the cabinet, ensure that the water covers the image intensifier and is in the directbeam.

4. Energize x-rays and bring the kV and uA up to the full power position.

5. Starting around the access panels, slowly scan the outer edges of the access panels paying attention to the areas where the access panel meets the cabinet. Scan the four sides, top and bottom of the cabinet.

Scan at about 4 cm/second (about 1.6 inches/ second) across each surface about 2 to 2.5 cm (.08 to 1 inch) from the face of the surface. Scans are made in horizontal movements from one edge to the other. Move the meter down an average of 5 cm (2") each pass. Scan in a parallel line back and forth until the whole side is scanned. If there is an increase in the meter reading while scanning, by leakage or by a burst of background radiation an area of approximately 5 cm x 5 cm (2"x2") shall be very slowly scanned. Go over the area two or three times until there is a stabilized reading on the meter. The highest stabilized reading (HR) is recorded for all four sides and for the top and bottom of the system.

6. Determine the lowest value of background radiation, by turning the x-ray system off and waiting for the meter to stabilize to its lowest level (BG). Record this value. Actual (NET) leakage values are determined by the following formula.

Actual Leakage =HR-BG

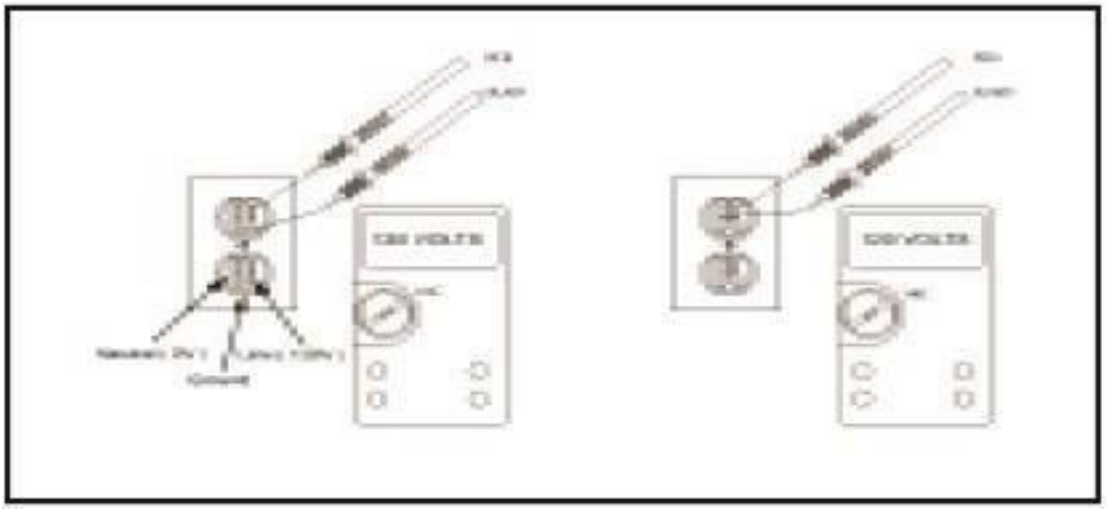
Before scanning the bottom of the system, remove all attenuation that may be in the beam such as water, manual manipulators and samples.

Check that all labels and operator safety instructions are in place.

Use the label location diagram in the Installation section of this manual as a guide and verify that all labels and safety instructions are in place.

Check for proper power receptacle / connector polarity.

With a digital multimeter check that the power receptacle to which the SCIENSCOPE X-Scope 1800 is to be connected, has the proper polarity.



Measure the AC voltage between Ground and the Neutral and the Line respectively.

Check the X-Ray On indicators.

The X-Scope systems has three x-ray on indicators. The first is a red indicator on the console control panel marked X-Ray On. The second is a red tower light on the top of the X-Scope systems cabinet and the third is the uA digital readout.

Ensure that all x-ray on indicators are functioning when x-rays are energized.

If an indicator is found to be defective, DO NOT OPERATE the X-Scope systems. Please call SCIENSCOPE for service advice.

The Tube Current meter is a direct indication that x-rays are being produced. When an x-ray exposure is stopped the meter should return to zero. If it does not indicate zero when x-rays are in the off state, DO NOT operate the SCIENSCOPE X-Scope Systems. Contact SCIENSCOPE for service advice.

Check the access panel interlocks.

1. Use the appropriate tool to open the access panels.
2. Adjust the kV and uA to the lowest levels.
3. Place the radiation meter near the access panel, positioned so that the display is visible.
4. Open the access panel while reading the meter. The meter should not rise above background levels.
5. The opening of the access panel should terminate the x-ray exposure.
6. Close the access panel without resetting the x-ray key switch, X-rays should not activate without resetting the x-ray "ON" key switch.

If the interlocks are found to be defective DO NOT USE the system, call SCIENSCOPE for service advice.
Interlock circuits should only be serviced by trained x-ray service personnel, DO NOT attempt to bypass the interlock circuits.

Clean and adjust the Camera lens. Legacy (2000\2300)

1. Remove the Camera assembly by loosing the retaining knob.
2. Disconnect the power and video cables from the camera.
3. Ensure that the camera lens is properly tightened by hand tightening the camera lens to the right, Do not over tighten the lens, a snug fit is all that is required.
4. Using a lens cleaning tissue and lens cleaning solution, wipe any dirt or debris from the lens. Follow the lens tissue and solution instruction when cleaning any lens.
5. Replace the camera assembly and adjust.

Check the kV and uA meters for operation.

Check the kV and uA meters for missing or defective LED elements.

NOTE: This PM operation is for older knob and meter system and does not apply to CNC computer controlled X--Scopes.

Lubricate all axis stage ball screws

Ensure that old grease is wiped away and apply a thin coating of lithium grease to all ball screws.

Clean the exterior of the machine

On a six month / annual basis, wipe the exterior of the X-Scope systems with a damp cloth and a nonabrasive cleaner. Do not soak the surface.

Clean the interior of the machine

On a six month / annual basis, wipe the interior of the X-Scope systems with a damp cloth and a nonabrasive cleaner.

NOTE:

Do not soak the surface of the image intensifier / FPD (detector) or x-ray tube housing.

DO NOT USE LIQUIDS ON THE X-RAY TUBE WINDOW, this will result in corrosion and premature x-ray tube failure. Do Not touch the x-ray tube window, oil from your skin will result in corrosion and premature x-ray tube.

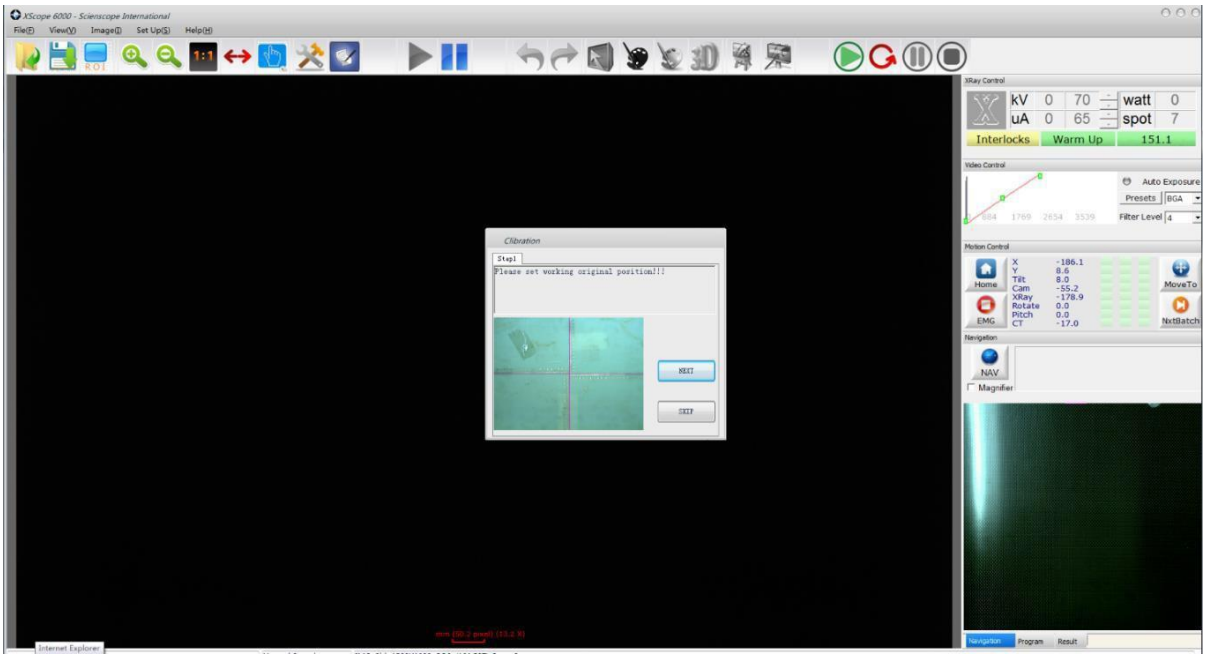
Check the cable connections.

On a six month / annual basis check the cable connections on the X-Scope systems for tightness and wear. Contact SCIENSCOPE for replacement parts if necessary.

Check the X-Ray ON Indicators.

On a six month / annual basis check the X-Ray ON indicators on the SCIENSCOPE X-Scope systems for correct operation. Contact SCIENSCOPE for replacement parts if necessary.

Navigation Calibration



Step 1

Click Home button

Set working (Home) position

Usually center of the X-Y table

Step 2

Set navigational image working area dimensions in millimeters

Width & Height

Step 3

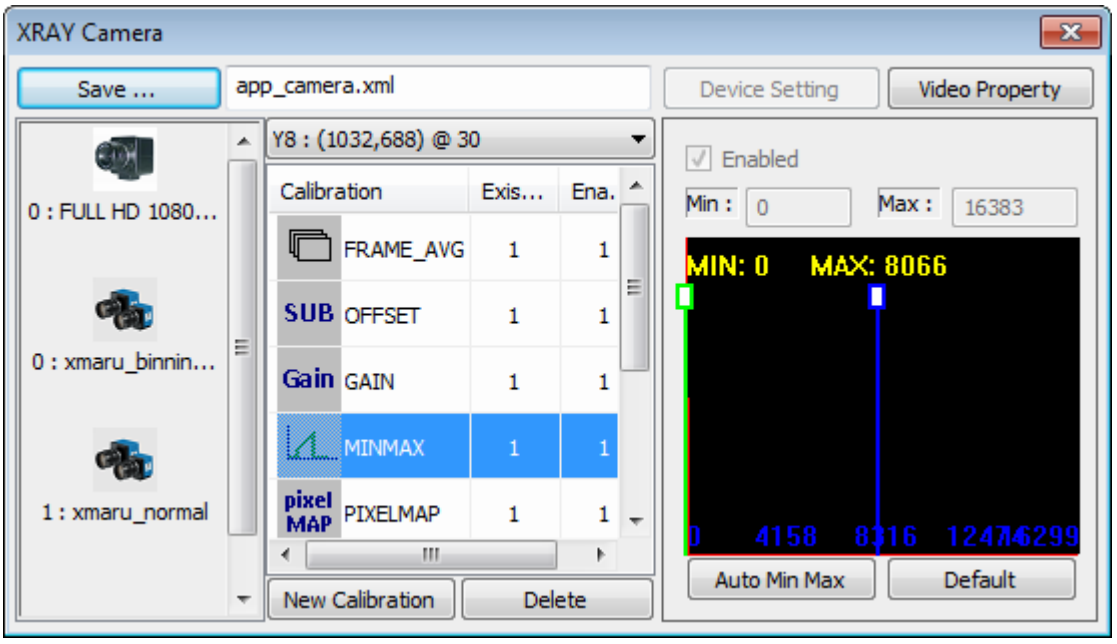
Set offset travel for the navigational camera center to x-ray detector center

*Note

These steps could be skipped if the system only requires, for example offset calibration. Click SKIP until the desired calibration Step is displayed, then click NEXT to start the calibration steps. Click END to save & exit NAV calibration

X-Ray Camera Set Up - Log In and Main Camera Calibration

The X-Ray Flat Panel Detector will require periodic re-calibration of the Offset and Gain may vary from daily, weekly, or monthly. Calibration will be required after the detector reaches room temperature.



Click on the Set up drop down menu
Click on Password
Log into the system as administrator using the Password (Default: *scienscope*)
Click OK in the Successful Login Pop Up
Click on the X-ray camera set up drop down menu

1. Create Offset Image

Click on set up drop down menu
Click on Camera Setup
Click MINMAX
Set min to 0, set max to half gray scale
Click OFFSET
With x-rays off click on Create Offset Image
Click SAVE Offset.xml
Click Save app_camera.xml

2. Create Gain Image

Verify MINMAX is set to (min=0; max=half gray scale)
Click on GAIN
With nothing in x-ray beam set kV to 50 kV and uA to 50
Turn on x-rays; wait until the system comes up to full power
Then adjust kV/uA until the gray scale peak is within 10% of max slider without going
over
Click Create Gain Image
Click Save Gain.xml
Click Save app_camera.xml

3. Pixel Map Calibration

Pixel Mapping should by performed by Experienced Operators Only, improper pixel mapping will result in poor performance of the Flat Panel Detector and require factory service via an internet connection.

With x-rays on Click on Pixel Map and turn kV\mA to Gain Cali. level
Click on Auto Create Pixel Map
To remove a line of pixels or single pixel on the detector type the appropriate pixel coordination
Example:

COL	512	513		0	1023	
Upper left pixel	(width)	(height)		Lower right pixel	(width)	(height)

Click Edit and Apply
Click Save pixelmap.xml
Click Save app_camera.xml
Close out window
NOTE:

COL = Column
ROW = Row
PX = Pixel

Radiation Form Sample

Date: _____ Routine Compliance Testing

For
Cabinet X-Ray Systems To Which
21 CFR Subchapter J Is Applicable

Customer Name : Contact:

Customer Address: Phone:

E-mail:

Date
System Model MFG

System Type: Baggage Inspection Special Purpose General Other

If Other

Manufacturer SCIENSCOPE System Serial #

Certification Label Present ? YES NO

Maintenance Schedule Available ? YES NO

Designed to Admit Humans? YES NO

Operator Instructions Available? YES NO

Warning Labels Present At Control's Stating :" X-Ray Produced When Energized"

YES NO

Warning Labels At Ports Stating: "Caution: Do Not Insert Any Part Of The Body When System Is Energized , X-Ray Hazard

YES NO N/A

Two Indicators Labeled "X-Ray On" Present At Controls (one may be labeled mA meter)

YES NO

At Least One Indicator Marked "X-Ray On", Visible From Each Port, Door and Access Panel

YES NO

Captured Key Control YES NO

Minimum Number Of Interlocks Visible At Any One Door

At Least One Interlock Dependent On No Moving Part Except The Door

YES NO

All Doors And Access Panels That Were Tested Prevent Generation Of X Radiation

YES NO

Use Of X-Ray Control Necessary To Resume Operation Following Interruption

YES NO

Some Part Of The Body Can Be Inserted Through A Port Into The Primary Beam

YES NO N/A

Some Part Of The Body Can Be Inserted Into An Aperture

YES NO N/A

Radiation Leakage

A. Horizontal beam with the manual inspection area, place the scatter object in the path of the unit, flat against the image receptor.

B. Horizontal beam Orientation with a conveyor, place the scatter object in an upright position on the conveyor belt.

C. Vertical beam orientation with a manual system, place the scatter object in a flat position at the approximate center of the inspection area.

D. Vertical beam orientation with a conveyor system, place the scatter object in a flat position On the conver belt.

Specific Test Procedure Used

A B C D

Scatter Block Description _____

Test Meter Model _____ Serial Number _____

Calibration Date _____

Technique Factors _____ kV _____ mA

Radiation Leakage Test

Test Point Description	Actual Radiation Reading
Door (center)	_____ micro R/hr
Door (left edge)	_____ micro R/hr
Door (right edge)	_____ micro R/hr
Door (top)	_____ micro R/hr
Door (bottom)	_____ micro R/hr
Control Panel (center)	_____ micro R/hr
Top (center)	_____ micro R/hr
Top (left edge)	_____ micro R/hr
Top (right edge)	_____ micro R/hr
Top (front)	_____ micro R/hr
Top (rear)	_____ micro R/hr
Left Side (bottom)	_____ micro R/hr
Left Side (middle)	_____ micro R/hr
Left Side (top)	_____ micro R/hr
Left Side (front)	_____ micro R/hr
Left Side (rear)	_____ micro R/hr

Right Side (bottom)		micro R/hr	
Right Side (middle)		micro R/hr	
Right Side (top)		micro R/hr	
Right Side (front)		micro R/hr	
Right Side (rear)		micro R/hr	
Rear (center)		micro R/hr	
Rear (left edge)		micro R/hr	
Rear (right edge)		micro R/hr	
Rear (top)		micro R/hr	
Rear (bottom)		micro R/hr	
Bottom (if accessable)	NA	micro R/hr	
Access Panel 1 (if applicable)		micro R/hr	N/A
Access Panel 2 (if applicable)		micro R/hr	N/A
Port 1 (if applicable)		micro R/hr	N/A
Port 2 (if applicable)		micro R/hr	N/A
Aperture 1 (if applicable)		micro R/hr	N/A
Aperture 2 (if applicable)		micro R/hr	N/A

Additional Information:

Surveyor Name: SCIENSCOPE INTERNATIONAL

Survey Date:

Remarks: X-ray tube Model: Total X-ray on hours:

Surveyor Name: SCIENSCOPE XSCOPE

Technician:

Survey Date:

Customer's Name:

Date:

8.2 DOSIMETRY:

CHPDOSIMETRY **Use Offer Code: "XSCOPE"**

Save $100 or more on Radiation Badges

CHP Dosimetry is a Veteran Owned Small Business that offers NVLAP accredited radiation badge services to clients nationwide.

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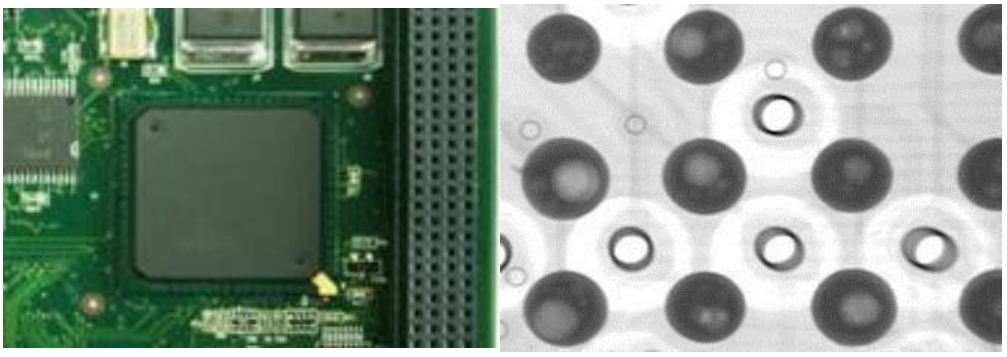
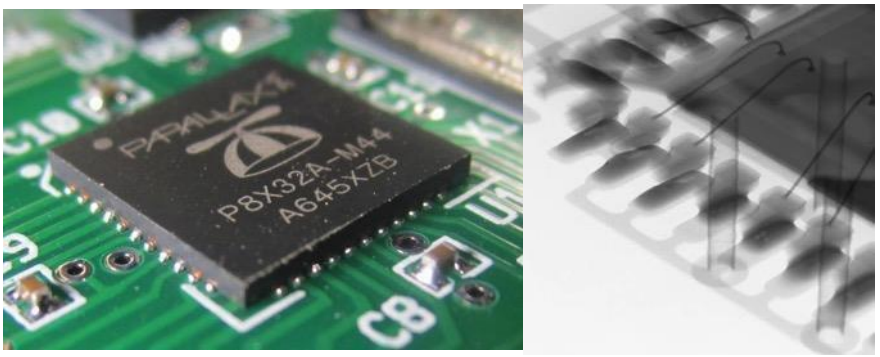
8.3 APPLICATIONS:

Application capabilities	
Multi-layer PCB's	Automobile components
BGA-Inspection	Semiconductor
Over molded electrical connectors	Pharmaceuticals
Encapsulated components	Medical devices
Aluminum die castings	Sensors
Molded plastic components	Agriculture
Ceramics	Counterfeit components
Aerospace parts	Battery inspection

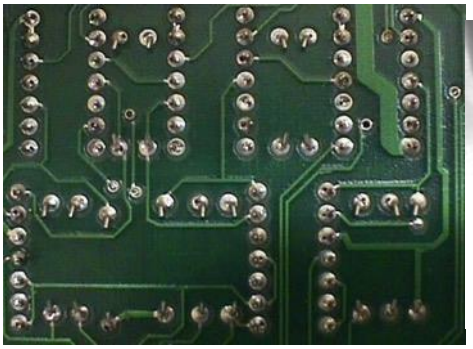
BGA

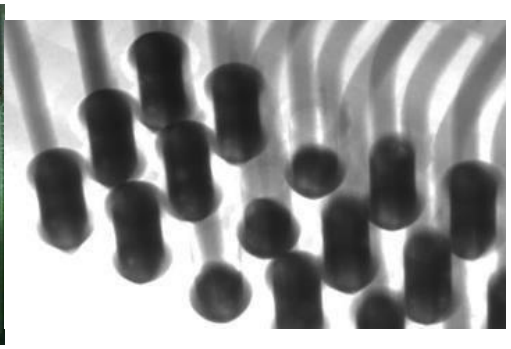


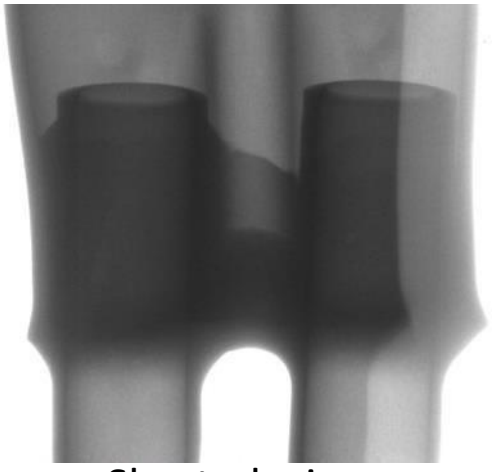
QFN -LEADS



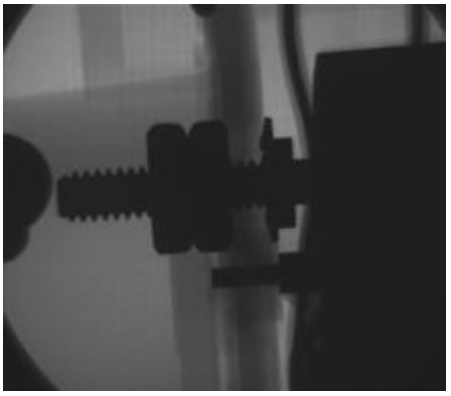
CONNECTOR







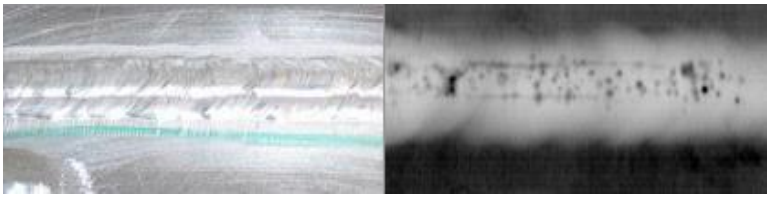
Shorted wires



Mechanical assemblies

Plastic welds

Automotive

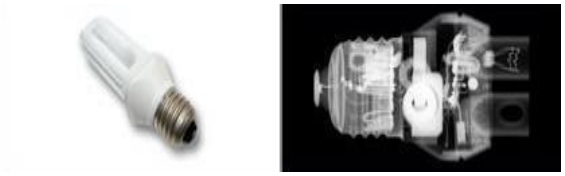


Metal welds

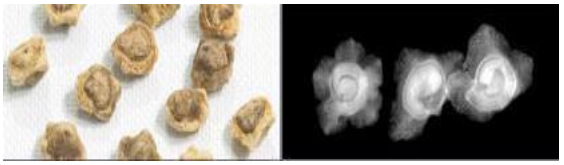
Food

Connectors

Switches



Light bulbs



Agriculture

Aluminum castings

8.4 X-RAY THEORY:

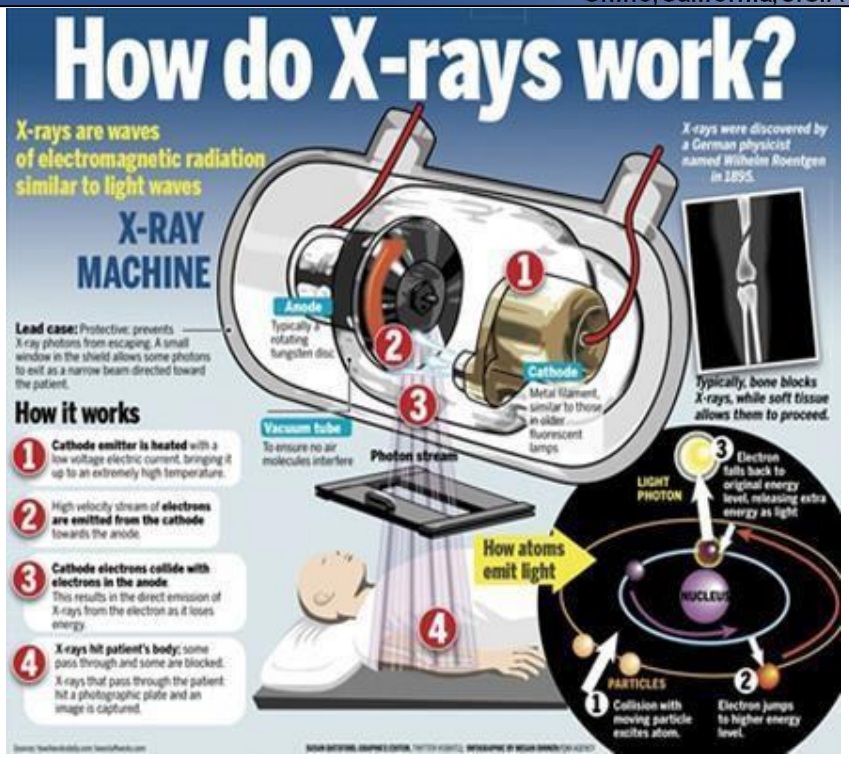
Principles of Operation

X-rays are generated by high voltage acceleration of electrons striking a target in a vacuum tube. When the electrons strike the target photons are released. The photon beam (x-ray beam) is filtered and collimated before it leaves the tube housing assembly. The photon beam travels through the sample object and forms an x-ray image due to differential attenuation (differences in material densities) in the object. This x-ray shadow passes through the light shield and impinges on the scintillator screen where the x-ray image is converted electricity by a photoelectric diodes. The resultant electricity is amplified and sent to the image processing computer for processing.

The image processing software enables the operator to view the image, preform pre and post image enhancement functions, basic measurement functions and save the image to the hard drive or network drive.

Never leave the X-Scope unattended when the x-rays are energized.

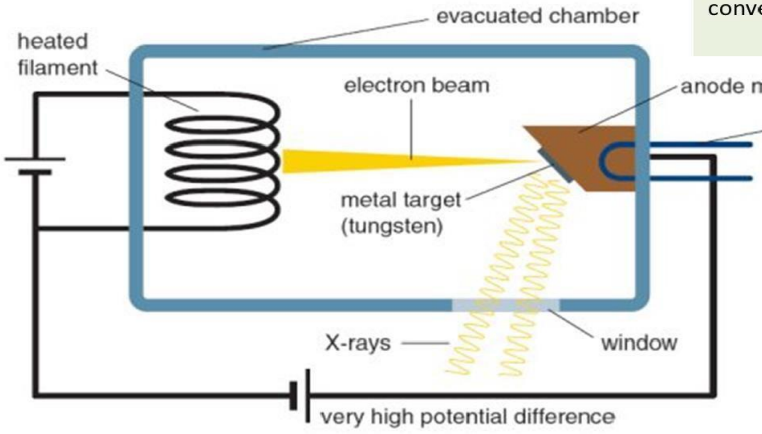
The Xscope-3000 x-ray inspection system incorporates an x-ray off timer that will turn off the x-rays if the sample stage and/or power controls are not moved for five minutes.



Components of an X-ray tube

X-rays are produced when electrons that have been accelerated using a high voltage source are abruptly decelerated by interacting with a metal target

1% of the electron's kinetic energy is converted to x-ray energy, the other 99% is lost as heat



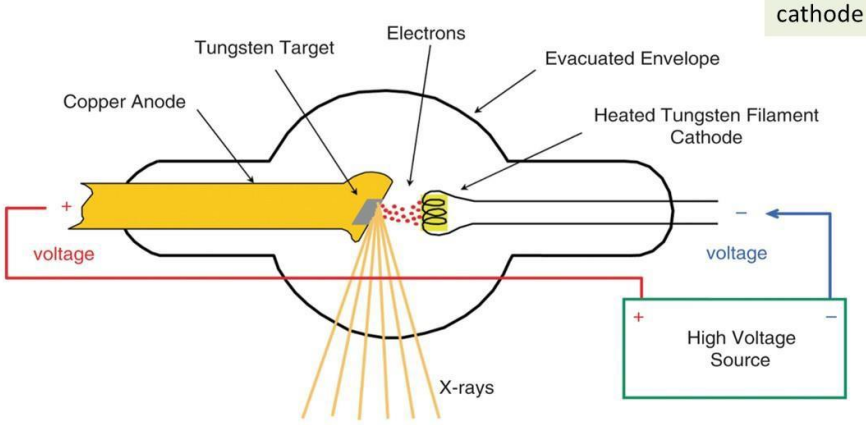
Copper heat sinks and coolant may be used to manage the excess heat

Components of an X-ray tube

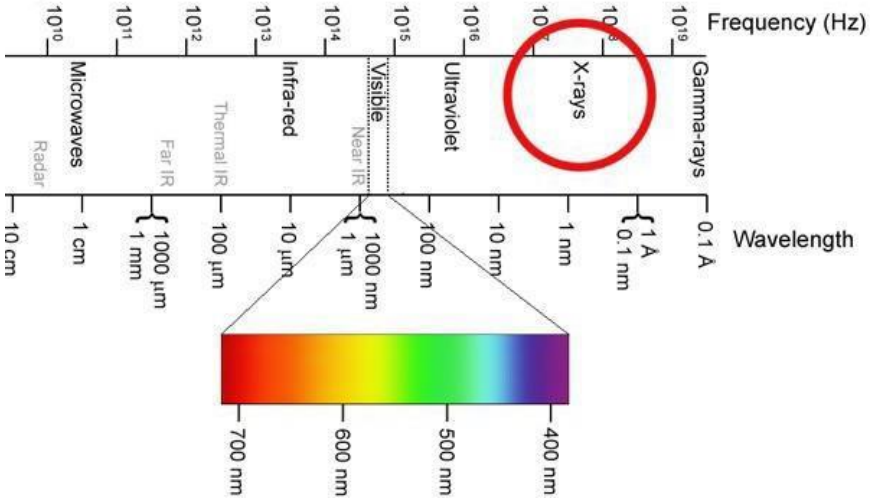
The mechanisms by which the kinetic energy of the electron is converted to x-ray radiation are called Bremsstrahlung and Characteristic x-rays. These mechanisms produce a spectrum of x-ray energies. The theoretical maximum x-ray photon energy produced is equal to the voltage on the x-ray tube.

Common metals used as the target in the anode include W, Cu, Mo.

Tungsten is also used in the cathode filament.



X-ray are only present when power is applied to the x-ray tube



8.5 RADIATION SAFETY PROCEDURE

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For information, please write, call, or email Scienscope at:

Scienscope
Tel: 909-590- 7273
Email: XscopeSupport@Scienscope.com

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Organization and Administration
Document the delegation and responsibility for each aspect of the radiation program and provisions for ensuring enforcement of radiation safety policies and procedures.

Fundamental Concepts of X-Ray Radiation
What is Radiation?
Radiation is everywhere around us. It is in the air we breathe, the foods we eat and the water we drink. We are exposed to radiation in the building materials of our homes and offices, the common medical practices most of us follow and even recreational activities like going to the beach or flying on an airplane to a vacation destination.
The naturally occurring radioactivity commonly referred to as "background", can vary greatly from one area of the world to another due to elevation and geographical properties. For instance, people in Denver, Colorado can receive two to four times more cosmic radiation than people in the Midwest. Likewise, some parts of South America and China can receive 10 to 20 times as much radiation from Thorium and Uranium found in the ground.

Types of Radiation
Radiation is generally divided into two types:
Particulate Radiation
Electromagnetic Radiation
Particulate radiations are actually small particles, which have mass, and in most cases an electric charge, which transfer energy from one point to another. Particles, by transferring there energy to atoms, can cause ionization, light and heat; therefore, they can be detected by using instruments such as ionization chambers, photo multiplier tubes or Geiger counters. The more common particles are Alpha, Beta, Neutron, Proton, Electron, and Positron. Gamma rays and X-rays are examples of electromagnetic radiation, and are composed of waves similar to

radio, heat, sound, and microwaves. One difference between these is the wavelength, with Gamma and X-rays being of a much shorter wavelength. Gamma rays originate from the nucleus of the atom, whereas X-rays are a product of interactions with the outer shells of electrons of the atom.

Radiation Safety Officer (RSO)

The Radiation Safety Officer is responsible for:

1. Reviewing all proposals for use of x-ray producing devices and recommending action to the Radiation Safety Committee.
2. Inspecting facilities and equipment through radiation safety evaluations and monitoring all facilities in which radiation-producing equipment resides.
3. Ensuring all personnel have been adequately training and comply with the requirements of the (State and or Country) for operating x-ray producingdevices.
4. Prescribing special conditions and requirements as may be necessary for safe and proper use of all x-ray producing devices.
5. Acting as consultant in the design of all new facilities using x-ray producing devices for the purpose of providing protection against radiation exposure.
6. Preparing and disseminating information on radiation safety for faculty, staff, and students as necessary.
7. Authorizing, receiving, storing, and processing incoming x-ray producing devices.
8. Providing personnel monitoring services, including the reviewing and recording of commercially processed dosimeter reports.
9. Reviewing and performing lead apron/protective device evaluations and removing any devices that are not in compliance.
10. Reviewing completed medical physics testing and recommending action tothe various departments.
11. Preparing registration and certification amendments and technical renewals as well as acting as the primary contact for correspondence with state radiation control authorities on a timely basis.
12. Investigating incidents involving radiation exposures including overexposures, incidents, theft, loss of devices, and accidents.
13. Notifying the (State and or Country) Health Services of all reportable incidents including overexposures, theft, loss of x-ray producing devices and submitting reports as required.
14. Reacting to any situation that is imminently dangerous to life and health and/or not in compliance with regulatory standards or (Management) policy. Corrective actions shall include the authority to stop or shut down use of radiation producing devices until the situation is deemed safe by the Radiation Safety Officer.
15. Ensuringthat radiation doses are maintained as low as reasonably achievable (ALARA).
16. Maintaining records required by Management for inspection purposes.

Corrective Action

Items of non-compliance or deficiency noted during an evaluation, an inspection, or a walk through will generate corrective actions depending upon the severity of the deficiency noted. The following action will be taken:

1. Serious deficiency:

Any uncorrected deficiency deemed to be serious in the opinion of the Safety Specialist will be evaluated by the RSO. The RSO will establish a corrective action plan, which may include an on-site re-evaluation within a specified time period or additional training.

a. Failure by the department or supervisor to correct a serious deficiency within the time frame specified will result in an Escalated Deficiency Notification follow-up.

2. Other deficiencies: Other deficiencies observed will be followed up by an e-mail (preferred) or written notification to the respective department by the evaluating Safety Specialist. The evaluating Safety Specialist will retain documentation of this notification in the appropriate investigator file.

Ionization

One common effect of both Particulate and Electromagnetic radiation is the phenomena called Ionization. This event occurs when an orbital electron is dislodged from an atom and a positively charged atom is left behind. The dislodged electron is eventually captured in an orbit around another atom, and the original atom will capture another electron. This can result in chemical changes, especially in biological or organic materials.

radiation" in German. Bremsstrahlung occurs when high energy electrons are slowed down in the presence of the field of the atom.

The deceleration of the electron causes the release of energy in the form of x-rays.

Bremsstrahlung

The bremsstrahlung produced is proportional to the square of the energy of the accelerated electrons used to produce it, and is also proportional to the atomic number (Z) of the target (absorber). The x-rays from bombardment of a target with electrons are emitted as a continuous spectrum of different x-ray energies. Depending on the target, the spectrum will also have characteristic photon peaks, which result from displacement of electrons in the shell of the target atom. When an electron falls to an inner shell to fill a vacancy, a characteristic x-ray is produced. The energy of this x-ray is characteristic to the element that produced it. X-Ray Fluorescence (XRF) Analysis uses the energy of the characteristic x-ray to identify the particular elements in a sample.

BREMSSTRAHLUNG X-RAYS: Emitted in a Range of Energies up to the Initial Kinetic Energy of the Electron

Bremsstrahlung or Characteristic X-Rays

In an x-ray tube, x-rays are produced when a stream of electrons is accelerated from the cathode to an anode (target). The target is usually a high atomic number metal absorber, like tungsten, or a crystalline structure. High atomic number material is used because the large positive charge associated with it drastically changes the direction of the electrons coming towards it. This method of x-ray production is known as bremsstrahlung. Bremsstrahlung means "braking

Scienscope Cabinet X-Ray Systems

Scienscope builds, modifies and distributes industrial X-ray inspection systems. This radiation safety program concerns the protection of employees and public from the hazards associated with exposure to x-ray radiation. Radiation is produced in x-ray tubes powered by associated electronics. X-ray radiation is ONLY present when electrical current is applied to an x-ray tube. Conversely, when electrical current is removed from the x-ray tube, radiation fields are not present. Radiation produced from an energized x-ray tube is such that it cannot cause materials, in which it interacts, to become radioactive. Without electrical power to an x-ray tube there is no radiation hazard, there is only the potential for a hazard.
A person who is properly trained to activate an x-ray tube and produce x-ray radiation is referred to as an authorized user.

Measured Dose

The energy imparted to matter by ionizing radiation per unit mass of irradiated material.
The unit of absorbed dose is the RAD (Radiation Absorbed Dose). Radiation is measured in many different units, depending on the type of radiation and the material it is interacting with. The original radiation dose unit used was the Roentgen, and was defined as a specified electrical charge produced in a volume of dry air by X-ray or gamma radiation. The Radiation Absorbed Dose (RAD) is used for all types of radiation being absorbed in all types of matter, and is defined as the deposition of 100 ergs of energy per gram of matter. Since different types of radiation would produce different effects in tissue, the Relative Biological Effectiveness (RBE) was developed, and each type of radiation was tested to establish a Quality Factor (QF) number used in calculations from RAD to the Roentgen Equivalent Man (REM).

Dose Equivalent

The quantity used by regulatory agencies related to risk of biological damage to radiation workers from ionizing radiation. This quantity generally pertains to external exposure. It is the product of the absorbed dose in tissue and all other necessary factors at the location of interest.
The unit of dose equivalent is the REM. 1000 mrem = one rem. One RAD equals one REM for X-ray exposure to human tissue in current radiation protection standards.
For x-ray and gamma radiation, the QF is one, so the determination of REM is accomplished through the following formula:
For example, 1 REM = 1 RAD x 1RBE (QF factor of 1 for gamma and X-rays). These units are further broken down into milliREMs (mREM) and microREM (uREM). On many survey

instruments, the readings will be displayed as mR/hr, the R representing Roentgen, which for gamma and X-ray conversions is the same value as a REM. The Gray and Sievert are the same entities expressed in international units based upon a joule/kilogram of absorbed energy. The conversion equivalences are as follows:

REM = RAD x RBE
1 Gray = 100RAD
1 Sievert = 100REM
1 microGy = 100 microRAD
1 microSievert = 100 microREM

Dose Equivalent

The quantity used by regulatory agencies related to risk of biological damage to radiation workers from ionizing radiation. This quantity generally pertains to external exposure. It is the product of the absorbed dose in tissue and all other necessary factors at the location of interest. The unit of dose equivalent is the REM. 1000 mrem = one rem. One RAD equals one REM for X-ray exposure to human tissue in current radiation protection standards.

Occupational Exposure Limits

Extremity(HandorFoot)ExposureLimit50,000milliremperyear
WholeBodyExposureLimit5,000milliremperyear
ForRaditionWorkers
RegulatoryGuide8.13500millirempergestationperiod
InstructionConcerningPrenatalRadiation
MembersOfTheGeneralPublic100milliremperyear

ALARA

Scienscope is committed to keeping exposures to radiation ALARA (as low as is reasonably achievable). This means that every reasonable effort shall be made to maintain radiation exposures as far below the dose limits as practical. Each authorized user shall keep radiation exposures to themselves and others ALARA. Authorized operators should contact Scienscope 909-576-6869 Email: ghomas@scienscope.com if there any any questions or concerns regarding the safety of the Scienscope X-Scope X-Ray systems. The use of the X-Scope should be stopped if there are safety concerns and resume use after a determination has been made by a trained x-ray system technician.

Biological Effects

There are two major types of biological effects of radiation; genetic effects and somatic effects. The genetic effects are caused by radiation that can alter genes and may cause birth defects in future generations, but it is very difficult to pinpoint exact causes of mutations, or their original source. Genetic effects are the result of irradiation of the reproductive organs only. Somatic effects of radiation are those experienced by the individual, are the most obvious, and are of primary concern in radiation protection. These effects can be either acute or

delayed, noticed immediately by sickness or death or an increase in the probability that an individual may develop leukemia or cancer and a shortening of the expected life span. A number of factors control the severity of somatic effects:
Living cells can repair themselves as soon as damage occurs; therefore, the body can keep pace with a certain amount of radiation.
A person is good physical health can recover from a certain radiation dose quicker than a person in poor health.
The type of radiation and its penetration power. Gamma and X-rays can penetrate all the way through the body, whereas Beta particles and low energy radiation barely passes through the skin.
Exposure time and total dose. A person who receives 500 R in one day has less than a 50% chance of living; whereas that same dose over a period of two months would leave a person with a 90% chance of total recovery.

Exposure limits
The amount of radiation exposure a person receives is defined under the governing regulations of the United States. Some of the agencies that establish these levels are the NRC (Nuclear Regulatory Commission), CDRH (Center for Devices and Radiological Health [part of the FDA]), as well as state departments of health and safety. These agencies have agreed on the following radiation exposure limits, based on an occupational worker, 18 years or older, being exposed to these levels over their working lifetime and suffering no observable ill effects.
Whole body, blood forming organs, gonads 5,000 mRem/year
Lens of eye 15,000 mRem/year
Extremities and skin 50,000 mRem/year
General public 100 mRem/year
Pregnant Females 500 mRem/term

Cosmic radiation at sea level = 40 mRem/year
Living in a wood house = 35 mRem/year
Living in a concrete house = 50 mRem/year
Working outdoors for eight hours/day = 15 mRem/year
Food and water = 25 mRem/year
Each 1500 mile airline flight = 1 mRem/year
Each chest X-ray = 50-100 mRem
Each dental X-ray = 20 mRem

Radiation Dose Effects
As mentioned earlier, people occupationally exposed to radiation may receive up to 5,000 mRem/year, with no observable effects. For comparison, some doses (in a 24 hour period) and their effects are as follows:
Dose in Rads 15-20 No obvious effect, except in minor blood changes.
Dose in Rads 50 Vomiting and nausea for about one day, but no serious disability.
Dose in Rads 100 Vomiting and nausea for about one day, but no serious disability.

Dose in Rads 300 Vomiting and nausea on first day, followed by loss of hair, fever, hemorrhage, diarrhea.About 20 percent deaths within two to six weeks.
Dose in Rads 1000 Vomiting and nausea within four hours of exposure. Up to 100 percent deaths, due to secondary infection and damage to the bone marrow, blood system, and lymph system.10,000 No survivors, all people die within two days due to severe internal damage.
To give some understanding of these numbers, the following are some values of background readings, as mentioned earlier, that are naturally occurring all around us:

Open Beam Operation

Safety procedures for open beam operation of an industrial open x-ray system or a cabinet x-ray system for
manufacturing or service purposes, in which an individual could accidently place some part of the body into
the primary beam during normal operation.
Authorized trained service personnel should be the only individuals that perform work in an open beam
environment.
Service personnel may have a need to "defeat" a door interlock or access panel interlock tp perform service
or tests on the x-ray system.
Service personnel may defeat a system interlock only under the following conditions;
The facility Radiation Officer has been notified.
Only trained service personnel can defeat the interlocks and perform the required service.
The adjacent area must be secured with a barrier and warning signs posted.
Service personnel must wear dissymmetry body badges and ringdosimeters

Industrial x-ray beam hazards

The principle hazard from analytical x-ray equipment is a localized skin burn from direct exposure to the primary x-ray beam. Serious radiation exposure will result if a person accidently holds an x-ray tube while it is energized. A local radiation burn could occur within 1-2 seconds if contact is made with the primary beam near the x-ray tube exit window. Symptoms of a localized radiation burn could take several weeks to manifest; depending upon the dose and in extreme cases would require amputation of the fingers.
Leakage of the primary beam through voids in the shielding or leaks in the tube housing has the potential to result in an exposure exceeding the Regulatory limits, but is not likely to result in a noticeable injury to personnel.
Scattered radiation or secondary photons occur when photons bounce off of the sample or other irradiated material this scattered radiation can also cause exposures. These exposures would be well below levels that could cause injury.

Radiation Levels

Primary Beam at the X-Ray Tube Window, Several thousand rads per second, Extreamly Dangerous
Primary Beam at the end of a 10 cm Skin to Source Limiter, Several thousand rads per minute, Very

Dangerous
Scatter Radiation, less than 1 millirad per hour depending upon distance, Serious Conditions

Cabinet X-Ray System Regulations

In addition to the limits people are allowed to receive, occupationally or generally, there are also strict limits in place governing the allowable limits for X-ray machines to emit. The machines we manufacture are, by definition, "Cabinet X-ray Systems" and are designed to meet the associated regulations under the Code of Error! Reference source not found. which state that radiation emitted shall not exceed 0.5 mRem/Hr any point 5 cm from the outside of the cabinet. Scienscope imposes a limit of less than half the government limit, which puts our units at a maximum radiation emission of 0.2 mRem/Hr before we ship or install the x-scope x-ray systems. We do this as an added measure of safety and to adhere to limits set in Europe, as well as peace of mind for our customers. This self-imposed limit is carried out in the theory of ALARA (As Low as Reasonably Achievable), to avoid all unnecessary exposure based on the premise that all exposure carries a certain amount of risk, regardless of size or duration.

Radiation Detectors

There are many different measurement devices used to measure radiation, from ionization detectors, to Scintillation detectors, Geiger counters to proportional counters. We will discuss the primary meters used to survey the X-ray cabinets.

The Muller Geiger counter is used to primarily "find" a potential leakage of radiation, but should not be relied upon for exact dose measurement because of the way it is designed to work. Inside the counter, the central electrode is surrounded by positive and negative ions, of which the negative is swept away quickly. The remaining positive ions form a blanket, and until they dissipate, they cause a dead time where any additional radioactive particles entering the counter will not be read. GM radiation survey meters cannot be used to certify the radiation leak of a cabinet x-rays system, only ion chamber meters can be used to certify a cabinet x-ray system.

The ion chambers, on the other hand, have an enclosed cavity pressurized and filled with dry air that integrates the total charge collected on the central electrode in a given time, thus giving a reading in R/hr.

Food and Drug Administration (FDA) Compliance Scienscope must complete safety evaluations of manufactured or modified industrial cabinet x-ray machine before distribution. These safety evaluation documents (initial report) must be submitted to the FDA prior to distribution.

The safety tests to be performed are written in 21 CFR part 1020.40

TITLE 21 - FOOD AND DRUGS
CHAPTER I - FOOD AND DRUG ADMINISTRATION, DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER J - RADIOLOGICAL HEALTH
PART 1020 - PERFORMANCE STANDARDS FOR IONIZING RADIATION EMITTING PRODUCTS

1020.40 - Cabinet x - ray systems.

(a) Applicability. The provisions of this section are applicable to cabinet x-ray systems manufactured or assembled on or after April 10, 1975, except that the provisions as applied to x-ray systems designed primarily for the inspection of carry-on baggage are applicable to such systems manufactured or assembled
on or after April 25, 1974. The provisions of this section are not applicable to systems which are designed
exclusively for microscopic examination of material, e.g., x-ray diffraction, spectroscopic, and electron microscope equipment or to systems for intentional exposure of humans to x-rays.

(b) Definitions. As used in this section the following definitions apply: (1) Access panel means any barrier
or panel which is designed to be removed or opened for maintenance or service purposes, requires tools to
open, and permits access to the interior of the cabinet.

(2) Aperture means any opening in the outside surface of the cabinet, other than a port, which remains open during generation of x radiation.

(3) Cabinet x-ray system means an x-ray system with the x-ray tube installed in an enclosure (hereinafter
termed cabinet) which, independently of existing architectural structures except the floor on which it may be
placed, is intended to contain at least that portion of a material being irradiated, provide radiation attenuation,
and exclude personnel from its interior during generation of x radiation. Included are all x-ray systems designed primarily for the inspection of carry-on baggage at airline, railroad, and bus terminals, and in similar
facilities. An x-ray tube used within a shielded part of a building, or x-ray equipment which may temporarily
or occasionally incorporate portable shielding is not considered a cabinet x-ray system.

(4) Door means any barrier which is designed to be movable or opened for routine operation purposes, does not generally require tools to open, and permits access to the interior of the cabinet. For the purposes
of paragraph (c)(4)(i) of this section, inflexible hardware rigidly affixed to the door shall be considered part
of the door.

(5) Exposure means the quotient of dQ by dm where dQ is the absolute value of the total charge of the ions of one sign produced in air when all the electrons (negatrons and positrons) liberated by photons in a
volume element of air having mass dm are completely stopped in air.

(6) External surface means the outside surface of the cabinet x-ray system, including the high-voltage generator, doors, access panels, latches, control knobs, and other permanently mounted hardware and including the plane across any aperture or port.

(7) Floor means the underside external surface of the cabinet.

(8) Ground fault means an accidental electrical grounding of an electrical conductor.

(9) Port means any opening in the outside surface of the cabinet which is designed to remain open, during
generation of x-rays, for the purpose of conveying material to be irradiated into and out of the cabinet, or
for partial insertion for irradiation of an object whose dimensions do not permit complete insertion into the
cabinet.
(10) Primary beam means the x radiation emitted directly from the target and passing through the window of the x-ray tube.
(11) Safety interlock means a device which is intended to prevent the generation of x radiation when access by any part of the human body to the interior of the cabinet x-ray system through a door or access
panel is possible.
(12) X-ray system means an assemblage of components for the controlled generation of x-rays.
(13) X-ray tube means any electron tube which is designed for the conversion of electrical energy into x-ray
energy.
(c) Requirements (1) Emission limit. (i) Radiation emitted from the cabinet x-ray system shall not exceed an
exposure of 0.5 milliroentgen in one hour at any point five centimeters outside the external surface.
(ii) Compliance with the exposure limit in paragraph (c)(1)(i) of this section shall be determined by measurements
averaged over a cross-sectional area of ten square centimeters with no linear dimension greater than 5 centimeters, with the cabinet x-ray system operated at those combinations of x-ray tube potential,
current, beam orientation, and conditions of scatter radiation which produce the maximum x-ray exposure at
the external surface, and with the door(s) and access panel(s) fully closed as well as fixed at any other position(s) which will allow the generation of x radiation.
(2) Floors. A cabinet x-ray system shall have a permanent floor. Any support surface to which a cabinet x-ray
system is permanently affixed may be deemed the floor of the system.
(3) Ports and apertures. (i) The insertion of any part of the human body through any port into the primary
beam shall not be possible.
(ii) The insertion of any part of the human body through any aperture shall not be possible.
(4) Safety interlocks. (i) Each door of a cabinet x-ray system shall have a minimum of two safety interlocks.
One, but not both of the required interlocks shall be such that door opening results in physical disconnection
of the energy supply circuit to the high-voltage generator, and such disconnection shall not be dependent upon any moving part other than the door.
(ii) Each access panel shall have at least one safety interlock.

(iii) Following interruption of x-ray generation by the functioning of any safety interlock, use of a control provided in accordance with paragraph (c)(6)(ii) of this section shall be necessary for resumption of x-ray
generation.
(iv) Failure of any single component of the cabinet x-ray system shall not cause failure of more than one
required safety interlock.
(5) Ground fault. A ground fault shall not result in the generation of x-rays.
(6) Controls and indicators for all cabinet x-ray systems. For all systems to which this section is applicable
there shall be provided: (i) A key-actuated control to ensure that x-ray generation is not possible with the key
removed.
(ii) A control or controls to initiate and terminate the generation of x-rays other than by functioning of a
safety interlock or the main power control.
(iii) Two independent means which indicate when and only when x-rays are being generated, unless the x-ray
generation period is less than one-half second, in which case the indicators shall be activated for one-half
second, and which are discernible from any point at which initiation of x-ray generation is possible.
Failure of a single component of the cabinet x-ray system shall not cause failure of both indicators to perform
their intended function. One, but not both, of the indicators required by this subdivision may be a millimeter labeled to indicate x-ray tube current. All other indicators shall be legibly labeled X-RAY ON.
(iv) Additional means other than millimeters which indicate when and only when x-rays are being generated, unless the x-ray generation period is less than one-half second in which case the indicators shall
be activated for one-half second, as needed to ensure that at least one indicator is visible from each door,
access panel, and port, and is legibly labeled X-RAY ON.
(7) Additional controls and indicators for cabinet x-ray systems designed to admit humans. For cabinet xray
systems designed to admit humans there shall also be provided: (i) A control within the cabinet for preventing and terminating x-ray generation, which cannot be reset, overridden or bypassed from the outside of the cabinet.
(ii) No means by which x-ray generation can be initiated from within the cabinet.
(iii) Audible and visible warning signals within the cabinet which are actuated for at least 10 seconds immediately prior to the first initiation of x-ray generation after closing any door designed to admit humans.
Failure of any single component of the cabinet x-ray system shall not cause failure of both the audible and
visible warning signals.
(iv) A visible warning signal within the cabinet which remains actuated when and only when x-rays are

being generated, unless the x-ray generation period is less than one-half second in which case the indicators
shall be activated for one-half second.
(v) Signs indicating the meaning of the warning signals provided pursuant to paragraphs (c)(7) (iii) and (iv)
of this section and containing instructions for the use of the control provided pursuant to paragraph (c)(7)(i)
of this section. These signs shall be legible, accessible to view, and illuminated when the main power control
is in the on position.
(8) Warning labels. (i) There shall be permanently affixed or inscribed on the cabinet x-ray system at the
location of any controls which can be used to initiate x-ray generation, a clearly legible and visible label bearing the statement: Caution: X-Rays Produced When Energized (ii) There shall be permanently affixed or
inscribed on the cabinet x-ray system adjacent to each port a clearly legible and visible label bearing the
statement: caution: Do Not Insert Any Part of the Body When System is Energized X-ray Hazard (9) Instructions. (i) Manufacturers of cabinet x-ray systems shall provide for purchasers, and to others upon
request at a cost not to exceed the cost of preparation and distribution, manuals and instructions which shall
include at least the following technical and safety information: Potential, current, and duty cycle ratings of the
x-ray generation equipment; adequate instructions concerning any radiological safety procedures and precautions which may be necessary because of unique features of the system; and a schedule of maintenance
necessary to keep the system in compliance with this section.
(ii) Manufacturers of cabinet x-ray systems which are intended to be assembled or installed by the purchaser
shall provide instructions for assembly, installation, adjustment and testing of the cabinet x-ray system adequate to assure that the system is in compliance with applicable provisions of this section when assembled,
installed, adjusted and tested as directed.
(10) Additional requirements for x-ray baggage inspection systems. X-ray systems designed primarily for
the inspection of carry-on baggage at airline, railroad, and bus terminals, and at similar facilities, shall be
provided with means, pursuant to paragraphs (c)(10) (i) and (ii) of this section, to insure operator presence
at the control area in a position which permits surveillance of the ports and doors during generation of x-radiation.
(i) During an exposure or preset succession of exposures of one-half second or greater duration, the

means provided shall enable the operator to terminate the exposure or preset succession of exposures at
any time.
(ii) During an exposure or preset succession of exposures of less than one-half second duration, the means
provided may allow completion of the exposure in progress but shall enable the operator to prevent additional
exposures.
(d) Modification of a certified system. The modification of a cabinet x-ray system, previously certified pursuant to 1010.2 by any person engaged in the business of manufacturing, assembling or modifying cabinet x-ray systems shall be construed as manufacturing under the act if the modification affects any aspect of the system's performance for which this section has an applicable requirement. The manufacturer
who performs such modification shall recertify and re identify the system in accordance with the provisions of
1010.2 and 1010.3 of this chapter.
[39 FR 12986, Apr. 10, 1974]
Read more: http://cfr.vlex.com/vid/1020-40-cabinet-ray-systems-19716362#ixzz0npmSnkiW

Time, Distance, Shielding

Time, distance and shielding are vital components to radiation safety, and should be kept in Mind when working with the machines. Keeping in mind the federally allowable dosage for an occupational worker of 5,000 mR/year to the whole body, the following are some examples of exposure doses and how distance and time factors into the equation. X-rays, which are energy in wavelengths much like light, are applicable to the inverse square law, which states the intensity (measured dose) is proportional to 1/R2, where R is distance.
Some examples:
.25 mR/Hr at the surface, the dose at 2 feet = .0625 mR/Hr
4 feet = .0156 mR/Hr
6 feet = .0069 mR/Hr
0.5 mR/Hr at the surface, the dose at 2 feet = .1250 mR/Hr
4 feet = .0312 mR/Hr
6 feet = .0138 mR/Hr
5 mR/Hr at the surface, the dose at 2 feet = 1.250 mR/Hr
4 feet = .3125 mR/Hr
6 feet = .1388 mR/Hr
It is important to note that the last example is ten times the allowable Federal limit, so that represents a substantial leak, which would have to come from a major incident or intentional disregard for safety procedure. Some examples of this would be physically bypassing X-ray interlocks and generating with the doors open to the cabinet, or puncturing a hole through the cabinet with a fork lift, or incidents along those lines. Under normal operating conditions the x-ray system should never emit more than the 0.5 mR/Hr.
It is also important to remember that time plays a major role in exposure dosages. All the

readings are calculated as mR per hour, so the less time spent in the leakage area can further lessen the exposure dose.
Some examples:
0.25 mR/Hr is equal to 0.0041 mR per minute
0.5 mR/Hr is equal to 0.0083 mR per minute
5 mR/Hr is equal to 0.0830 mR per minute
Radiation Protection - External Sources
Time Minimize the time near a radiation source, reduce your exposure to radiation.
Distance Radiation levels decrease by the inverse square law. If you double your distance from an x-ray source the radiation level drops by a factor of four.

Shielding Lead, Steel, Stainless Steel, copper or any dense material including water.
Thickness of lead (mm) required for a primary beam barrier located 5 cm from the focal spot.
Anode Current kV
mA 50 kV 70 kV 100 kV
20 1.5 mm 5.6 mm 7.7 mm
40 1.6 mm 5.8 mm 7.9 mm
80 1.6 mm
160 1.7 mm

Personal Radiation Monitoring - Dosimeters

The personal monitoring devices Scienscope recommends are called Dosimeters. The control badge is kept in an office away from the x-ray system, the actual measurement badge is affixed to the x-ray system near the operator control panel. Both badges are collected and tested quarterly, and are the foremost record kept concerning potential exposure and dosage.
Most State radiation control regulations require employees to issue dosimeters to individuals who are likely to receive more than 10% of permissible occupational radiation exposure. Occupational radiation exposure to individuals who work near or around energized x-ray tubes is usually much less than 10% of permissible limits; however, due to the severity of x-ray exposure from direct exposure to x-ray tube radiation, both finger and whole body dosimeters are required for any person who tests x-ray systems. Dosimeters can be changed quarterly unless there is a reason to suspect an accidental exposure, then they must be submitted immediately for a rush processing.
Dosimeter Reports
The RSO shall review all radiation exposure reports to ensure occupational exposure limits are not exceeded and conduct formal and informal investigations as needed. The RSO shall initial

and date each exposure report to indicate the review was conducted.
Record Keeping
Records related to occupational exposure to radiation must be retained indefinitely.
Records related to internal audits, surveys, inventories, training, and another safety program documentation must be kept for a period of three (3) years.
Disposition of X-Ray Machines
The Radiation Safety Officer shall approve the transfer, relocation, or storage of X-ray producing equipment. X-ray equipment that is to be stored must be secured against unauthorized use and modified so
that it cannot be inadvertently energized. The X-ray tube maybe removed, or the current or voltage supplies
removed or some other modification that renders the equipment powerless so that an unauthorized person
cannot energize a connected x-ray tube.
Primary Beam Barrier

Requirements for Authorized Users
Authorized Users shall be responsible for the working conditions and for the safety instruction of all persons working in the area. Shields, interlocks, and other safety devices shall be used when the assembled industrial x-ray cabinet is operated. If interlocks must be defeated during assembly testing, the Authorized User shall be physically present and control radiation exposures by time, distance and shielding and shall use appropriate survey meters to ensure radiation levels at worker locations is less than 2 mR/hr.

Emergency Procedures
If a local radiation exposure is suspected, terminate the x-ray equipment immediately and contact the Radiation Safety Officer. If a radiation emergency occurs after regular working hours, contact the Radiation Safety Officer using this 24-hour telephone number:
24-hour phone number
Be prepared to submit your dosimeters for rush processing and to write a written description
Of the events leading to the incident. Follow up action will depend on the dosimetry reports.
Emergency contact information shall be posted in each x-ray test cell or area.
Summary
Radiation can be a very useful tool and when administered responsibly it can be very safe. Although radiation is naturally occurring around us, precaution and care should be a constant concern. Keep in mind the X-rays we generate are only present when the source is energized, and there is no residual radiation in the systems we produce and service.
There are some very important factors in keeping oneself safe from radiation, and these should be kept in mind and adhered to at all times.
Restrict the length of time you are exposed to a source of radiation, keeping it as short as possible. (applies to open sources not cabinet x-ray systems)
Maintain the greatest possible distance between yourself and the source of radiation as is practical. (applies to open sources not cabinet x-ray systems)

Place as much shielding material between yourself and the source of radiation. (applies to open sources not cabinet x-ray systems)
Wear your personal Dosimeter at all times, and return it monthly for evaluation.
Radiation emits energy that has the potential to damage living tissue. (applies to open sources not cabinet x-ray systems)

Dosimetry Program

All registrants are responsible for the protection of individuals that enter the registrants' controlled areas. The registrant is also responsible for ensuring that the public is protected and that the public dose does not exceed the limits found in 10 CFR 20.
Each facility must evaluate whether or not personnel monitoring for occupational exposures is required. If a facility chooses to or is required to monitor, then those who are occupationally exposed to radiation should be instructed in the following:
1. Types of individual monitoring devices used and exchange frequency.
2. Use of control badges.
3. Instructions to employees on proper use of individual monitoring devices, including consequences of deceptive exposure of the device.
4. Procedures for ensuring that the combined occupational total effective dose equivalent (TEDE) to any employees receiving occupational exposure at your facility and at other facilities does not exceed 5 rem per year
5. Procedures for obtaining and maintaining employees' concurrent occupational doses during that year.
6. Procedures for ensuring that if minors are employed, their occupational TEDE does not exceed 500 millirem per year
7. Procedures for addressing a declaration of pregnancy.
8. Procedures for maintaining documentation of dose to the embryo/fetus and associated documentation for the declared pregnant worker.

Area Monitoring and Control

∑
Radiation Area Monitoring
The need for area monitoring shall be evaluated and documented.
∑
Instrument Calibration and Maintenance
Instruments used to verify compliance with regulatory requirements must be appropriate for use and calibrated at required frequencies. Specify instruments to be used and procedures to verify conformity.
Maintenance of the machine should be addressed. This may be addressed in part by the operator's manual from the manufacturer.

Radiological Controls

∑

Entry and Exit Controls
Entry and exit from controlled areas must be adequate to ensure radiation safety.
Design of emergency escape routes shall comply with applicable building codes.
Document procedures addressing this requirement.
∑
Posting
Areas that are required to be posted should be identified in the Radiation Protection Program, in addition to procedures for ensuring that such areas are properly posted. Also, include procedures for ensuring that areas or rooms containing as the only source of radiation is posted with a sign or signs that read "CAUTION X-RAY". Identify who is responsible for maintaining those signs and/or labels. In addition, certain documents must be posted. This requirement is found in 17 CCR 30255(b).

Record Keeping and Reporting
All record keeping and reporting requirements are specified in regulations. Document the applicable requirements and commitments to compliance. The facility must also maintain all records of the Radiation Protection Program, including annual program audits and program content review. The following items should also be identified:
1. The person responsible for maintaining all required records.
2. Where the records will be maintained.
3. The format for maintenance of records and documentation.
4. Procedures for record keeping regarding additional authorized sites (mobile providers).

Registration of the X-Ray System
All States require that you register your x-ray system and pay an annual fee. All States will do an on-site inspection on a regular basis. The time frame between inspections varies with each state.
Registration is a simple process and the paperwork can be completed in less than a half hour. Most if not all States require that an Employee Notice be posted in a conspicuous place, the Employee Notice give employees phone numbers to contact the State Agency if they think the x-ray system is being used in an unsafe condition or is exposing employees.

Sample Radiation Machine Registration Form (State of California)

Print Form

State of California — Health and Human Services Agency

California Department of Public Health
Radiologic Health Branch

Registration (Facility) Number

RADIATION MACHINE REGISTRATION

*** IT IS RECOMMENDED THAT A PERSON WITH KNOWLEDGE OF THE MACHINE USE COMPLETE THIS FORM. ***

The California Code of Regulations (CCR), title 17, section 30185 states, "Every person possessing a reportable source of radiation shall register with the Department in accordance with the provisions of Sections 30119 through 30146." Every person (registrant) having physical possession or control of a radiation machine capable of producing radiation in the State of California shall complete a separate registration form for each installation within 30 calendar days of acquisition of each radiation machine. A radiation machine is any device capable of producing X-rays when its associated control devices are operated. Additionally, CCR, title 17, section 30115 states, "The registrant shall report in writing to the Department, within 30 days, any change in registrant's name, address, location of the installation or receipt, sale, transfer, disposal or discontinuance of use of any reportable source of radiation."

Please review the statements below. Identify all situation(s) that apply to you.

1. ☐ Yes ☐ No Our facility is a new radiography provider.

If you answer yes to any statement(s) (number 2 and/or 3), complete sections A, B, and D of this form.

2. ☐ Yes ☐ No Our facility has changed the name or the name under which we are Doing Business As (DBA).
3. ☐ Yes ☐ No Our facility's mailing address only has changed.

If you answer yes to any statement(s) (numbers 4 through 8), complete sections A, C, D, and E of this form.

4. ☐ Yes ☐ No This is a new facility that has never been registered with CDPH-RHB.
5. ☐ Yes ☐ No Our facility purchased or acquired a radiation machine(s).
6. ☐ Yes ☐ No Our facility has closed with no known buyer or lessee to-date.
7. ☐ Yes ☐ No One or more of our facility's radiation machines have been sold, disposed of, or rendered incapable of producing radiation.
8. ☐ Yes ☐ No One or more of our facility's radiation machines have a new serial number due to a component replacement.

If you answer yes to any statement(s) (number 9 and/or 10), complete **all sections** of this form.

9. ☐ Yes ☐ No This facility has been sold, leased or purchased. Date of sale, lease or purchase: _____
10. ☐ Yes ☐ No Our facility has moved.

[A] New or Existing Facility, or Seller's / Landlord's Facility Registration Information

(Please print legibly and complete all fields)

Taxpayer Identification Number **Registration (Facility) Number**

Name of Registrant (Person, e.g., Individual, Corporation, Partnership, Public or Private Institution, etc.)	Total Number of X-ray Tubes (operable to this facility registration)
Doing Business As (DBA), if applicable	Type of Business or Medical Specialty

Mailing Address of Registrant (number and street or PO Box)	City	State	ZIP Code
Address (Physical Location) of the X-ray Tube(s) (specific to this facility registration) ☐ Same as above	City	State	ZIP Code

Telephone Number of Registrant	Fax Number	E-mail Address
Contact Name (Responsible Individual)	Contact Title	Contact Telephone Number

RHB 251 (01/09)

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Radiation Safety Quiz

NAME:_____

DATE:_____

RADIATION SAFETY QUIZ

Circle the answer

Naturally occurring radiation is known as "standard" radiation.

True False

Gamma and X-rays are examples of electromagnetic radiation.

True False

Ionization occurs in both particulate and electromagnetic radiation.

True False

1 micro Gray = 10 RAD

True False

The whole body can have exposure of 15,000 mR/year.

True False

Radiation has the potential to damage living tissue.

True False

Particulate radiation is composed of waves, such as sound

True False

REM stands for Roentgen Equivalent Man

True False

100 REM = 1 Sievert

True False

Background radiation is:

Radiation scattered from an X-ray tube

Radiation absorbed from your front to your back

Naturally occurring radiation

The radiation you measure behind the machine

Somatic effects of radiation occur to:

The individual exposed

Someone who flies a lot

The children of the person exposed

Someone from Samoa

Three important factors to radiation protection are:

Clothing, eyewear, steel toe boots

Training, job description, money

Time, distance, shielding

Diet, exercise, no smoking

The general public shouldn't be exposed to more than:

20,000 mR/yr

7,342 mR/yr

100 mR/yr

13 mR/yr

Good physical health can help lessen the severity of somatic effects of radiation.

True False

ALARA stands for:

American League After Radiation Awareness

All Lemurs Are Rotten Animals

As Low As Reasonably Achievable

All Loud Alarms Represent Accidents

Radiation safety should be practiced:

Always

Radiation Safety Trainer Sign off
Name Date
Circle the correct answer.
The meter used to detect cabinet X-ray leakage:
Voltmeter
Survey Meter / Ion Chamber
Dosimeter
Thermometer
RAD stands for:
Radioactive All Day
Radiation Activated Detector
Reproduce All Drawings
Radiation Absorbed Dose

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