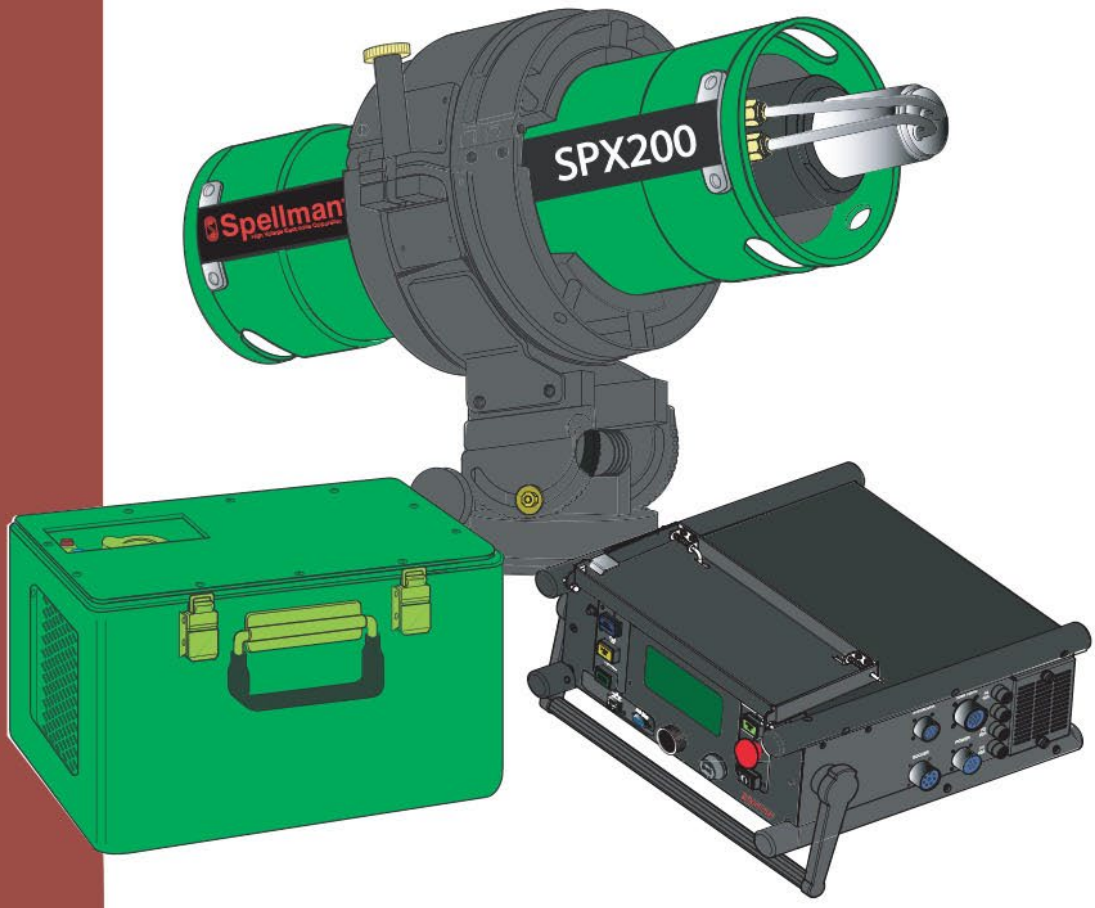
SPX SERIES X-RAY

INDUSTRIAL IMAGING SYSTEM

SPX SERIES SYSTEM MANUAL



Spellman®
High Voltage Electronics Corporation

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Chapter 1:

Introduction and General Information

Introduction

This manual describes the SPX series portable Industrial X-ray Unit and explains the procedures To properly set up, inspect operate and maintain

Intended Use

The SPX series is designed to meet the needs of the commercial NDT user. The system is intended for, but not limited to, the inspection of materials for:

- Defects
- Inclusions
- Cracks
- Corrosion
- Porosity

SYSTEM OVERVIEW

The SPX series can generate x-ray potential up to 160, 200 and 300 kilovolts (kV) and tube current up to 10 milliampers (mA). The maximum allowable dissipation is 800 watts for the SPX-160 and 900W for the SPX-200 and SPX-300. Maximum tube current is limited automatically by the Control unit to 10mA, or to a value that does not cause dissipation greater than rated power (watts) at a set kV level.

The system offers 100% duty cycle and consists of the following assemblies:

- The Control Unit
- The Tube Head
- The Cooling Unit, liquid cooled units only)
- The Electric Cooling Fan (air cooled units only)

These assemblies are described in detail next.

The SPX X-ray System

Figure 1-1

The Control Unit

The radiographer uses the Control Unit to set the radiographic exposure parameters, and to activate/deactivate x-ray emissions from the Tube Head. One hundred feet of cable is supplied with the system, which enables the Control Unit and operator to maintain a safe distance from the X-ray Tube Head during use.

The digital-based, micro-processor-regulated Control Unit houses all the system pushbutton operating controls, and exposure factor Vacuum Fluorescent Display (for display of exposure factors, a Message Vacuum Fluorescent Screen (for display of operating mode and system messages), and the circuitry required to provide power to the Tube Head and Cooling Unit.

The Control Unit is enclosed in a metal chassis and a handle is provided as a means of transporting it.

The Tube Head

The Tube Head is a cylindrical aluminum shell assembly housing the x-ray tube, the high voltage power supply and the filament supply. It is insulated with sulfur hexafluoride gas that is pressurized to 50 psi @ 70˚F. Power to operate the x-ray tube is supplied through a shielded cable that connects the Tube Head to the Control Unit. The x-ray tube is end-grounded, with an exposed anode that contains a beryllium window approximately 2 inches from the anode end. Built-in carrying handles are at each end of the Tube Head.

There are two Tube Head models available:

- Liquid-cooled
- Air-cooled

The liquid cooled Tube Head uses a separate Cooling Unit to dissipate anode heat. These models have a length of twin hoses attaching the Tube Head to the Cooling Unit. Air-cooled models have an electric cooling fan mounted at the end of Tube head. The fan is powered by an inter-connecting cable from the Control Unit.

The Cooling Unit (*liquid cooled units only*)

The Cooling Unit dissipates heat generated at the anode of the x-ray tube. Liquid coolant from a self-contained reservoir is pumped through one side of a twin hose assembly into the Tube Head. Coolant flows through a manifold in the Tube Head into the anode and returned to the Cooling Unit through the second half of the twin assembly.

Once in the Cooling Unit, coolant passes through a flow switch that is electrically interlocked with the Control Unit, and then through a filter to screen out contaminants. The coolant exits the filter and flows through a forced air radiator where the conducted heat is dissipated and then back into the reservoir.

An electric motor-driven fan and pump assembly circulates coolant and creates airflow through the radiator. Power is supplied via an interconnecting cable from the Control Unit. When properly connected to the system, the Cooling Unit is automatically activated by a switch circuit within the Control Unit.

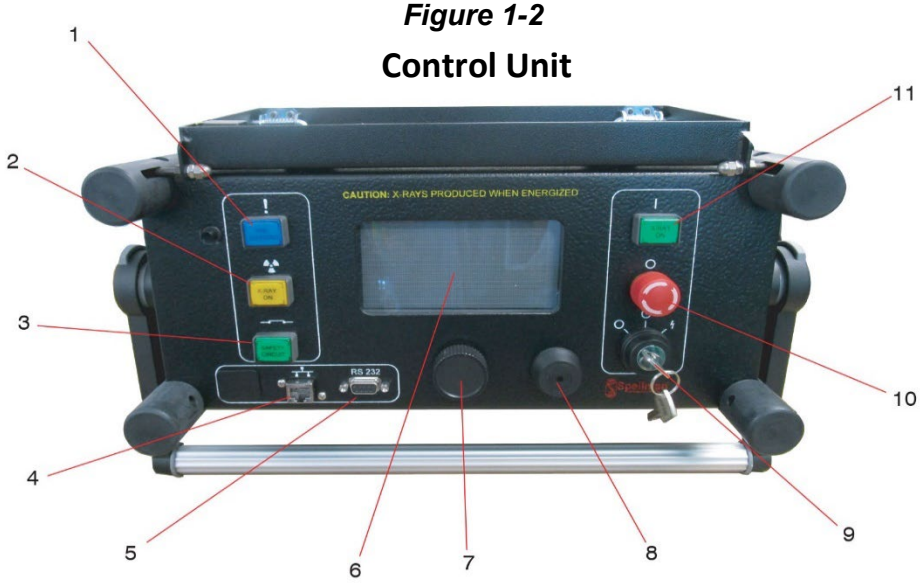
Legend – SPX X-ray System

Use the following legend as a reference for parts identification.

1. Pre-Warning Indicator
2. X-ray Indicator
3. Interlock Indicator
4. Ethernet Port
5. RS-232 Port
6. VFD Display
7. Rotary Dial
8. Buzzer
9. Key Control
10. E-Stop
11. X-ray On Button
12. Tube Head Coolant Hose Fittings
13. Tube Head Gas Pressure Gage
14. Tube Head Cable Connector
15. Tube Head Pressure Relief Valve
16. Tube Head Gas Fill Valve
17. Cooling Unit Coolant Hose Fittings
18. Cooling Unit Reservoir Cap
19. Cooling Power Connector
20. Nut Safety

Figure 1-2

Control Unit



Tube Head Assembly

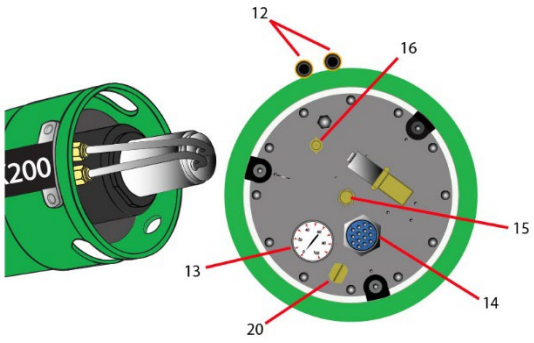


Figure 1-3

Cooling Unit

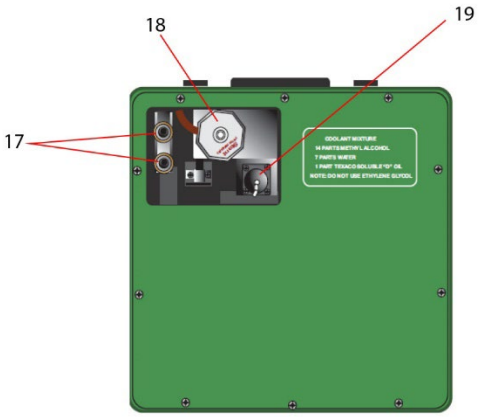


Figure 1-4

Manual Outline

This manual provides qualified radiographers and technicians with a means to logically inspect, operate and maintain the SPX series portable x-ray unit. The following paragraphs describe the arrangement of this manual and the information contained in each section.

Chapter 1:
Introduction and General Information

This section provides general information about the SPX series units. Included in this section is a safety summary.

Chapter 2:
Preparation for Use and Shipment

In this chapter, the user is provided instructions for unpacking and reshipment, along with equipment checklists and the basic specifications for assembly. Also included in chapter 2 are the locations of warning labels and I.D. tags.

Chapter 3:
Installing the SPX X-ray System

This chapter provides instructions making interconnections for both liquid cooled and air cooled units. It also includes a description of the various interlock connections.

Chapter 4:
SPX X-ray Controls and Indicators

Chapter 4 details the controls and indicators on the SPX Control Unit. Refer to this chapter during use for operational details.

Chapter 5:
SPX X-ray System Operation

The warm up and operating instructions for the SPX X-ray Unit is detailed in chapter 5. Included are descriptions of error messages.

Chapter 6:
Routine Upkeep and Care

This chapter covers preventative maintenance and care schedules for each assembly of the system. Included are procedures for pressurizing and refilling the Tube Head, cleaning the apparatus and various general care practices.

Safety Summary

When properly installed, maintained and operated, x-ray equipment can be used effectively and safely. If any component of the unit is incorrectly installed, operated by unqualified personnel, or the maintenance schedule has been neglected, it is a potentially dangerous apparatus.

Before operating or performing any maintenance on the SPX series, the user MUST have a thorough understanding of x-ray machinery, generation, high voltage potential and x-ray control. The user MUST understand all hazards associated with x-ray generation.

Read this “Safety Summary” completely and thoroughly to understand the contents. Read all of the safety warnings, cautions and notes throughout the manual prior to commencing any operating or maintenance procedures.

All operators and technicians MUST adhere to the following safety practices.

- Read and understand the x-ray protection warning published in the beginning of this manual.
- Read this manual in its entirety before operation or maintenance is performed.
- Understand all the procedures before operating the unit.
- Read thoroughly and understand completely all NOTE, CAUTION and WARNING statements before beginning operation or maintenance procedures.

Use the following summary as a checklist to assure comprehension of the safety indicators.

NOTE:
An essential operating procedure, condition or statement, must be observed to ensure proper understanding and operating of the system.

! CAUTION !
An operating or maintenance procedure, practice, condition, or statement, which, if not strictly observed, could result in damage to, or destruction of equipment.

! WARNING !
An operating or maintenance procedure, practice, condition, or statement, which, if not strictly observed, could result in injury to or death of personnel.

Radiation Hazard

This equipment generates X-radiation at levels that can be lethal. This unit must only be operated by personnel that are certified and experienced in industrial x-ray generation. All operators must also understand the characteristics of radiation and the associated dangers of exposure to primary, secondary, and residual sources of radiation.

Lethal Voltages

High power radiation sources depend upon the generation of extremely high, yet well-protected voltages. Under no circumstances should the operator access the interior of the Tube Head. Under no circumstances should the operator access the interior of the Control Unit or the Cooling Unit except for the procedures outlined in Section 5 of this manual.

Badges

All personnel who work around X-ray equipment must wear a functional exposure dosage indicator.

Radiation Protection

X-ray equipment must be operated within properly designated protective barriers. Otherwise, personnel must not approach closer than 100 feet from the Tube head, and in no cases cross the direct path of the primary beam.

Radiation Monitoring

After installation, re-installation, transporting, performing maintenance, and during all radiographic operations not within a radiation enclosure, a radiation survey should be performed.

Warm-Up Procedures

Explicit procedures are outlined for “running-up” high voltage with new equipment, equipment with a new tube, equipment that has been inactive for a period of time, and for daily use. These procedures must be strictly followed at all times.

Operation

Equipment must be operated at correct source voltage and frequency, and must never be left running unattended. The gas pressure in the Tube head must be checked to ensure it is within allowable limits before operating the unit. Never operate this apparatus if output voltage/current is unstable.

Cooling Unit Operation

Regularly check the coolant solution in the Cooling Unit to ensure:

- the coolant level is within specification
- the pump circulates the coolant properly
- the fittings, hoses, and coolant reservoir does not leak

Always allow the Cooling Unit, or the fan on air-cooled units, to run approximately 5 minutes after completion of x-ray generation.

Caution:
Cooling unit shipped without coolant. Cooling unit must be filled to the appropriate level prior to operation.

Care in Handling

Extreme care must be taken when handling this x-ray apparatus. Exercise caution when packing, unpacking, shipping, and while performing maintenance. Remember, the X-ray tube is durable but breakable: be sure to store and ship it in the upright position.

Chapter 2:

Preparation for Use and Shipment

UNPACKING INSTRUCTIONS

The SPX X-ray Unit is shipped in a single wooden container. To gain access to the unit, perform the following:

- Remove the top cover from the crate.
- Carefully lift each component from the container.
- Perform a thorough visual inspection on each component.

If damage to any component has occurred, immediately contact the carrier. Keep all damaged containers until the carrier completes an inspection by the carrier. If it is necessary to re-package and ship the unit, follow the instructions outlined under "Reshipment Guidelines".

Reshipment Guidelines

In the event that the SPX X-ray Unit must be transported or shipped, use the original wooden container and packaging material whenever possible. If the original shipping material is not available, comply with the following re-packing guidelines.

1. Construct a wooden shipping carton for the Tube head Assembly similar to the one in Figure 2-1. Build the carton so that the top can be completely removed to facilitate packing and unpacking.
2. Cushion the Tube head with 3" of shock absorbent, foam type, packing material (MINIMUM). This material MUST surround the assembly on all sides, including above and below the Tube head.
3. Affix supporting blocks to the bottom of the carton. Make sure the legs are positioned to accommodate a pallet jack as shown in Figure 2-1.
4. Pack the Control Unit in a container rated for 60 lbs. surround the Control Unit with a MINIMUM of "2" of shock absorbent packing material (sheet or loose type), including the top and bottom.
5. Pack the Cooling Unit in the same manner as the Control Unit.

! WARNING!
The coolant solution is a flammable substance and must be drained from the Cooling Unit's reservoir before it can be shipped.

Transporting the Unit

When transporting by commercial carrier (i.e., truck, rail, etc.), select the shipping method and carrier on the basis of safe shipment, especially when shipping the fragile Tube head Assembly. Distinctly mark the Tube head carton on all sides with labeling which provides the carrier the following information:

- Contents contains fragile glass instrumentation.
- Container is to be shipped in upright container only.

Customarily, the Tube Head is shipped via air, generally avoiding ground transportation if possible. When shipping via air, affix an additional label to the carton stating the following:

"Sulfur hexafluoride, non-flammable gas is present in limited quantities in one or more packages of this shipment. This is to certify that the above mentioned materials are properly classified, described, packaged, marked, and labeled, and are in proper condition for transportation according to the applicable regulations of the U.S. Department of Transportation."

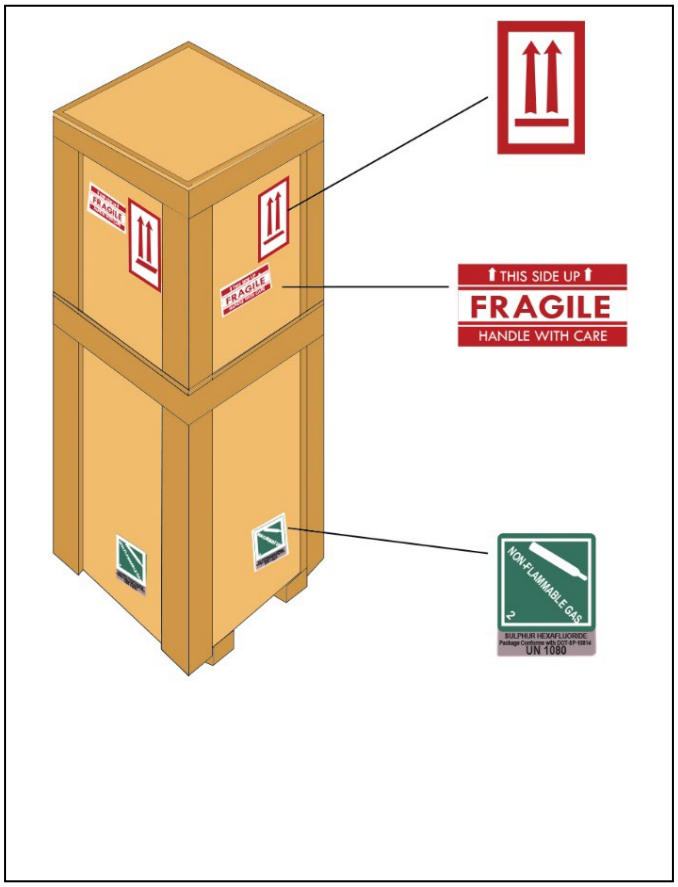


Figure 2-1
Tube Head Shipping Container

EQUIPMENT CHECKLISTS

The following checklists outline the standard and optional equipment of the SPX X-ray Unit. After unpacking the unit, and completing a thorough visual inspection, compare each item with this list to assure completeness.

Note that several Tube Head models are available. Verify that the Tube head shipped with your unit matches the model that was originally ordered.

Checklist – Tube Head

SPX-160

- Assembly, Tube Head* 3-000-0768-1
  Air Cooled Unit; 40° cone,
  Glass Insert
  Beryllium Window
- Assembly, Tube Head 3-000-0736-1
  Liquid Cooled; 40° cone,
  Glass Insert
  Beryllium Window
- Assembly, Tube Head 3-000-0772-1
  Liquid Cooled; 360°
  Panoramic, Glass Insert
  Beryllium Window

SPX-200

- Assembly, Tube Head* 3-000-3071-1
  Air Cooled Unit; 40° x 60°
  cone, Metal Ceramic Insert
- Assembly, Tube Head 3-000-3072-1
  Liquid Cooled; 40° x 60°
  cone, Metal Ceramic Insert
- Assembly, Tube Head 3-000-3073-1
  Liquid Cooled; 360° Panoramic
- Assembly, Tube Head 3-000-3258-1
  Air Cooled; 40° Cone
  Glass Insert
  Beryllium Window
- Assembly, Tube Head 3-000-3224-1
  Liquid Cooled; 40° Cone
  Glass Insert
  Beryllium Window

SPX-300

- Assembly, Tube head* 3-000-3192-1
  Air Cooled Unit;
  40° x 60° cone,
  1.5mm Focal Spot,
  1mm Beryllium
  Window
- Assembly, Tube head 3-000-3191-1
  Liquid Cooled; 40° x 60°
  cone, 1.5mm Focal Spot,
  1mm Beryllium Window

**** All Air Cooled Units are equipped with Fan Power Cable (p/n: 1-040A-0355). The liquid Cooling Unit is not equipped with this cable.***

Checklist - Standard Equipment

- Control Unit, Digital (1) 408574-001 (SPX160)
  408574-002 (SPX200)
  408574-003 (SPX300)
- Cooling Unit Assembly (1) 3-000A-0737
  (Liquid Cooled Units Only)
- Power Cable Assembly (1) 1-040-0341
  (3 Pin Connector, 25ft.) (SPX160,200,300)
- Control Cable Assembly (1)
  (14 Pin Connector, 100ft.) 1-040-0824 (SPX200,300)
  (10 Pin Connector, 100ft.) 1-040-0342 (SPX160)
- Cooler Power Cable (1)
  (Liquid Cooled Units Only)
  (8 Pin Connector, 50ft.) 1-040-0823
  (8 Pin Connector, 100ft.) 1-040-0342 (SPX160)
- Power Cable, Fan (1) 1-040-0355
  (Air Cooled Units Only, 100ft.)
- Interlock Jumper (1)
  (Dummy Plug) 305531-001

Checklist - Optional Equipment

MODEL NUMBER	DESCRIPTION
3-000-0754	SPX160/200 tubehead stand
3-000-0756	SPX300 tubehead stand
3-000-0792	Laser pointer for liquid cooled tube
K935	SPX160 Laser pointer for air cooled tube
K936	SPX200 Laser pointer for air cooled tube
K937	SPX200/300 Laser pointer for liquid cooled tube
K938	SPX300 Laser pointer for liquid cooled tube

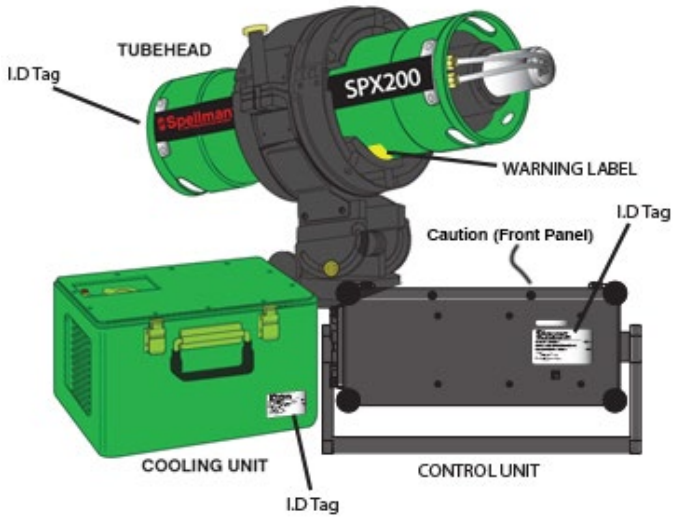


Figure 2-3

WARNINGS LABELS & CONTROL NUMBERS

Each assembly of the SPX X-ray System is equipped with an I.D. tag (Control Tag) providing the serial number, description, and part number. This data is used for identification, if warranty or service information is needed, and will be requested when contacting Spellman regarding the apparatus.

Attached to the Control Unit and Tube head are warning labels. Fig 2-3 illustrates the location of the I.D. tags and warning labels for each assembly of the SPX-systems.

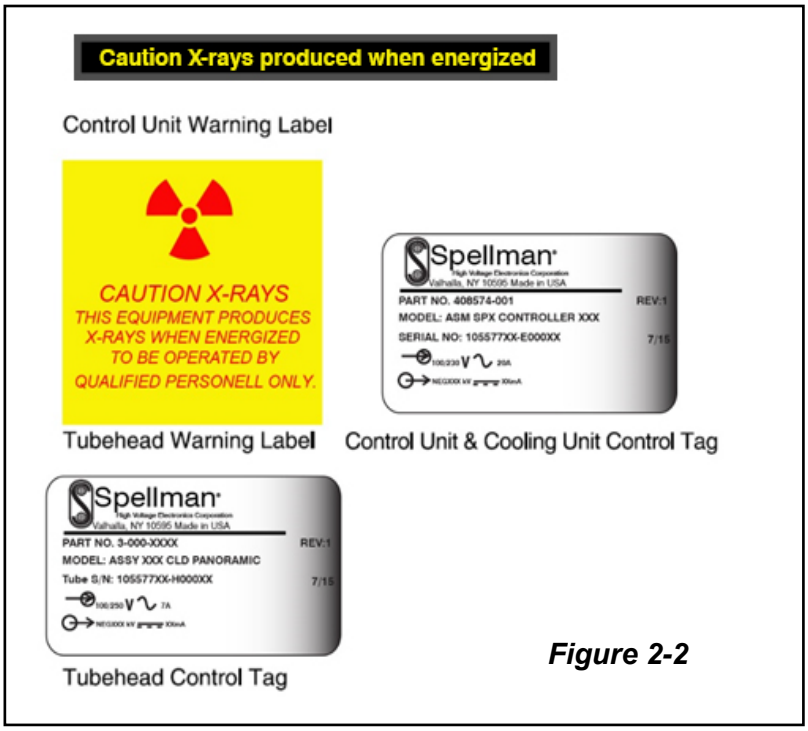


Figure 2-2

Laser Pointer

Tube Head Stand

Figure 2-4

Specifications - General System

The following outlines the general operating and environmental limits of the SPX- system.

- Line Voltage: 100 to 130 VAC - 50/60 Hz, 20amps (max.); or 200 to 250VAC - 50/60 Hz, 10 amps (max.).

  Line voltage selection is automatic. The system is operable from either line voltage range without any switch or jumper configuration.

- Operating Potential:

  SPX-160: 10kV to 160kV @ 0.5 to 5.0 mA, 800 Watts maximum

  SPX-200: 10kV to 200kV @ 0.5 to 10.0 mA, 900 Watts maximum

  SPX-300: 10kV to 300kV @ 0.5 to 10.0 mA, 900 Watts maximum

- Operating Temperature Range: 32°F to 120°F (Ambient), or 0°C to 49°C (Ambient)

- Humidity: 0 to 100% relative humidity

- Stabilization: kV and mA remain within 1% of set levels. Line voltage varied from 100-130/200-250 VAC.

- Storage Temperature Range _ -30°F to 160°F (-35C°C to 71°C)

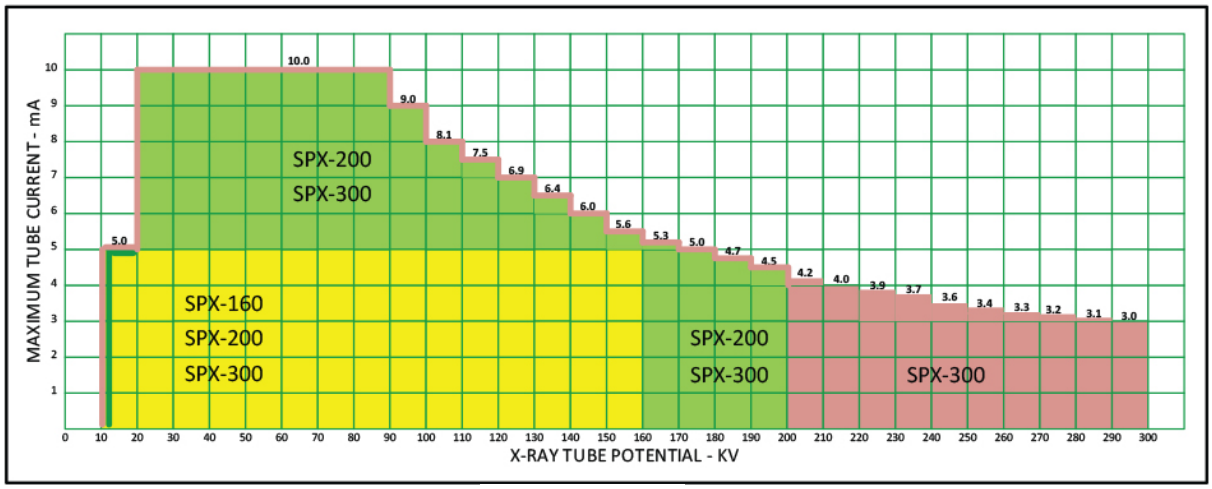


Figure 2-5

Specifications - General Tube Head

See Datasheet regarding the specifications of the Tube Head Assembly.

- Tube Pressure Sense : Monitors pressure of the SF6 gas within the Tube Head. Shuts unit down if pressure falls below 25 psi.
- Anode Thermal Sense: Monitors temperature of the X-ray Tube Anode. Shuts down unit if Anode temperature rises above 220°F.
- Pressure Relief Valve: Automatically releases SF6 gas from Tube Head if pressure rises between 75 - 80 psi.
- Pressure Gauge: Displays SF6 gas pressure within Tube Head. Used in conjunction with Temperature Compensation chart to visually inspect Tube Head pressure.

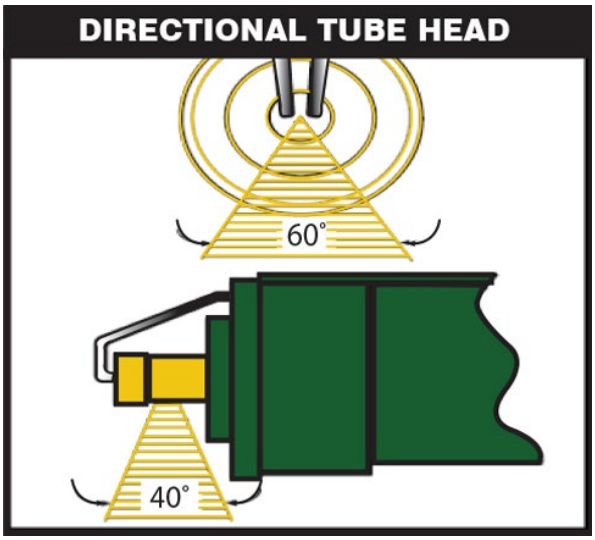


Figure 2-6

Specifications - Optional Tube Head

The information that follows furnishes the specifications for several available Tube Head assemblies. Figure 2-6 and 2-7 illustrate the direction of the X-ray beam for both the 40° x 60° cone and the 360° panoramic models.

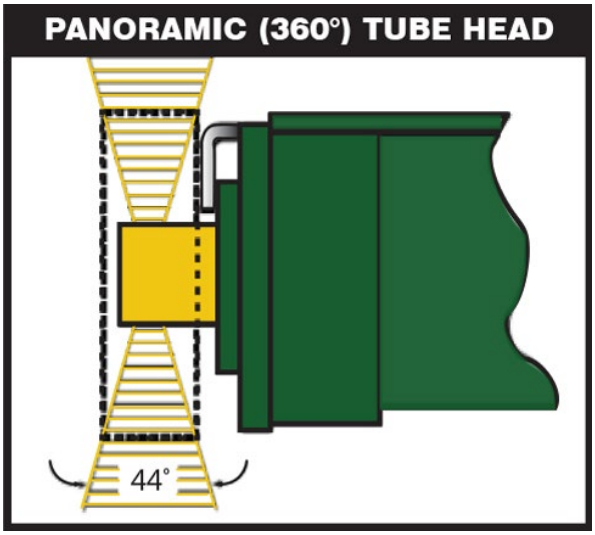


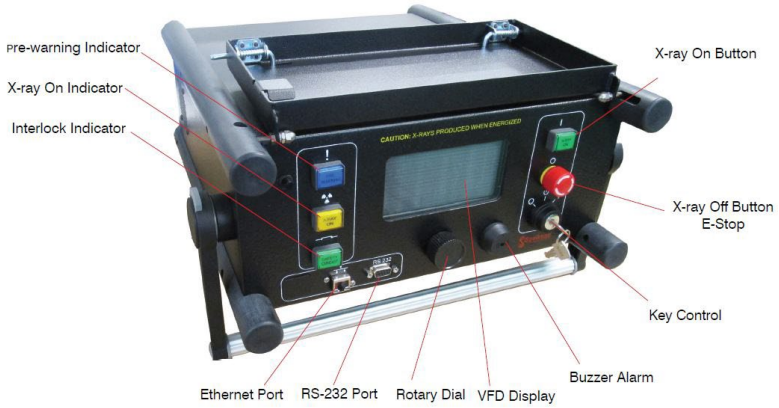
Figure 2-7

Specifications - Control Unit

Below are the physical and operating specifications of the Control Unit. Included are the physical dimensions, and the operating indicators and controls. The controls are explained in detail in other section of this manual.

- **Fluorescent Screen:** Display the set KV, mA level and show the feedback reading.
- **Decoder:** Used to navigate through the screens and to set KV, mA levels and time.
-
- **Control Key:** Turns on the unit in warm-up position and enables Cooler and high voltage circuit.
- **Buzzer:** Sounds alarm when X-ray activates.
- **Communication Ports:** Serial RS-232 and Ethernet.
- **X-Ray ON Switch:** Green Pushbutton switch with radiation symbol. Enables x-ray generation.
- **X-Ray OFF Switch:** Red Pushbutton E-Stop terminates x-ray generation. May be depressed any time x-rays are in use.
- **Pre-Warning Light:** Illuminates for 20 seconds max. to indicate that X-ray will be generated.
- **X-Ray ON Light:** Illuminates when x-ray ramps to the pre-set level. Remains on during normal operation until X-ray is turned off.
- **Safety Circuit Light:** Illuminates after all interlock circuits are closed. If light is off the controller will not allow x-ray generation.

Figure 2-8



Specifications - Cooling Unit

Below are the operating and physical specifications of the Cooling Unit.

- **Dimensions:** 12" H x 15" W x 14" L
- **Weight:** 55 lbs. (approximate)
- **Coolant Solution** : 14 parts methyl alcohol, 7 parts distilled water, 1 part soluble oil (Chevron Soluble “B”)
- **Coolant Flow:** 0.5 gallons per minute @ 50 foot-head.
- **Cooling Unit Connections:** Self-sealing quick disconnects.

Figure 2-9

Caution:
Cooling unit shipped without coolant. Cooling unit must be filled to the appropriate level prior to connecting the system.

Chapter 3:

Installing the SPX-X-ray System PRE-OPERATIONAL CHECKS & INSPECTION

The following paragraphs outline the steps to properly check and inspect the SPX- X-ray unit. Perform these procedures before setting up the system to ensure integrity.

Check – Tube Head Gas Pressure
This check verifies that the gas pressure inside the Tube head assembly is within limits. Note that Tube head gas pressure normally varies 1 psi for every 7°F increase or decrease in ambient air temperature.

! CAUTION !
DO NOT operate this unit if theTube Head Pressure is below 45 psig at 70°F or damage to the Tube Head may occur.

1. Check the Tube Head gas pressure gauge and verify that the gas pressure is within acceptable limits for the ambient temperature (see Figure 1-3).

2. If the gauge indicates Tube Head gas pressure below the acceptable limit, but greater than 5 psi, perform the procedures for “Pressurizing the Tube Head” (refer to section 7).

3. If Tube Head gas pressure is below 5 psi at 70°F, purge the Tube Head of all remaining gas, then perform the procedures for “Refilling the Tube Head” (see section 7-3).

Check - Cooling Unit
This check verifies the integrity of the Cooling Unit (liquid cooled Tube Heads only).

1. Inspect the twin hose assembly and hose connections for damage. The connector couplings must be firmly attached to the hose, and the hose must be free of punctures, frays, or dry rot.

2. Remove the Radiator cap on the Cooling Unit and check that the coolant level is within 1/2" from the top of the reservoir. Add coolant solution at this time if necessary (refer to figure 4-16).

Check - Control Unit
This check verifies the integrity of the Control Unit.

1. Perform a thorough visual inspection for damage.
2. Check the four connectors along the right side of the unit for foreign material and signs of corrosion.
3. Inspect the front panel controls for missing or broken switches and displays.

SYSTEM SET UP PROCEDURES

The procedures below describe the set up procedures for both SPX Unit configurations; liquid-cooled units, and air-cooled units. Use Figure 3-1 (liquid-cooled), or Figure 3-2 (air-cooled) as a reference while making the necessary system connections.

System Interconnections - Liquid Cooled

The following details the connections for setting up a liquid cooled SPX X-ray System.

! WARNING !
All cables MUST be connected to their appropriate connectors on the Control Unit, Cooling Unit, and Tube Head before applying power to the system.

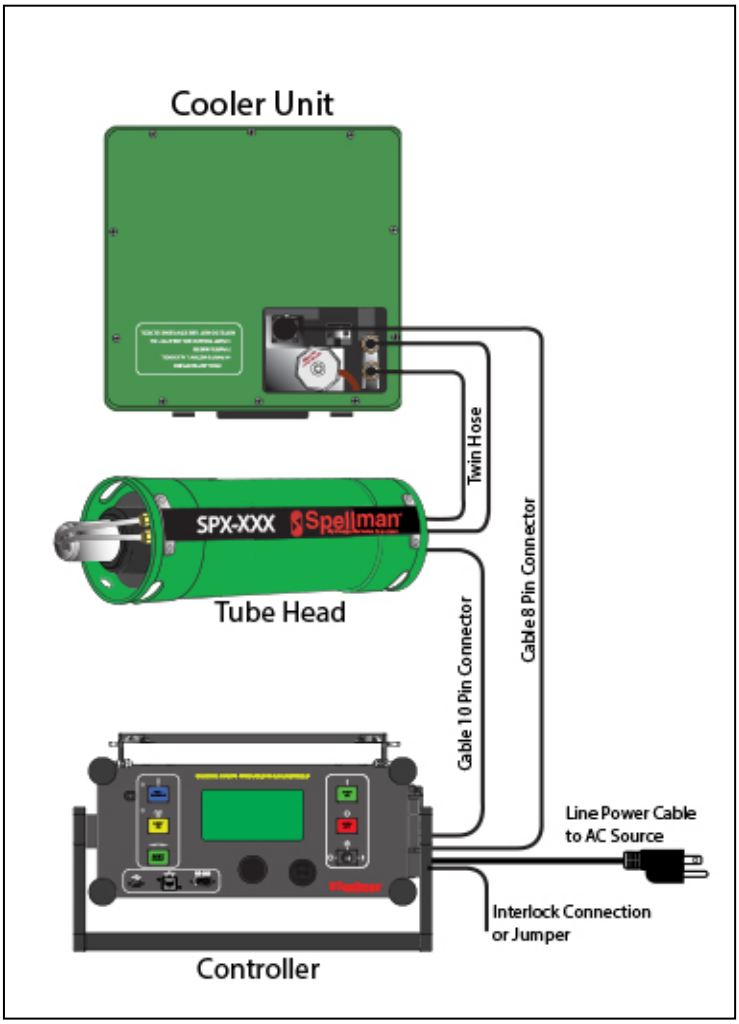
1. Connect the twin hose assembly between the Tube Head and the Cooling Unit:
   _ Attach the two angled couplings to the fittings on the back of the Tube Head.
   _ Attach the couplings on the opposite end to the female fittings on the Cooling Unit.

NOTE:
There is no designated left or right side to the twin hose assembly. If each coupling is properly seated, coolant flow through the Tube Head will be achieved.

2. Install the Cooling Unit power cable:
Connect the male end of the power cable to the connector labeled “Cooler” on the Control Unit.
Connect the female end of the power cable to the connector on the Cooling Unit.

3. Install the Tube Head Control cable:
Connect the male end of the Control cable to the connector labeled “Tube Head” on the Control Unit.
Connect the female end of the Control cable to the connector on the Tube Head base plate.
4. Install the line power cable:
Connect the female end of the line power cable to the connector labeled “Power” on the Control Unit.
Connect the “plug” end of the line power cable to the AC voltage source (see Connecting to Power instructions later in this section).
5. Make the External Interlock connection:
If available, connect the Interlock cable to the connector labeled “Interlock” on the Control Unit (see External Interlock instructions later in this section).
Connect the “jumper” (supplied) to the connector labeled “Interlock” on the Control Unit for units that do not employ an external interlock system.

Figure 3-1
SPX-System Setup *(Liquid Cooled)*



System Interconnections - Air Cooled

The following details the connections for setting up an air cooled SPX X-ray System.

! WARNING !
All cables MUST be connected to their appropriate connectors on the Control Unit, Cooling Unit, and Tube Head before applying power to the system.

1. **Install the Cooling Fan power cable:**
   - Connect the male end of the power cable to the connector labeled “Cooler” on the Control Unit.
   - Connect the female end of the power cable to the connector on the Tube Head base plate.
2. **Install the Tube Head Control cable:**
   - Connect the male end of the Control cable to the connector labeled “Tube Head” on the Control Unit.
   - Connect the female end of the Control cable to the connector on the Tube Head base plate.
3. **Install the line power cable:**
   - Connect the female end of the line power cable to the connector labeled “Power” on the Control Unit.
   - Connect the “plug” end of the line power cable to the AC voltage source (see Connecting to Power instructions later in this section).
4. **Make the External Interlock connection:**
   - If available, connect the Interlock cable to the connector labeled “Interlock” on the Control Unit (see External Interlock instructions later in this section).
   - Connect the “jumper” (supplied) to the connector labeled “Interlock” on the Control Unit for units that do not employ an external interlock system.

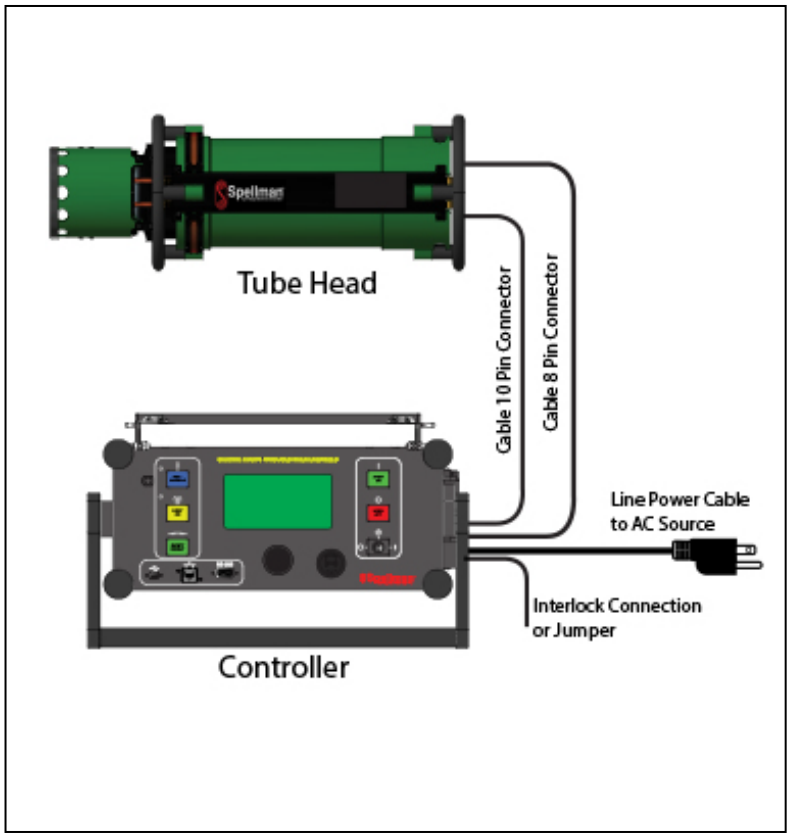


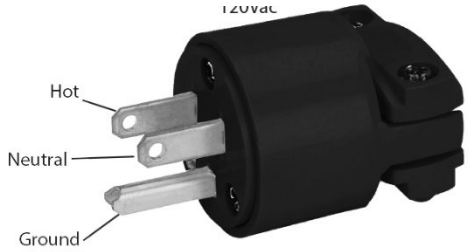
Figure 3-2
SPX-System Setup (*air-cooled*)

Connecting to Power

Note that the AC voltage source MUST be rated as either:

- 120 VAC, 20 Amps, 50/60 Hz
- 230 VAC, 10 Amps, 50/60 Hz

Figure 3-3



Ships with standard 120Vac Plug

External Interlock Connections

The Interlock connector on the side panel (J-4) of the Control Unit enables the interconnection of the x-ray enclosure doors and/or external warning devices with the internal safety interlock circuitry of the system. Figure 3-4 illustrates the two circuits provided for this purpose.

Pins A and B are used to connect the enclosure door switches. When pins A and B are properly connected, x-ray generation is only possible when the enclosure doors housing the Tube Head are closed. Note that pins “A” and “B” of the interlock connector must form a closed circuit to operate the X-ray unit. If no external switch interlocks are incorporated, a jumper connection is provided within the mating connector to form the closed circuit. Pin “B” connects to a “Fail Safe” circuit. A 24Vdc signal must be applied to pin “B” in order to enable x-rays.

Pins “D” and “E” provide a switch closure to operate a warning device such as a light for X-ray Pre-warning and Pins “C” and “D” operate a 24Vdc warning device such as a light for “X-ray On” when x-rays are being generated. The pre-warning operates for a specified amount of time before X-rays can be generated.

Pins “F” and “G” serve to confirm warning 24Vdc indicators are functional as a test for the operator. The signal can be configured high or low depending on the operator preference. Pin “G” supplies a +24V source.

Figure 3-4

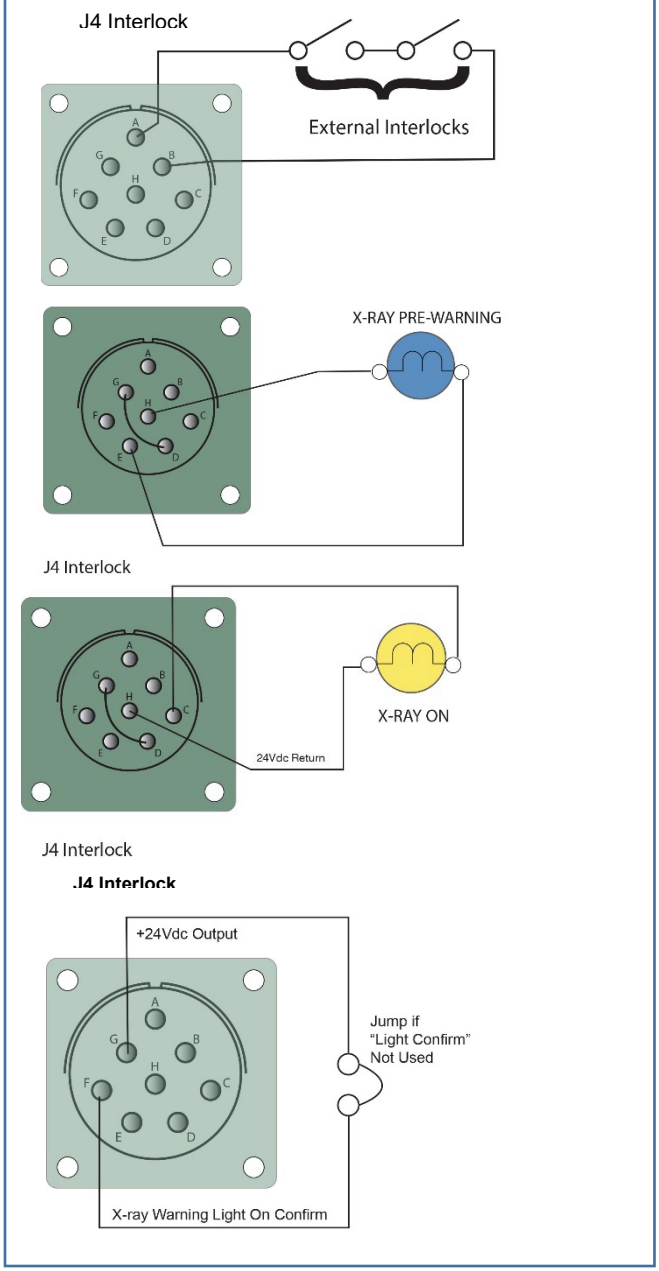


Figure 3-5

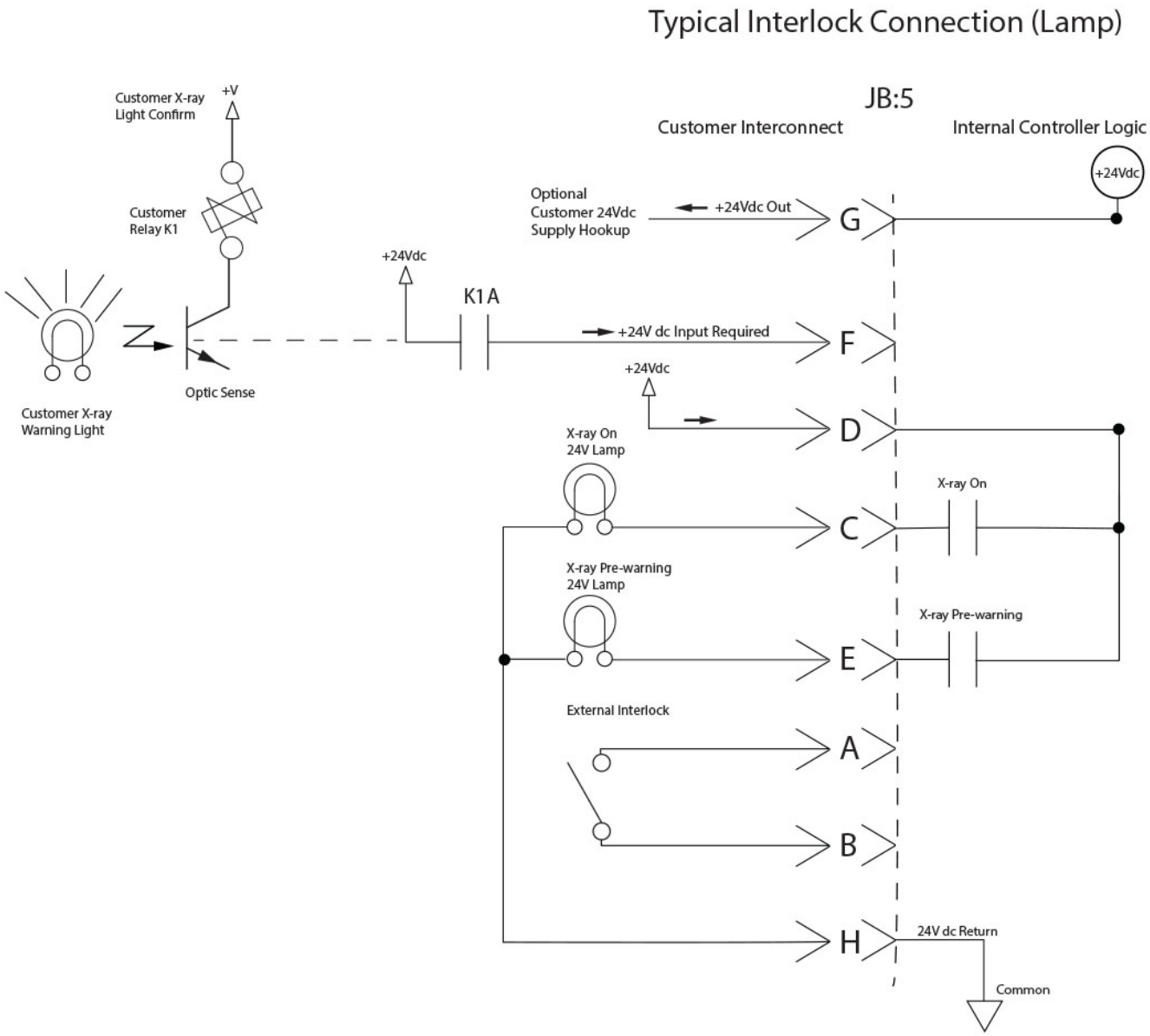
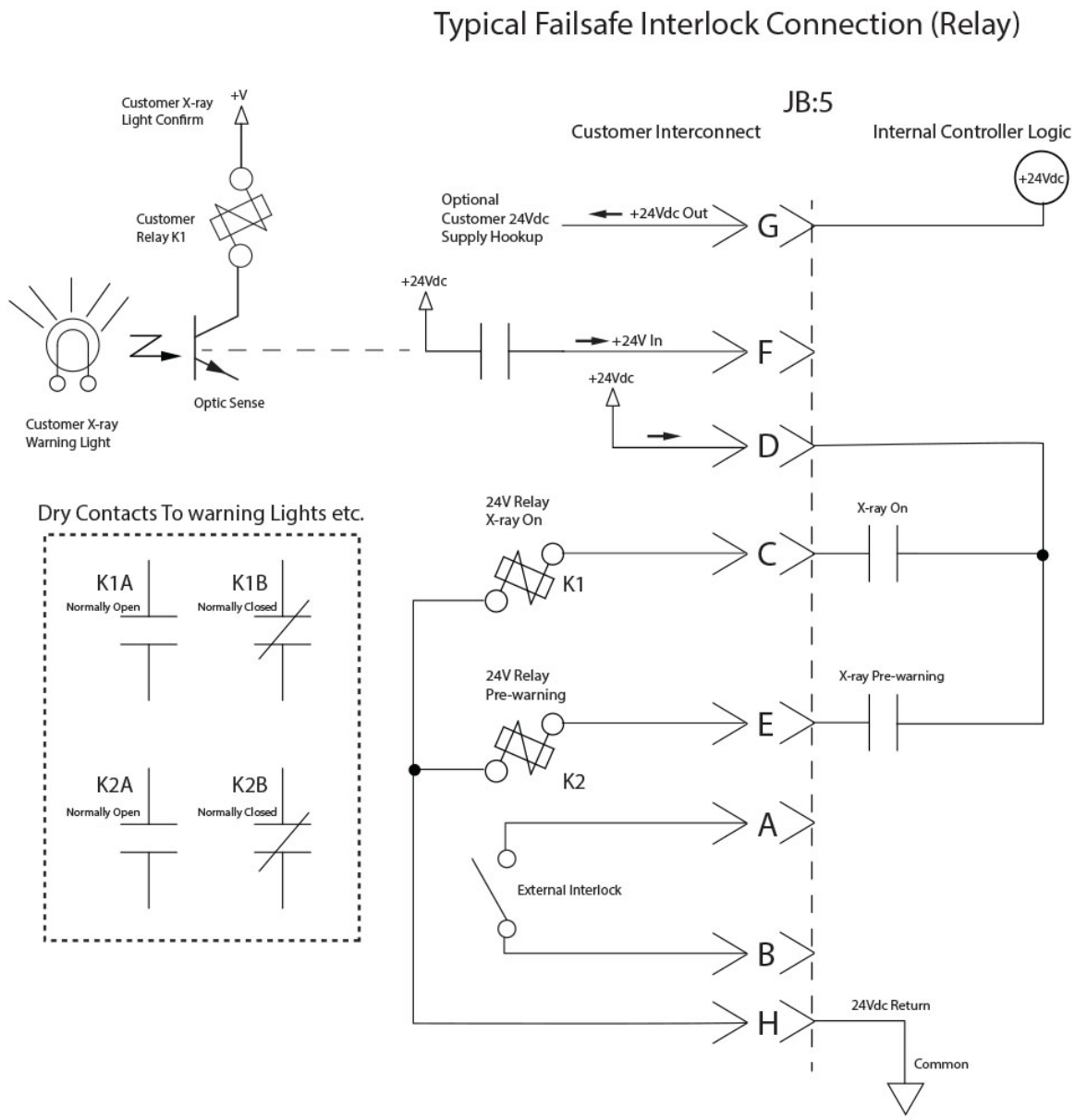

Typical Interlock Connection (Lamp)
JB:5
Customer Interconnect
Internal Controller Logic
Customer X-ray Light Confirm
+V
Customer Relay K1
Optic Sense
Customer X-ray Warning Light
+24Vdc
K1A
Optional Customer 24Vdc Supply Hookup
+24Vdc Out
+24V dc Input Required
+24Vdc
X-ray On 24V Lamp
X-ray Pre-warning 24V Lamp
External Interlock
X-ray On
X-ray Pre-warning
24V dc Return
Common
G
F
D
C
E
A
B
H

Figure 3-6


Typical Failsafe Interlock Connection (Relay)
JB:5
Customer Interconnect
Internal Controller Logic
Customer X-ray Light Confirm
+V
Customer Relay K1
Optic Sense
Customer X-ray Warning Light
Optional Customer 24Vdc Supply Hookup
+24Vdc Out
+24Vdc
+24V In
+24Vdc
+24Vdc
G
F
D
Dry Contacts To warning Lights etc.
K1A
Normally Open
K1B
Normally Closed
K2A
Normally Open
K2B
Normally Closed
24V Relay X-ray On
K1
X-ray On
C
24V Relay Pre-warning
K2
X-ray Pre-warning
E
A
External Interlock
B
H
24Vdc Return
Common

Chapter 4:

SPX Series Controls and Indicators

The front panel is the primary user interface for the SPX system. It includes a key switch, two buttons, 3 indicators, a buzzer, a command dial, with a VFD display. There are also three ports for communications with a PC.

Pre-Warning Indicator This blue indicator illuminates during the pre-warning time of an exposure.

X-Ray On Indicator-This yellow indicator illuminates during the exposure time.

Interlock Indicator -This green indicator illuminates indicating all safety interlocks are closed.

X-Ray On Pushbutton-This green push-button initiates an exposure.

X-Ray Off E-Stop -This red push-button terminates the exposure (manual mode).

Key Control- The key control has three positions:

Power Off -The system is off.

Power On- The system is powered on.

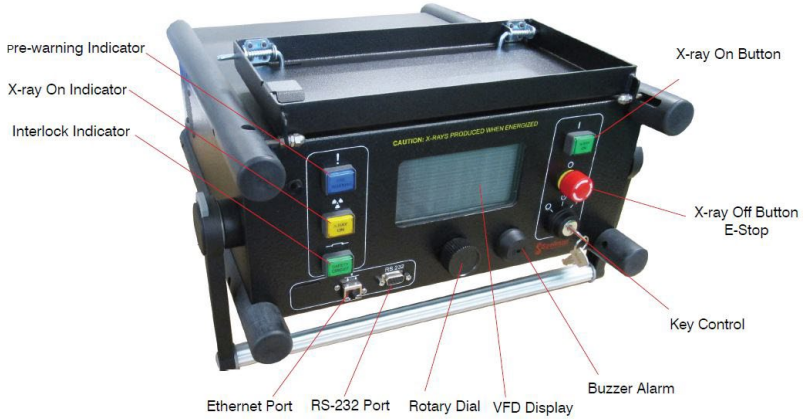
Energized- The Cooler and inverter/HV driver is energized, and the system is ready to enable high voltage

USB Port- Used for USB communications with a PC. A Micro B USB connector is required for the port. (*currently unavailable*)

Ethernet Port- Used for Ethernet communications with a PC.

RS-232 Port- used for serial communications with a PC.

***Figure 4-1*: SPX Front Panel Layout**



Buzzer- audibly indicates when an exposure is about to take place. It can be configured to beep once per second during a pre-warning, beep continuously during a pre-warning time, or be completely disabled.

Rotary Dial- primary user control for the SPX menu system. Turning the dial will select a function highlighted on the screen, and depressing the dial will execute that function.

VFD Display- primary display for system status and for operation of the system using the menu commands.

***Figure 4-2*: SPX Home Screen**

SPX Series Control Connections

The SPX Controller interfaces with all of the necessary power and signal cables for operation of the system. Each connector plug / receptacle identified with a label incorporates a dedicated military style connector for ease of connections.

Fuses- A set of 20 ampere fuses protect the main power circuitry while a set of 10 ampere fuses protect the cooler power circuitry A fan with an air filter circulates air within the chassis while the unit is in operation. Figure 4-3.

Controller Power Cable - Terminated with a 120V standard plug and a 3-pin Cannon connector (3106-16-10) that mates with the power input connector (J1). Figures 4-4 and 4-5.

Tube Head Interconnect Cable – Cable fitted with two military style connectors at a minimum of 100' in length (J3). Figures 4-6, 4-7, 4-8 and 4-9.

Cooler Power/ Interlock Cable – Provides power to the cooling unit for either air-cooled or water cooled units and monitors the flow rate in liquid cooled units to prevent overheating to the X-ray tube. (J2) Figures 4-10 and 4-11.

Interlock / Indicator Cable – Provides customer X-ray status indicators and system safety interlock connections. (J4) Figures 4-12 and 4-13.

Cooling Hose *(Liquid Cooled Units)* – Provides coolant flow between the Cooler Unit and the Tube Head. Figures 4-15 and 4-16.

Figure: 4-5 Power Input Cable

Figure: 4-3 **SPX Control Side Panel**

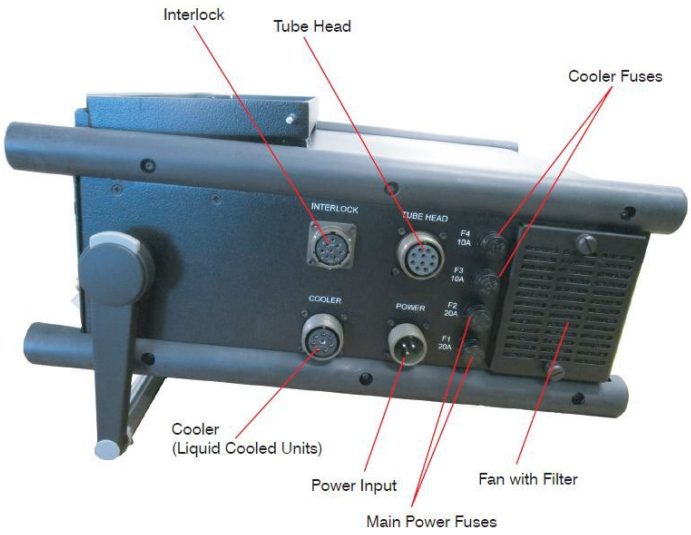
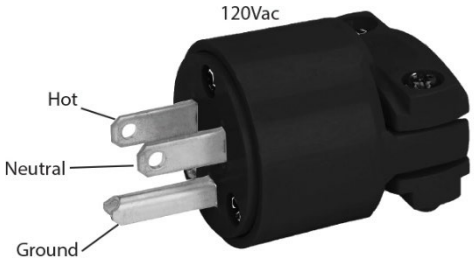
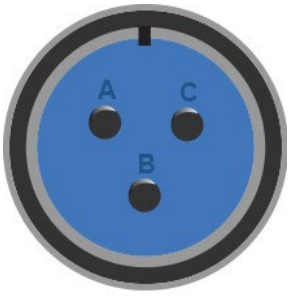


Figure: 4-4 **Power Cable Detail**





MS3102R16-10P

Figure: 4-6 Tube Head Power Cable

Figure 4-7 Tube Head 200kV/300kV 14 Pin Connector

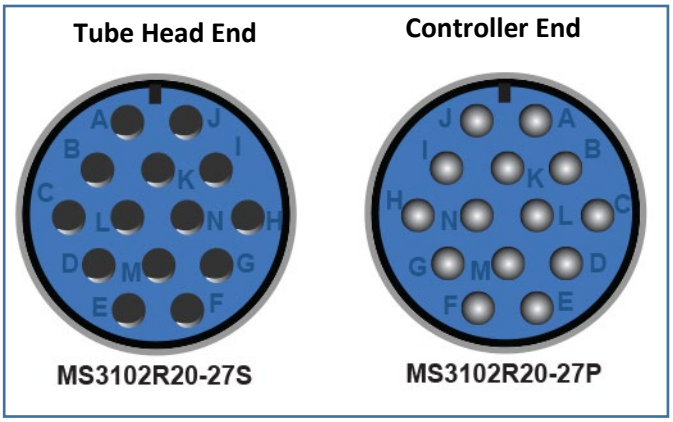


Figure: 4-8 Tube Head Power Cable

Figure 4-9 Tube Head (160kV unit) 10 Pin Connector

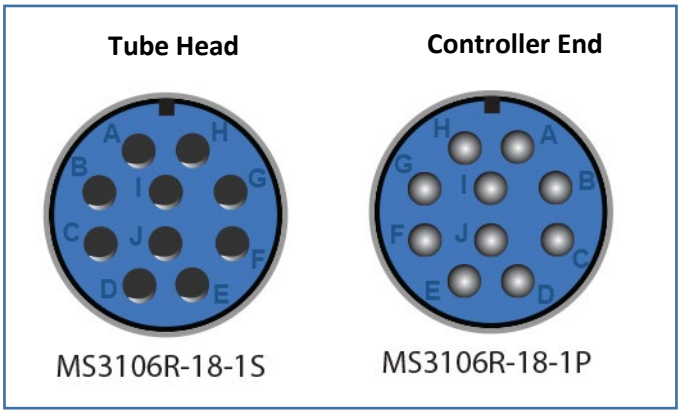


Figure: 4-10 Tube Head Cooling

Figure 4-11 Cooler Cable 8 Pin Connector

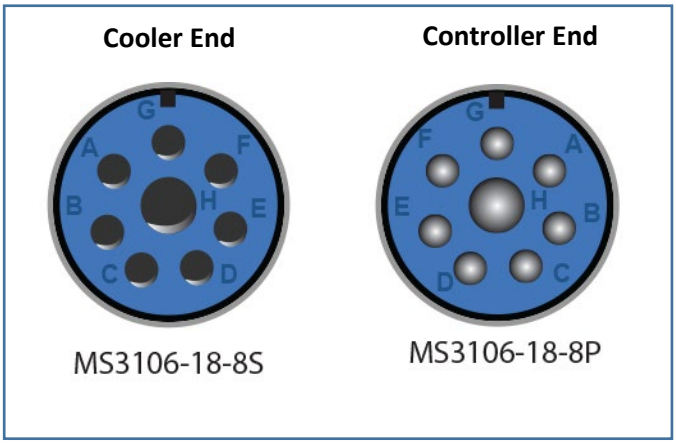
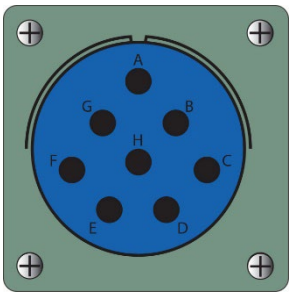
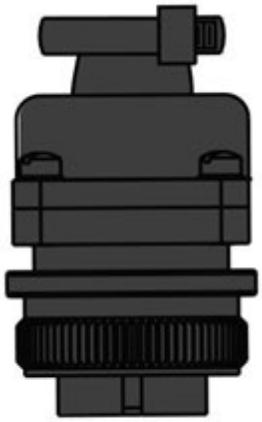


Figure 4-12 Interlock (Controller)



PTO2A-16-8S

Figure 4-13 Interlock Connector



PTO6A-16-8P

Dummy Plug: Pins “A” and “B” connected for interlock closure.

Figure: 4-14 Tube Head Cooler Hose

Figure: 4-15 Cooler Hose Couplings

Coupling Tube Head **Coupling Cooler**

Figure 4-16

SYSTEM INTERCONNECT DIAGRAM

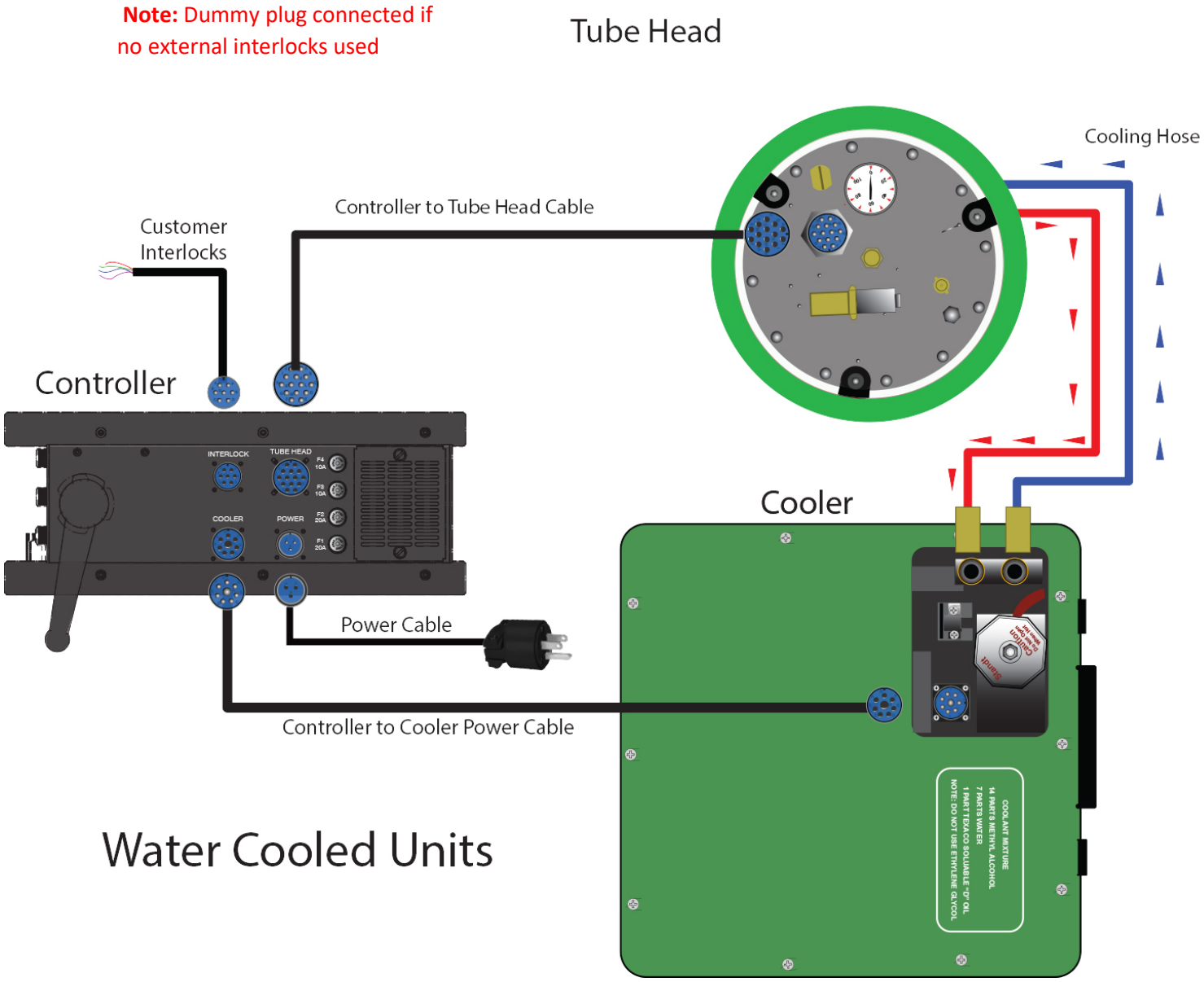
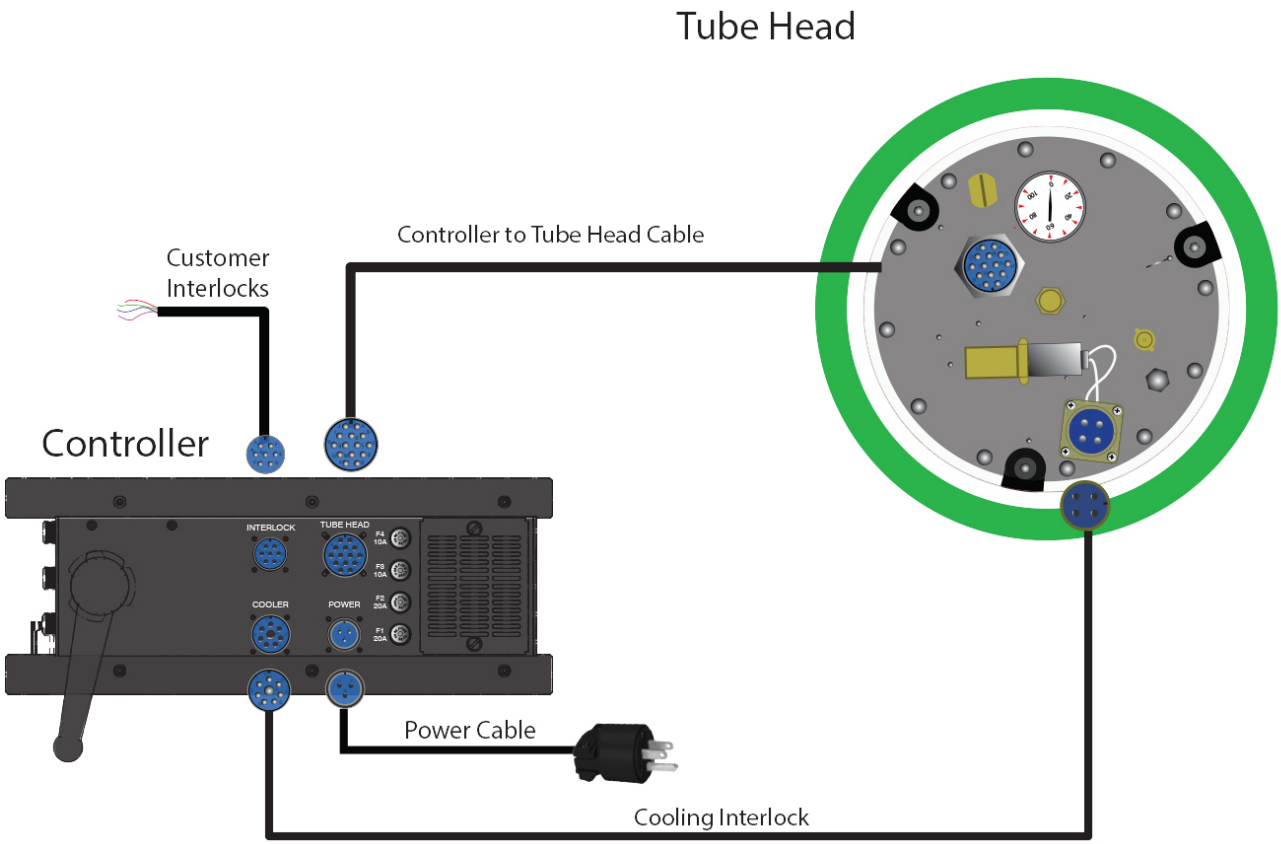


Figure 4-17

SYSTEM INTERCONNECT DIAGRAM



Air Cooled Units

Chapter 5:

SPX Series Pre-operation

Before operating the unit, the X-ray Warm Up procedures must be performed. The X-ray tube provided with this system has been pre-aged by the original manufacturer, and also tested and aged by Spellman. It is necessary, however, that the voltage be run up to the required kV level at a fixed rate when the equipment has not been used for a period of time.

Pre-Operational Safety Precautions

While performing the warm-up sequence, or during X-ray generation, the following safety precautions must be strictly observed before the x-ray tube is energized.

! WARNING!

To avoid radiation hazards under unshielded, outdoor operating conditions, the Control Unit must be placed a considerable distance from the Tubehead. A sufficient length of cable is provided, and must be used to help protect the operator and others in the immediate vicinity. Refer to NCRP (National Council on Radiation Protection) recommended practices.

! WARNING!

The operator of this apparatus must ensure all personnel are clear of the hazardous X-ray area before generating X-rays. Flashing beacons and/or audible alarms should be utilized during exposures, warning personnel of the radiation hazards. Personal radiation monitoring devices shall be worn by all personnel in the immediate vicinity. Radiation warning signs shall be posted where necessary.

! WARNING!

All cables MUST be connected to their appropriate connectors on the Control Unit, Cooling Unit, and Tube Head before applying power to the System

! WARNING!

The operator of this X-ray unit, or any person in the immediate vicinity, may be subject to receiving some exposure to X-radiation during the time that the X-ray unit is generating X-rays. Since X-rays can cause harmful effects to the human body, unnecessary exposure should be avoided, and all exposure held to an absolute minimum compatible with practical requirements and current safety regulations. An X-ray survey meter, placed in the vicinity of the Control Unit and operator, is recommended.

X-Ray Tube Warm Up

Seasoning “Auto-Warming” is important to preserve the x-ray tube. It is required whenever the tube is operated above 80 kV and four hours have elapsed since the x-ray tube was operated at the level required for the next exposure, or when operating a new tube having less than ten hours of operation. Tubes having been previously operated, but not run over 80 kV for 30 days or longer, must be treated as new tubes.

The following section outlines the steps to properly complete the x-ray tube warm-up sequence. Tables 1, 2 and 3 relate the tube’s inactive time to the required warm-up rate and must be used while performing the warm-up sequence. **For detailed instructions for seasoning (auto-warming), refer to section 4.6.1 in the SPX User Guide.**

NOTE: If the warm-up procedure is unnecessary, HOME can be selected to bypass the warm-up.

Table 1: SPX160 X-ray Tube Warm-Up Instructions

Auto-Warm Modes	Auto-Warm Rate @ 5 mA
4 to 8 Hours	Starting at 80 kV, 1 minute at every 30 kV interval until desired kV level is attained.
8 to 16 Hours	Starting at 80 kV, 1 minute at every 20 kV interval until desired kV level is attained.
16 Hours to 7 Days	Starting at 80 kV, 1 minute at every 10 kV interval until desired kV level is attained.
7 to 30 Days	Starting at 80 kV, 1 minute at every 5 kV interval until desired kV level is attained.
Over 30 Days	Starting at 80 kV, 2 minutes at every 5 kV interval until desired kV level is attained.
New Tube (Warm Up Manually)	Start manually at 50 kV, 5 mA. Run for 5 minutes. Advance in 10 kV increments every 2 minutes after than to 100 kV. From 100 kV to 160 kV advance in 5 kV increments every 5 minutes. After reaching 160 kV, run for a minimum of 5 hours, with no ARCs.
If ARC Occurs (During Burn In)	If an ARC occurs warm the tube up using Over 30 Day Mode. After reaching 160 kV run for a minimum of 5 hours, with no ARCs.

Table 2: SPX200 X-ray Tube Warm-Up Instructions

Auto-Warm Modes	Auto-Warm Rate @ 5 mA
4 to 8 Hours	Starting at 80 kV, 1 minute at every 25 kV interval until desired kV level is attained.
8 to 16 Hours	Starting at 80 kV, 1 minute at every 20 kV interval until desired kV level is attained.
16 Hours to 7 Days	Starting at 80 kV, 1 minute at every 10 kV interval until desired kV level is attained.
7 to 30 Days	Starting at 80 kV, 1 minute at every 5 kV interval until desired kV level is attained.
Over 30 Days	Starting at 80 kV, 2 minutes at every 5 kV interval until desired kV level is attained.
New Tube (Warm Up Manually)	Start manually at 50 kV, 10 mA. Run for 5 minutes. Advance in 10 kV increments every 2 minutes after than to 100 kV. From 100 kV to 200 kV advance in 5 kV increments every 5 minutes. After reaching 200 kV, run for a minimum of 8 hours, with no ARCs.
If ARC Occurs (During Burn In)	If an ARC occurs warm the tube up using Over 30 Day Mode. After reaching 200 kV run for a minimum of 8 hours, with no ARCs.

Table 3: SPX300 X-ray Tube Warm-Up Instructions

Auto-Warm Modes	Auto-Warm Rate @ 5 mA
4 to 8 Hours	Starting at 100 kV, 1 minute at every 25 kV interval until desired kV level is attained.
8 to 16 Hours	Starting at 100 kV, 1 minute at every 20 kV interval until desired kV level is attained.
16 Hours to 7 Days	Starting at 100 kV, 1 minute at every 10 kV interval until desired kV level is attained.
7 to 30 Days	Starting at 100 kV, 1 minute at every 5 kV interval until desired kV level is attained.
Over 30 Days	Starting at 100 kV, 2 minutes at every 5 kV interval until desired kV level is attained.
New Tube (Warm Up Manually)	Start manually at 50 kV, 5 mA. Run for 5 minutes. Advance in 10 kV increments every 2 minutes after than to 150 kV. From 150 kV to 300 kV advance in 5 kV increments every 5 minutes. After reaching 300 kV, run for a minimum of 8 hours, with no ARCs.
If ARC Occurs (During Burn In)	If an ARC occurs warm the tube up using Over 30 Day Mode. After reaching 300 kV run for a minimum of 5 hours, with no ARCs.

Chapter 6:

SPX Series System Operation

When the system is properly assembled, the warm-up sequence complete, and all safety precautions/practices taken, x-ray exposures can be made by following the steps below.

All NOTES, CAUTIONS, and WARNINGS outlined in this section must be strictly observed to avoid damaging equipment, or injuring personnel.

Operating Procedures

1. If the operator has not read the "SAFETY SUMMARY" in Chapter 1, “SAFETY SUMMARY”, on page 1-3, and the WARNINGS outlined under “Pre-Operational Safety Precautions” on page 3-5 in this chapter, do so before proceeding.

2. Perform all pre-operational checks and inspections before operating this unit. Also, confirm that all external interlock connections are closed, or that the jumper is installed in the INTERLOCK connector.

! WARNING!
All cables MUST be connected to their appropriate connectors on the Control Unit, Cooling Unit, and Tubehead before power is applied to the System.

3. Make sure the SAFETY KEYSWITCH is in the LOCKED OFF position, and then remove the key. Turn the MAINS switch ON. After approximately 2 seconds, the green Safety Interlock indicator will illuminate, and the Main Screen menu will start. Depending on the system.

4. Insert the key into the Safety Key lock, then turn it to the ON position, either the cooling fan or the coolant pump will energize to cool the tube.

5. If it has been more than four hours since the SPX was last operated or if operating with a new x-ray tube, it is necessary to perform the appropriate warm-up procedure (outlined earlier in this chapter). If the warm-up procedure is unnecessary, proceed to Step #6.

6. Using the SCROLL pushbutton, select Home and set the desired x-ray exposure technique or previous custom created menu list.

7. Position the film holder and Tube Head for the ensuing exposure. Make sure all personnel are clear of the area, and that all external warning devices are working properly. Insert the key into the SAFETY KEYSWITCH and turn it to the ON position. The SPX system is now ready to make an exposure. Press the X-RAY ON switch to begin the

! WARNING!

NEVER allow the x-ray unit to run unattended. NEVER approach the x-ray Tube Head when power is applied, or if the key is in the SAFETY LOCK.

! CAUTION!

Tube current (mA) can be attained up to the maximum value it can produce at the Kv level up to the rating of the tube. At no time should the tube be permitted to operate above the rated current. Lower Kv settings will inhibit x-ray generation. See specification sheet for Kv, mA, and power ratings for the specific SPX model number.

8. The exposure will continue for the duration set by the operator, after which time the unit will automatically shut off. During the exposure, x-ray emission can be interrupted anytime by pressing the red X-RAY OFF E-STOP. To restart an interrupted exposure, twist E-STOP button to release and press the X-RAY ON switch. **For detailed operation procedures and program settings, see section 4 of the SPX user guide**

9. At the end of the exposure, turn the key in the **SAFETY KEYSWITCH** to the **LOCKED OFF** position. Remove the key while making any positioning adjustments to the Tube Head or replacing film holders. To repeat the exposure, re-insert the key and turn it to the ON position and press
10. the X-RAY ON button. If the next exposure requires new parameters, scroll to the appropriate menu on the display screen to set in the new parameters, then turn the key to the ON position and press the X-RAY ON switch.

11. If further operation is not necessary, leave the key to the ON position and allow the Cooling Unit, or cooling fan (air cooled units) to operate for an additional five minutes.

NOTE... The Cooling Fan MUST BE allowed to operate for five minutes after the exposure before turning the unit OFF. During this time, heat generated at the anode during operation is dissipated.

12. Turn the key to the off position. Remove the power cord from its source, disconnect all cables and hoses, and replace all covers. Place the key in a safe, controlled area to prevent unauthorized use of the unit. Store the x-ray unit in a cool, dry location that provides secure storage.

FAULT MESSAGES

During operation, if a fault condition occurs, x-ray generation is automatically terminated and FAULT messages will appear on the displayscreen. The following table lists the fault messages that may appear and instructions on how to remedy the fault.

1. **Interlock: The connection between pins "A" and "B" of the INTERLOCK connector has been interrupted. Check that the interlocked enclosure door switches are operable and closed, or that the jumper is properly installed.**

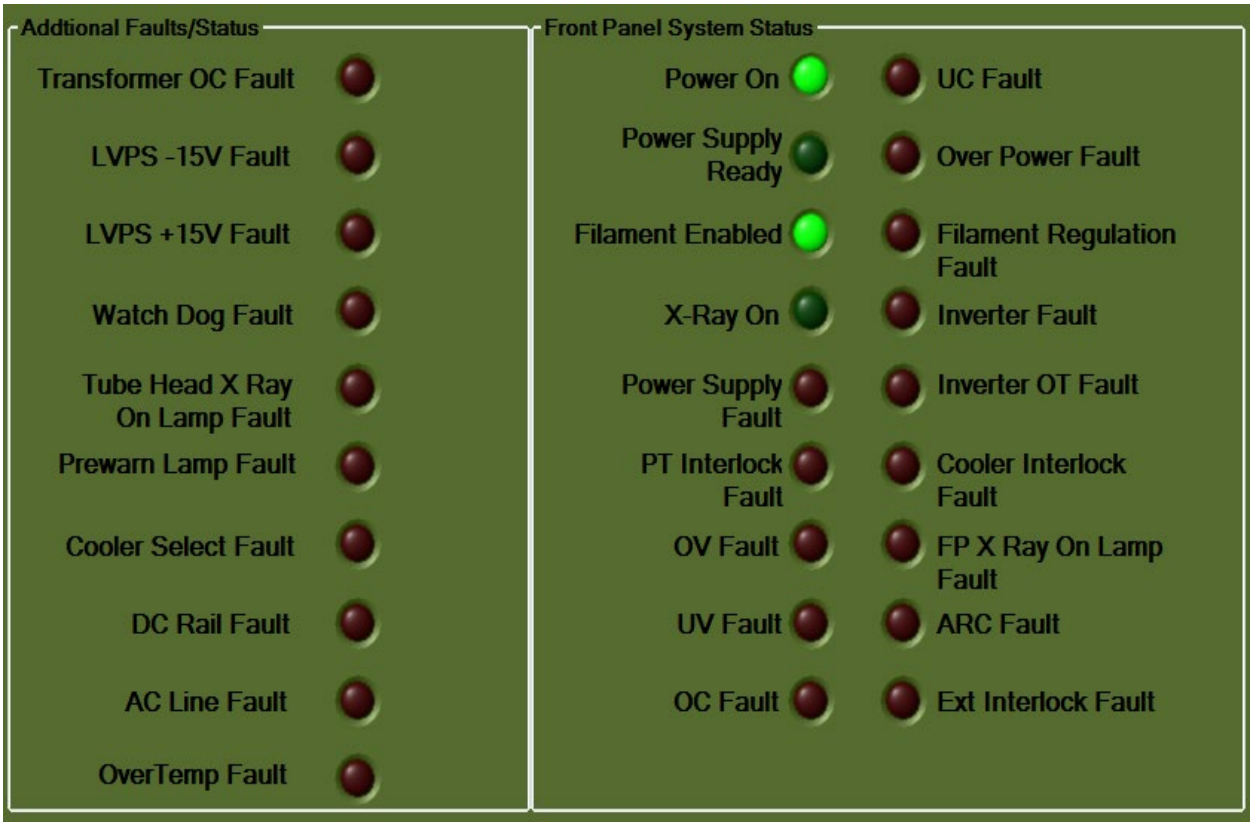
2. **Temperature/Pressure:** The Tube Head has overheated or the gas pressure has dropped below 25 psi. Make sure the Cooling Fan is working properly. Check the gas pressure within the Tubehead. If the pressure is below 25 psi @ 70º F, perform the Re-pressurization procedures in Chapter 7, “Re-Pressurizing the Tube Head”, on page 33 of this manual.

3. **Arc Detected:** This fault condition is usually due to instability from a new tube or from an inadequate warm up sequence. Re-start the system and perform an additional warm up sequence. If the ARC DETECTED fault occurs repeatedly on restart, service is necessary.

4. **Over Voltage:** This condition occurs if the output voltage kV exceeds a factory set level. If the Over Voltage fault occurs repeatedly after restart, service is necessary.

FAULT MESSAGES (Cont.)

GUI Display



FAULT MESSAGES (Cont.)
Fault Descriptions

Fault Indicator	Description
Transformer OC Fault	Transformer Over Current Fault
LVPS-15V Fault	Low Voltage Power Supply -15V Under/ Over Voltage
LVPS+ 15V Fault	Low Voltage Power Supply +15V Under/ Over Voltage
Watch Dog Fault	Firmware Timeout
Tube Head X-ray On Lamp Fault	X-Ray “on” Lamp Fault
Prewarn Lamp Fault	Front Panel Pre-warning Lamp Fault
Cooler Select Fault	X-ray Tube Cooler Fault
DC Rail Fault	DC Switch Voltage Drive Fault
AC Line Fault	Line Voltage Incorrect
Over Temp. Fault	Over Temperature Power Supply
Power Supply Fault	Power Supply Inhibited Due to 1 or More Faults
PT Interlock Fault	Pressure/Temperature Tube Head Fault
OV Fault	Over Voltage Fault
UV Fault	Under Voltage Fault
OC Fault	Power Supply Output Over Current Fault
UC Fault	Power Supply Under Current Fault
Over Power Fault	Power Supply Exceeded Power Rating
Filament Regulator Fault	X-Ray Tube Filament Current Regulator Not Working Properly
Inverter Fault	HV Transformer Primary Drive Not Working Correctly
Inverter OT Fault	Temperature on Inverter Driver too High
Cooler Interlock Fault	Coolant Not Flowing Through X-ray Tube
FP X Ray ON Lamp Fault	Front Panel X-Ray On Lamp Not Working
ARC Fault	Power Supply or X-Ray-Tube ARC Occurred
External Interlock Fault	External Interlock Pins A & B not Jumped
Light Confirm	External Light Fault

attention only when the need arises (re-pressurizing the Tube Head).

Chapter 7:

SPX Series Routine Care and Maintenance

Introduction

The SPX Series Portable X-ray Unit is a reliable, easily maintained, industrial x-ray device. With modest amounts of upkeep and care, this system will provide years of trouble free operation. This chapter provides inspections and maintenance practices, that when followed, reduce the possibility of equipment breakdown, and optimize the unit's reliability.

Some of these practices are conducted in accordance to a pre-arranged schedule (inspections and cleaning), while others require

Inspection Checklist

To assist in early detection of potential problems, the following "Inspection Checklist" should be followed. Discrepancies discovered during these inspections must be noted and immediately corrected to avoid the possibility of equipment breakdown. The inspections described in these checklists should be performed in accordance with general care and maintenance of this product.

NOTE... When operating in harsh environments, the following inspection checklists must be performed more often due to the higher concentration of dust and debris accumulating within each assembly

Table 7-1: Tubehead Checklist

COMPONENT	INSPECTION
Pressure Gauge	Gauge in good condition; gas pressure 50 @ 70º F.
Gas Valve Cap	Securely fastened to charging valve.
Cable Connector	Ensure all pins are straight; check for corrosion or debris; check condition of threads.
Tube Head Handles	Check for cracks or breaks.
Tube Head Housing	Paint finish in good condition; check for dents and visible damage.

Table 7-2: Control Unit Checklist

COMPONENT	INSPECTION
Cabinet and Cover	Paint finish in good condition; check for dents and visible damage; check for loose hardware.
Cable Connectors	Firmly seated on front panel; check for bent or broken pins; check for corrosion or debris; check for cracked receptacles; check thread condition.
Indicator Lamps	Illuminate when activated.
Fan	Operates when power is applied.
Push Buttons	Buttons are preset: labels are readable.

Table 7-3: Interconnecting Cable Checklist

COMPONENT	INSPECTION
Military Connectors	Secured firmly to cable; check for corrosion or debris; check for bent or broken pins; check for cracked or broken housing.
Cable Insulation	Check for cracks, holes or frays; check for signs of wear or dry rot.

two top tubular side rails and then removing the screws from the top panel.

Care and Maintenance

During normal periods of use, but especially in harsh environmental operating conditions, it becomes necessary to clean each assembly of the system. This cleaning should be performed once a month under normal operating condition, to optimize performance, and minimizes equipment failure during use.

Required Cleaning Materials

- Clean lint free cloths;
- Mild detergent;
- 1 inch soft bristled paint brush;
- Electronic cleaning solution;
- Acid brushes;
- Low pressure air station, hose and nozzle set.

Control Unit Maintenance

! WARNING!
Under no circumstances should the interior of the Tube Head be accessed. When cleaning the Control Unit, power MUST be OFF and the unit MUST be disconnected from the power source.

1. Dampen a clean lint free cloth in a solution of warm water and mild detergent. Wring any excess water from the cloth to prevent dripping. Remove dirt, dust, or debris from the top cover of the Control Unit. Clean the outer casing of the Tube Head and Control Unit.

2. Remove dirt, dust, or debris from the front panel of the Control Unit using a 1" soft bristled paint brush. Dirt that is not easily dislodged can be removed with a lint free cloth dampened in a warm water and mild detergent solution.

3. Remove the top cover from the Control unit by first removing the bolts from the

Carefully remove the top cover. Using a low pressure air and nozzle system, blow any dirt, dust, or debris out of the unit. Re-install the top cover and the side rails

NOTE... Material that cannot be removed from around circuitry can be cleaned using a standard electronic cleaning solution and an acid brush.

4. Inspect the connectors on each cable assembly. Remove any dirt, dust, debris, or foreign material from the pins/sockets with electronic cleaning solution and an acid brush. DO NOT use water. Check for corrosion on the pins or connectors and remove if necessary.

Tube Head Maintenance

The following paragraphs describe the general maintenance procedures to be performed periodically on the Tube Head assembly. Outlined below are the steps for Re-pressurizing the Tube Head with sulfur hexafluoride gas, and the conditions under which each are performed. A Temperature Compensation chart is provided for use while conducting these tasks.

NOTE... A charger and maintenance kit (P/N 9-200-0102) for the Tubehead is available, and can be purchased through Spellman.

Re-Pressurizing the Tube Head

This x-ray unit can be safely operated at Tube Head pressures as low as 45 psig @ 70º F. Should the Tube Head pressure fall below this value, but remain above 5 psi (as indicated on the pressure gauge), the Tube Head will need re-pressurizing.

The following procedures outline re-pressurizing the Tube Head to 50 psi with dry sulfur hexafluoride gas (SF6) at 70º F through the charging valve (automobile tire type) on the back of the Tube Head. Use a hose incorporated with a relief valve or pressure regulator, and a gauge having an accuracy of at least ±4 psi. Refer to Figure 7 -1 and Figure 7-2 while performing these procedures.

! CAUTION!

DO NOT re-pressurize if Tube Head pressure has fallen below 5 psi @ 70º F. Such low pressures may have caused contaminants to enter the Tube Head chamber, and can cause damage from high voltage arcing. If pressure is below 5 psi, the Tube Head must be purged of all remaining gas, then re-filled. If the Tube Head gas pressure is below 5 psi @ 70º F, the Tube Head service is necessary.

1. Remove the protective cover from the SF6 (sulfur hexafluoride) cylinder. Remove the plug from the cylinder valve with a 3/8" allen wrench. The cylinder valve outlet is left-hand threaded.

! WARNING!

Extreme care must be exercised while handling the cylinder so as not to drop it after the protective cover has been removed. The cylinder must be chained to a stationary post or otherwise secured against tipping.

2. Connect the SF_6 charging regulator assembly, or equivalent, to the SF_6 cylinder valve.

NOTE... The pressure regulator supplied with the optional Spellman recharge kit is factory set to 70 – 75 psi @ 70˚ F., and locked with a hex nut on the adjustment knob. However , due to spring tension ageing. And/or various ambient temperatures, this setting may need to be updated.

3. Connect the Tube Head to the regulator assembly using the hose, as shown in Figure 7-1. Leave the SF_6 cylinder closed at this time. For this procedure, hose and pump are not required.

4. Open the vacuum line valve slightly, to purge the hose of standing air. Open the SF_6 gas cylinder slightly to purge the regulator of any standing air. Now close the vacuum line valve and open the SF_6 cylinder valve to its fully open position (against its physical stop).

5. The Tube Head will begin filling with SF_6. When the Tube Head gauge indicates the correct pressure, close the SF_6 cylinder valve. To determine the correct pressure, refer to the "Pressure vs. Temperature" chart (Figure 7-2).

6. Remove the charging hose connection at the Tube Head. Secure the gas cylinder by removing the connections

and replacing the protective cover. Recheck the pressure and inspect the Tube Head for leakage.

Legend – Tube Head Pressurization Set Up

1. Tube Head
2. SF6 (sulfur hexafluoride) cylinder
3. Cylinder Valve
4. Pressure Gauge
5. Charging Regulator Assembly
6. Vacuum Line Valve
7. Hose
8. Hose
9. Vacuum Pump

Temperature Compensation

As shown in Figure 7-2, temperature changes cause SF6 gas to expand or contract at the rate of 1 psi for every 7°F increase/decrease in ambient air temperature. Allowances for these changes must be made when checking the Tube Head gas pressure, or while re-pressurizing/re-filling the Tube Head. Figure 7-2 charts the maximum and minimum pressure limitation of the Tube Head at various temperature ranges. This chart is to be used whenever the Tube Head is inspected, re-pressurized, or re-filled.

Note… It is standard practice to allow both the gas supply and the Tube Head to achieve room temperature before attempting to re-pressurize. Temperature equilibrium eliminates errors resulting from differences between the gas supply and the Tube Head temperatures.

Figure 7-2 **Pressure vs Temperature Chart**

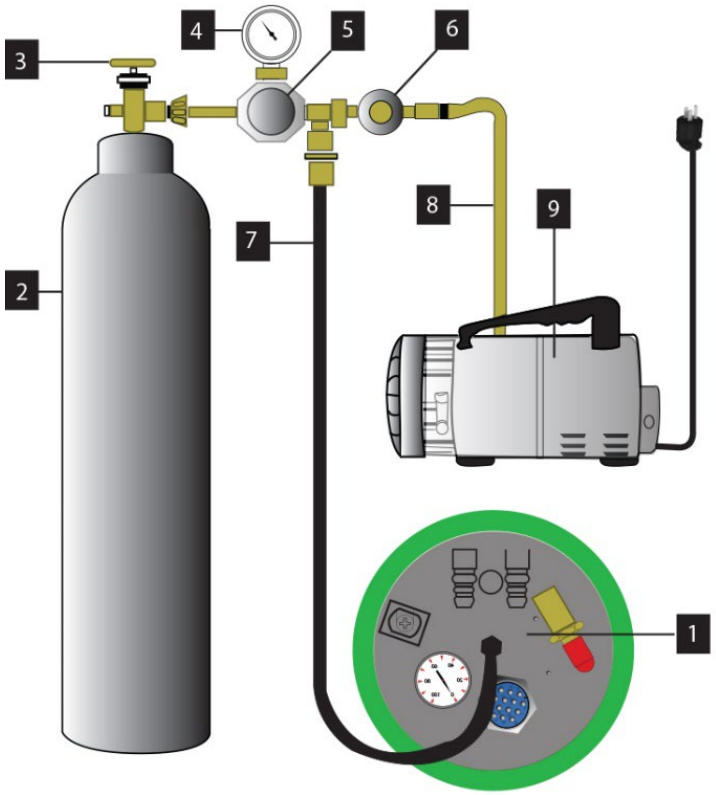
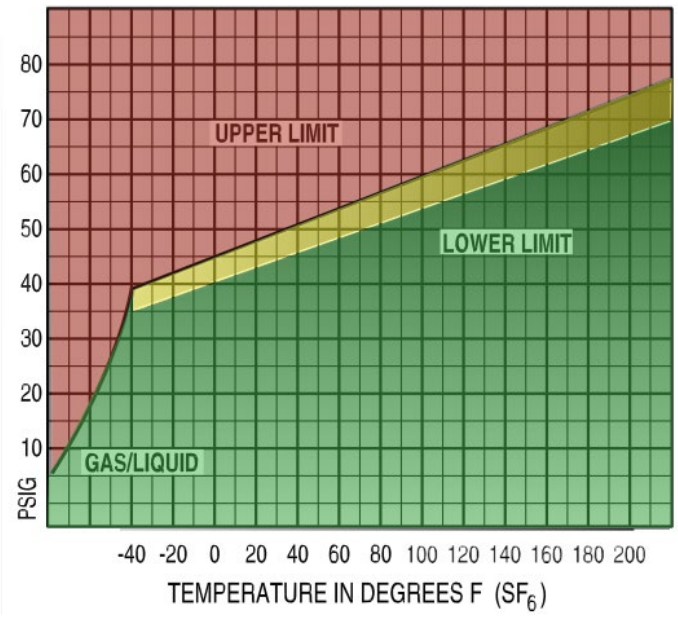


Figure 7-1 **Tube Head Pressurization Setup**



Re-Filling the Tube Head

This procedure is used when the pressure within the Tube Head has dropped below 5 psi @ 70˚F, or after major maintenance on the Tube Head has occurred. To re-fill the Tube Head, follow the procedures outlined below while referring to figures 7-1 and 7-2.

1) Remove the protective cover from the SF6 cylinder (2) Remove the plug from the cylinder valve (3) with a 3/8" Allen Wrench. The cylinder valve outlet is left-hand threaded.

Warning!

Extreme care must be exercised while handling the cylinder so as not to drop it after the protective cover has been removed.

2) Connect the SF6 charging regulator assembly (6) to the SF6 cylinder valve.

Note… the pressure regulator supplied with the optional recharge kit is factory set to 50 psi @ 70˚F, and locked with a hex nut on the adjustment knob. However, due to spring tension aging, and/or various ambient temperatures, this setting may need to be updated.

3) Connect the vacuum pump (10) and the Tube Head (1) to the regulator assembly (6), using the hoses (7) and (8) as shown in figure 7-1.

4) Leaving the SF6 gas cylinder valve (3) closed, open the vacuum line (6) counter-clockwise.

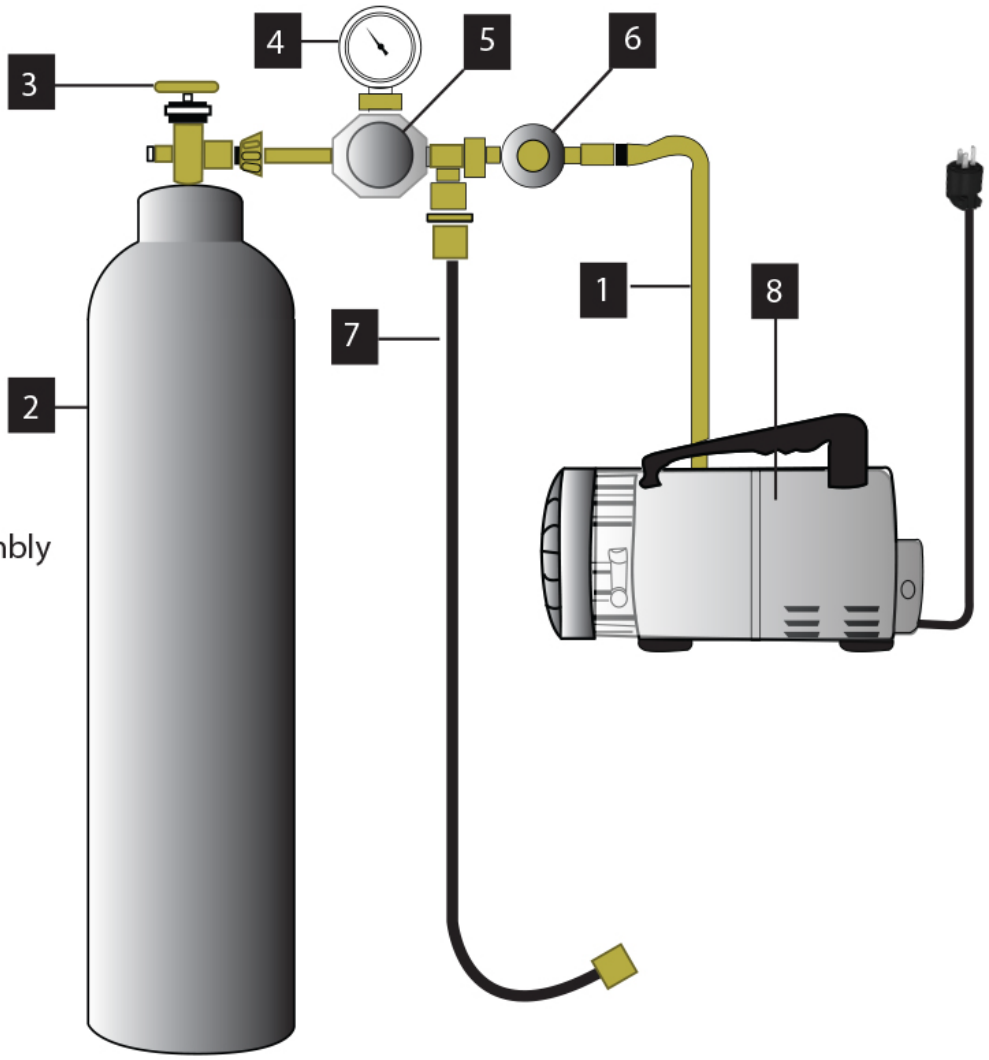
5) Start the vacuum pump and allow it to run for at least 20 minutes for 160kV, (1 hour for 200kV and 300kV units). The final vacuum indicated on the regulator gauge should be at least 25" Hg.

6) Close the vacuum line (6) and turn the vacuum pump off. Open the SF6 cylinder valve (3) to its' fully open position (until reaching its' physical stop). Fill the Tube Head until the gauge indicates 25 psi, then close the cylinder valve.

7) Open the vacuum valve and run the pump an additional hour. Close the vacuum line and stop the pump. Open the SF6 cylinder valve again and fill the Tube Head to the pressure indicated on the "Pressure vs Temperature" chart (Figure 7-2). When the Tube Head is at the correct pressure, close the SF^ cylinder valve.

8) Remove the charging hose connection at the Tube Head, secure the gas cylinder, and replace the protective cover. Re-check the pressure and inspect the Tube Head for leaks.

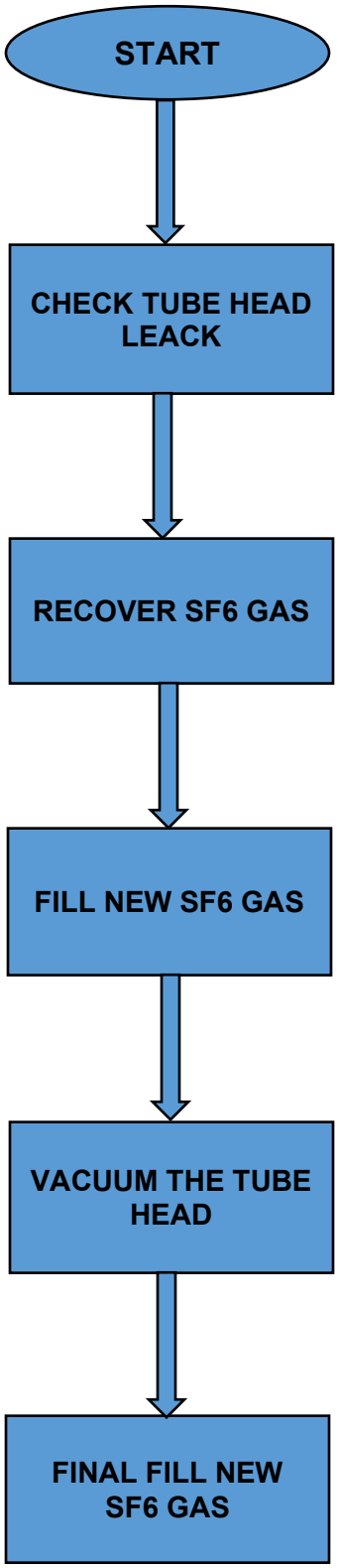
1. Hose
2. SF6 Gas Cylinder
3. Cylinder Valve
4. Pressure Gauge
5. Charging Regulator Assembly
6. Vacuum Line Valve
7. Hose
8. Vacuum Pump



Tube Head Re-charge Kit

P/N 9-200-0102

SPX-160kV, 200kV and 300kV TUBEHEAD PRESSURE SETUP



- Connect Recover SF6 Cylinder to Tube Head
- Fill Recover SF6 gas
- When gauge indicates 20 psi, Stop this process
- Check for a leak

- Connect SF6 Gas Re-claimer to the Tube Head
- Start Re-claimer Process
- When Vacuum gauge indicate least 10“Hg, switch to vacuum Pump
- Vacuum for 20 minutes**(1 hour for 200 and 300kV systems)**
- Vacuum gauge should indicate least 25” Hg

- Connect New SF6 Cylinder Gas to Tube Head
- Start fill SF6 gas
- When gauge indicates 25 psi, Stop to this process

- Connect SF6 Gas Re-claimer to the Tube Head
- Start Re-claimer Process
- When Vacuum gauge indicate least 10“Hg, switch to vacuum Pump
- Vacuum for 20 minutes **(1 hour for 200 and 300kV systems)**
- Vacuum gauge should indicate least 25” Hg

- Connect New SF6 Cylinder Gas to Tube Head
- Start fill SF6 gas
- When gauge indicates 50 psi, Stop this process

COOLING UNIT UPKEEP

The following paragraphs describe the monthly general maintenance procedures for the Cooling Unit. These tasks include mixing/adding coolant solution, cleaning the air filter, and cleaning the coolant filter. Note that the frequency of these procedures should be adjusted appropriately during times of heavy use or while operation under severe environmental conditions.

Mixing & Adding Coolant Solution

After prolonged use (due to evaporation or spillage), or after performing maintenance on the Cooling Unit, add coolant solution to the reservoir. The following procedures describe the methods used to properly formulate and add coolant solution to the Cooling Unit.

1. A plastic container is needed to mix and store the coolant solution. The container should be appropriately sized to accommodate easy handling, have a means of pouring the solution, and a means of capping it off for storage.

2. In this container mix 14 parts of methyl alcohol, with 7 parts distilled water, and 1 part soluble oil (Chevron Soluble D or MOBIL S-122 Soluble). Gently agitate the container to help blend the solution.

3. Remove the top cover from the Cooling Unit, then remove the radiator cap. Check that the coolant level is within specifications. If the coolant level is more than 1/2" from the top of the reservoir, add coolant solution to the reservoir until the level is approximately 1/2" from the top, then replace the radiator cap.

4. Install the twin hose assembly between the Cooling Unit and the Tube Head. Connect the power cable between the Control Unit and the Tube Head, and the power cord between the Control Unit and the Cooling Unit. Turn the Key to ON position and allow the coolant to circulate through the system for approximately three minutes.

5. Turn the system OFF and remove the radiator cap. Inspect the coolant level and ensure it remained within 1/2" from the top of the reservoir. Add more coolant solution if necessary, and repeat step 4.

! CAUTION !
Store the coolant container in a cool, dry area with the cap on. Clearly mark the container so that the contents are easily identifiable.

Cleaning - Cooling Unit Air Filter

Clean the wire mesh air filter within the Cooling Unit each month to remove dust, dirt, or debris collected during use. Large accumulations of dirt can impede the flow of air through the radiator assembly, resulting in restricted or limited cooling of the anode. The following procedures describe the steps to remove and clean the Cooling Unit's air filter.

1. Release the four latches that fasten the top cover to the Cooling Unit, then lift the cover off the unit. Remove the ten screws from the top plate, and the four bolts from the bottom of the case. Lift the entire Cooling Unit chassis from the protective case.

2. Remove the four screws (with nuts) securing the grille and filter to the inner side of the protective case.

3. Remove dirt, dust, or debris from the filter by washing it in a solution of mild detergent and warm water. When complete, rinse the filter thoroughly with clean, warm water. DO NOT use gasoline or other solvents to clean the filter. Allow the filter to dry completely, or blow off any remaining moisture with compressed air.

4. Re-install the filter and grille assembly to the protective case. DO NOT over tighten the mounting hardware or distortion to the filter frame may occur.

5. Insert the Cooling Unit chassis into the protective
case. Make sure the filter assembly is positioned directly in front of the radiator before tightening mounting hardware.

Cleaning - Coolant Filter

The Cooling Unit contains a screen-type filter contained within the in-line strainer assembly. This filter is attached to the Cooling Unit chassis. To prevent restricted coolant flow and over-heating of the anode, perform this inspection and cleaning procedure every month.

1. Release the four latches that fasten the top cover to the Cooling Unit, then lift the cover off the unit. Remove the ten screws from the top plate, and the four bolts from the bottom of the case. Lift the entire Cooling Unit chassis from the protective case.

2. Unscrew and remove the cap nut from the strainer assembly (expect coolant solution to seep out while the cap is removed). Lift the filter/strainer out of the assembly, and quickly replace the cap nut to stem the flow of coolant solution.

3. Remove contaminants from the filter with a solution of warm water and mild detergent. The screen is made of delicate material and can be deformed quite easily. Handle the filter with extreme care.

4. Rinse the filter in clean, warm water to remove excess detergent. Remove the cap nut and re-install the filter. Replace the cap nut and tighten.

5. Add coolant solution to the reservoir to compensate for spillage that occurred during cleaning. Clean any coolant solution from the chassis that leaked out during this procedure. Install the chassis into the protective case.

6. Attach the twin hose assembly between the Cooling Unit and the Tube Head, and the Control Unit to the Cooling Unit. Apply power, and allow coolant to circulate for three minutes. Re-check the coolant level to ensure it is 1/2" from the top. Add Cooling Solution as needed.