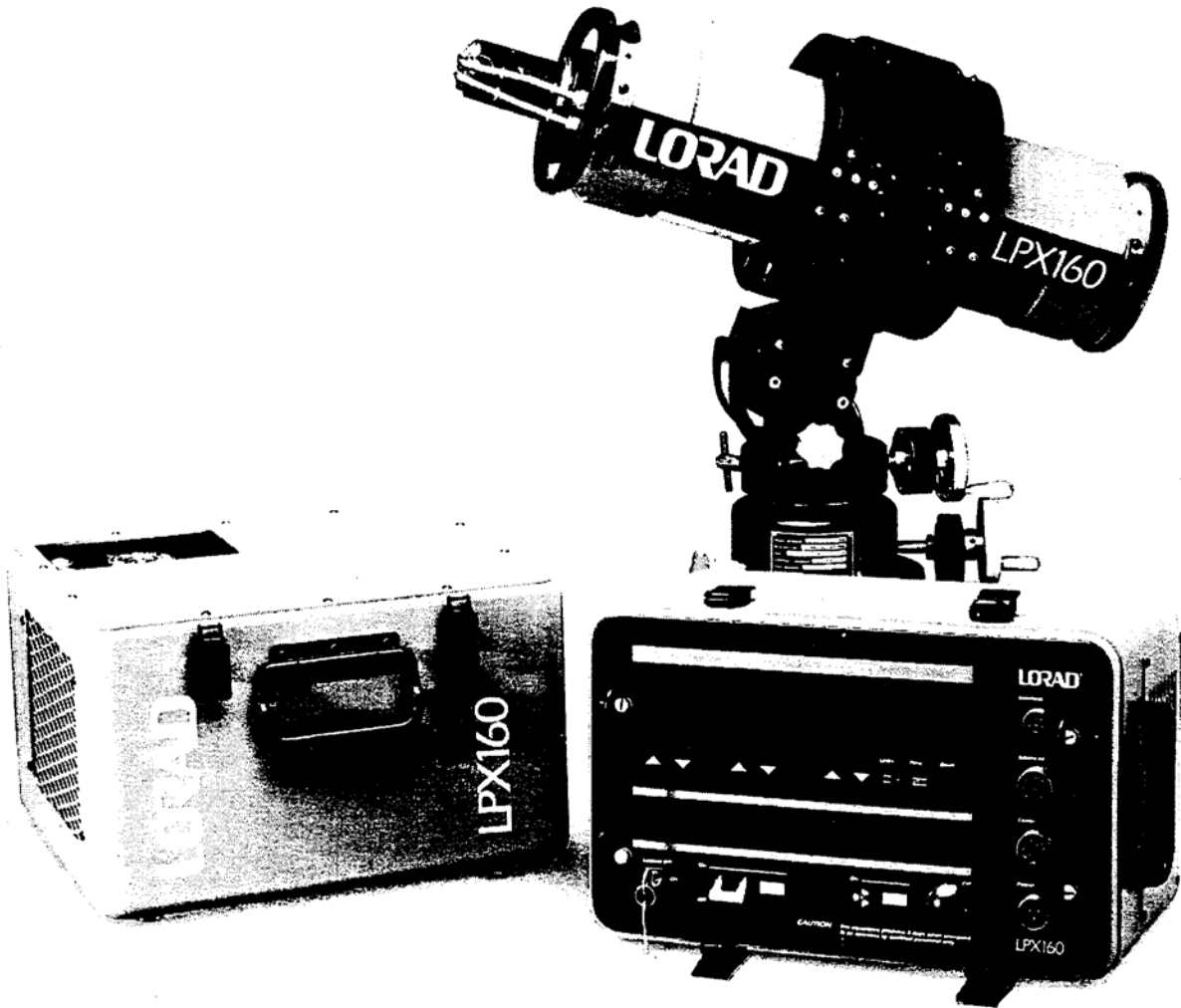


LPX-160

OPERATOR'S MANUAL



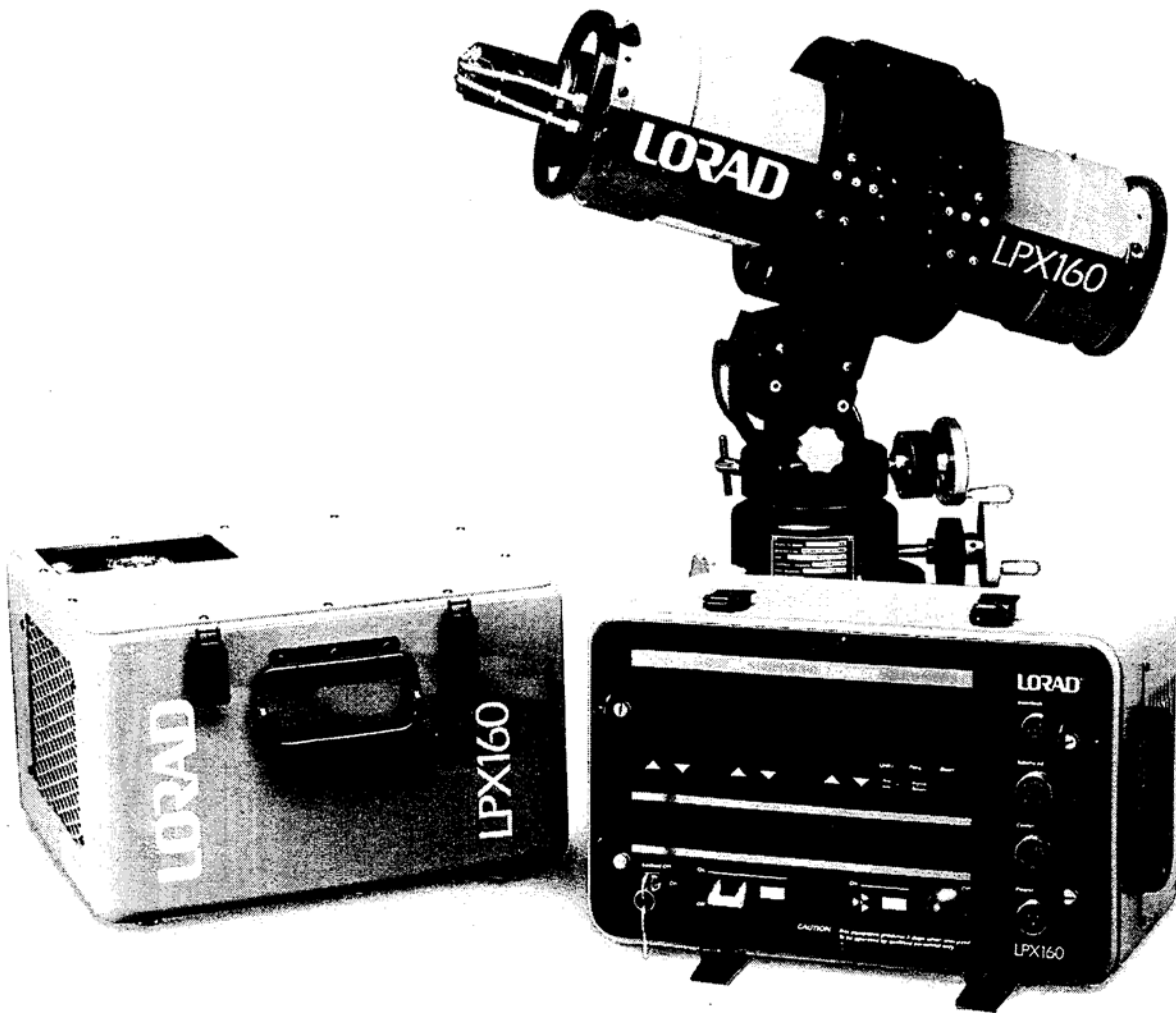
LORAD[®] INDUSTRIAL IMAGING

9-500A-0077

U.S. Patent 5,231,564
U.S. Patent 5,335,161
U.S. Patent 5,450,467
U.S. Patent 5,563,569

LPX-160

OPERATOR'S MANUAL



LORAD[®] *INDUSTRIAL IMAGING*

REVISION 2
November 1996

**CAUTION: THIS EQUIPMENT PRODUCES
X-RAYS WHEN ENERGIZED!**



**DO NOT OPERATE THIS EQUIPMENT WITHOUT
FORMAL HARDWARE TRAINING FROM
SPELLMAN HIGH VOLTAGE ELECTRONICS.
ASNT LEVEL 3 RADIOGRAPHIC CERTIFICATION
IS HIGHLY RECOMMENDED.**

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GENERAL UNIT DESCRIPTION

This manual describes the LORAD LPX-160 Series Portable Industrial X-ray Units, and contains the information necessary to properly set up, inspect, operate, and maintain these systems. The LPX-160 series is designed to meet the needs of the commercial NDT user, and is intended for inspection of materials for defects, inclusions, cracks, corrosion, porosity, etc. X-ray potential up to 160 kilovolts (kV), and tube current up to 5 milliamperes (mA) can be generated by this apparatus. The system offers a 100% duty cycle and consists of the following assemblies;

1. the Control Unit;
2. the Tube Head;
3. the Cooling Unit, (liquid cooled units only).

These assemblies are described in detail below.

THE CONTROL UNIT

The Control Unit is used by the radiographer to set the radiographic exposure parameters, and to activate/deactivate x-ray emissions from the Tube Head. Two types of Control Units are available; the LPX-160: a microprocessor regulated digital Control Unit, and the LPX-160A: an analog based Control Unit. Both types house all system operating controls, and the circuitry needed to provide the appropriate drive power to the Tube Head and Cooling Unit.

The digital unit contains pushbutton switches, logic circuitry, and two LCD readouts that regulate the various operating modes and two incrementing numeric LCD readouts. The digital unit also features five automatic warm up modes. The analog unit uses rotating knobs and deflecting needle type meters for controls and parameter readouts.

One hundred feet of cable is supplied with the unit enabling the Tube Head to be placed a safe distance from the Control Unit and operator. The Control Unit is enclosed in a metal container with a removable cover. A collapsible handle is attached to the cover as a means of transporting the unit when the cover is attached to the Control.

THE TUBE HEAD

The Tube Head is a cylindrical aluminum shelled assembly housing the x-ray tube, the high voltage power supply, and the filament supply. It is insulated with sulfur hexafluoride gas, 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 of the end grounded, exposed anode configuration, with a beryllium window located approximately 2 inches from the end. Built in carrying handles are located at each end of the Tube Head.

Two Tube Head models are available; liquid-cooled and air-cooled. Liquid-cooled models use a

separate cooling unit to dissipate anode heat, and have a length of twin hose attaching the Tube Head to the Cooling Unit. Air cooled models have an electric cooling fan mounted at the anode end of the Tube Head. The fan is powered by an interconnecting cable from the Control Unit.

THE COOLING UNIT (used with liquid-cooled Tube Head)

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, through a cooling manifold, into the anode, then back to the Cooling Unit through the second half of the twin hose assembly.

In the Cooling Unit, coolant passes through a flow switch that is electrically interlocked with the Control Unit, through a filter that screens out contaminants, through a forced air radiator, where 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 switching circuit within the Control Unit.

USING THIS MANUAL

! WARNING !

Before operating or performing any maintenance on the LPX-160 or LPX-160A, the user MUST have a thorough understanding of X-ray machinery, X-ray generation, X-ray potential, and X-ray control. The user MUST understand all hazards associated with X-ray generation. The "Safety Summary" in this section MUST be read completely, and thoroughly understood. The numerous safety warnings, cautions, and notes throughout this manual MUST be read prior to commencing any operating or maintenance procedures.

MANUAL OUTLINE

This manual is written to provide qualified radiographers and technicians a means to logically inspect, operate, and maintain the LORAD LPX-160 and LPX-160A Portable X-ray Units. The following paragraphs describe the arrangement of this manual, and the information contained in each section.

Section One: Introduction

This section provides general information about the LPX-160 Series X-ray Unit. Included in this section is a safety summary.

Section Two: Preparation For Use and Shipment

This section provides instructions for unpacking and reshipment, equipment checklists, and the basic specifications of each assembly. Also included in Section Two are the locations of warning labels and I.D. tags.

Section Three: System Set-Up

Section Three covers the required pre-operational checks, inspections, and system set-up procedures for the Tube Head Assembly, Control Unit, Cooling Unit, associated hoses, and interconnecting cables. Also discussed are external interlock connections.

Section Four: LPX-160 Operation

Section Four covers the warm up and operating instructions for the LPX-160 (digital) X-ray Unit. Included are descriptions of the operating controls and indicators, operating mode displays, and fault detection.

Section Five: LPX-160A Operation

Section Five covers the warm up and operating instruction for the LPX-160A (analog) X-ray Unit. Included are descriptions of the operating controls and switches and the warm-up procedures.

Section Six: Routine Upkeep and Care

This section 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 this unit is incorrectly installed, and/or operated by unqualified personnel, or if the maintenance schedule is neglected, it is a potentially dangerous apparatus. All operators and technicians must read and understand the x-ray protection warning published at the front of this manual. This manual must be read in its entirety and all procedures completely understood before operating the unit. Also, all NOTE, CAUTION, and WARNING statements must be read and thoroughly understood before beginning operation or maintenance procedures. The following summary should be used as a checklist to assure comprehension.

*** NOTE BOX ***

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

*** CAUTION BOX ***

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

! WARNING BOX !

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. Also, under no circumstances should the operator access the interior of the Control or Cooling Units except for the procedures outlined in Section 6 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 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 level to make sure it is within specification, is circulating properly, and 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.

Care in Handling

Extreme care must be taken when handling the apparatus. Exercise caution while packing, unpacking, shipping, and while performing maintenance. Remember, the X-ray tube is durable but breakable, and should be stored and shipped in the upright position.

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SECTION TWO

PREPARATION FOR USE AND SHIPMENT

UNPACKING INSTRUCTIONS

The LPX-160 Series Portable X-ray Unit is shipped in a single wooden container. To gain access to the unit, remove the top cover from the crate. Once the crate is opened, carefully lift each component from the container and perform a thorough visual inspection.

If damage to any component has occurred, immediately contact the carrier. All damaged containers must be retained until an inspection by the carrier has been completed. If it is necessary to re-package and ship the unit, follow the instructions outlined under "Reshipment Guidelines".

RESHIPMENT GUIDELINES

If, for any reason, the LPX-160 Series Industrial X-ray Unit must be transported or shipped, the original wooden container should be used if possible. If the original container is not available, comply with the following re-packing guidelines.

- Step #1** Construct a wooden shipping carton for the Tube Head Assembly similar to the one in Figure 2-1. The carton must be built so that the top can be completely removed, facilitating packing and unpacking.
- Step #2** The Tube Head **MUST** be cushioned with at least 3" of shock absorbent, foam type, packing material around all sides, including above and below the Tube Head.
- Step #3** Supporting legs are to be securely affixed to the bottom of the carton, and extend 7 to 10 inches from the edges as shown in the illustration below.
- Step #4** The Control Unit must be packed in a container rated for 60lbs. It must be surrounded by at least 2" of shock absorbent packing (sheet or loose type) around all sides, including the top and bottom. The Cooling Unit is packed 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.

- Step #5** When transporting by commercial carrier (i.e., truck, rail, etc.), the shipping method and carrier should be selected on the basis of safe shipment, especially when shipping the fragile Tube Head Assembly. The carton containing the Tube Head must be distinctly marked on all sides as containing fragile glass instrumentation. A label must also be affixed to all sides indicating that the carton must be shipped in the upright position. Customarily, the Tube Head is shipped via air, generally avoiding ground transportation if possible. When shipping via air, an additional label must be affixed 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.

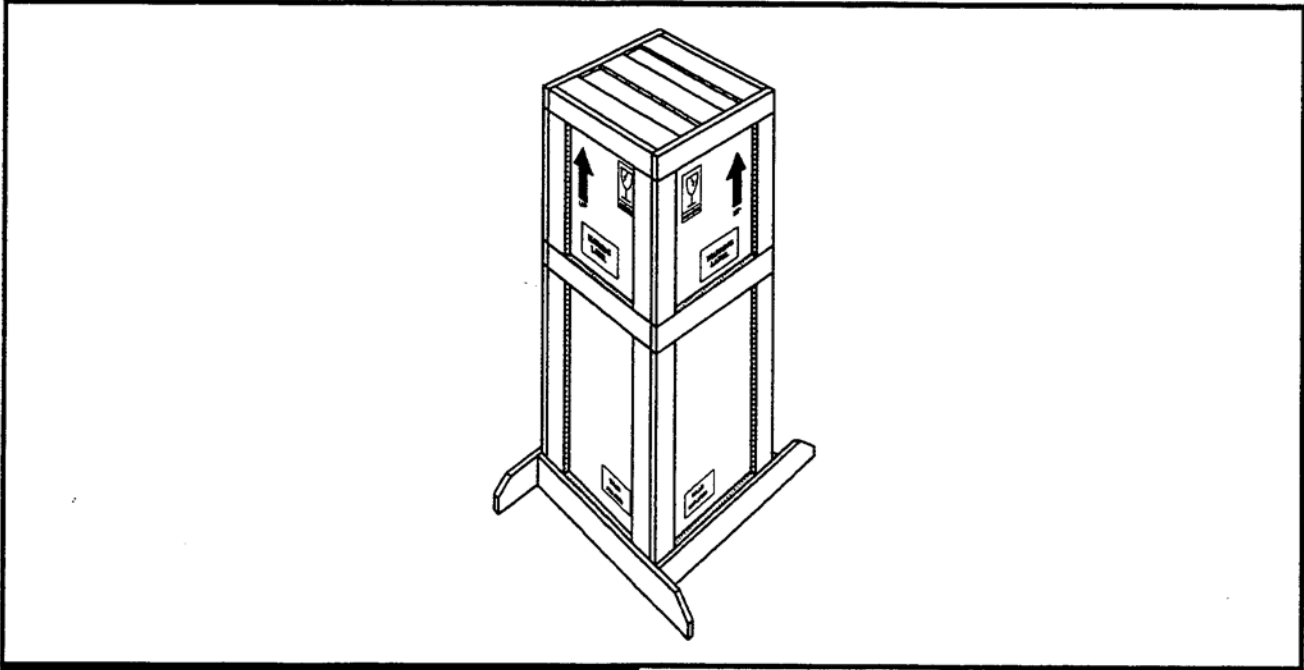


FIGURE 2-1: TUBE HEAD SHIPPING CONTAINER

EQUIPMENT CHECKLISTS

The following checklists outline the standard and optional equipment common to the LPX-160 Series Portable 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 models of Tube Head assemblies are available. Verify the Tube Head shipped with your unit matches the model that was originally ordered.

SECTION TWO

PREPARATION FOR USE AND SHIPMENT

TUBE HEAD CHECKLIST

- Assembly, Tube Head * 3-000A-0768
Air Cooled Unit; 40° cone
1.5 mm Focal Spot
.063" Beryllium Window
- Assembly, Tube Head * 3-000A-0782
Air Cooled Unit; 40° cone
1.5 mm Focal Spot
.020" Beryllium Window
- Assembly, Tube Head 3-000A-0736
Liquid Cooled; 40° cone
1.5 mm Focal Spot
.063" Beryllium Window
- Assembly, Tube Head 3-000A-0776
Liquid Cooled; 40° cone
1.5 mm Focal Spot
.020" Beryllium Window
- Assembly, Tube Head 3-000A-0772
Liquid Cooled; 360° Panoramic
1.5 mm Focal Spot
0.6 mm Nickel Window Tube

* 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.

STANDARD EQUIPMENT CHECKLIST

- Control Unit, Analog (1) 3-000A-0762
- Control Unit, Digital (1) 3-000A-0738
- Cooling Unit Assembly (1) 3-000A-0737
(Liquid Cooled Units Only)
- Power Cable Assembly (1) 1-040A-0341
(3 Pin Connector, 25ft.)
- Power Cable Assembly (1) 1-040A-0380
(3 Pin Connector, 100ft)
- Control Cable Assembly (1) 1-040A-0342
(10 Pin Connector, 100ft.)

SECTION TWO

PREPARATION FOR USE AND SHIPMENT

STANDARD EQUIPMENT CHECKLIST (Continued)

- Cooler Power Cable (1) 1-040A-0343
(8 Pin Connector, 50ft.)
- Power Cable, Fan (1) 1-040A-0355
(Air Cooled Units Only, 100ft.)
- Interlock Mating Connector (1)..... 1-040A-0394
(Jumper)
- Safety Switch Key (2) 2-610A-0001

AVAILABLE OPTIONAL EQUIPMENT CHECKLIST

- X-Ray Tube Head Stand 3-000A-0754
- Kit, Tube Head Re-charge..... 9-200A-0102

LOCATION OF WARNINGS LABELS AND CONTROL NUMBERS

Each assembly of the LPX-160 Series Portable X-ray System is equipped with I.D. tags 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 should contacting LORAD regarding the apparatus become necessary.

Attached to the Control Unit and Tube Head are warning labels. Figure 2-2 illustrates the location of the I.D. tags and warning labels for each assembly of the LPX-160 and LPX-160A.

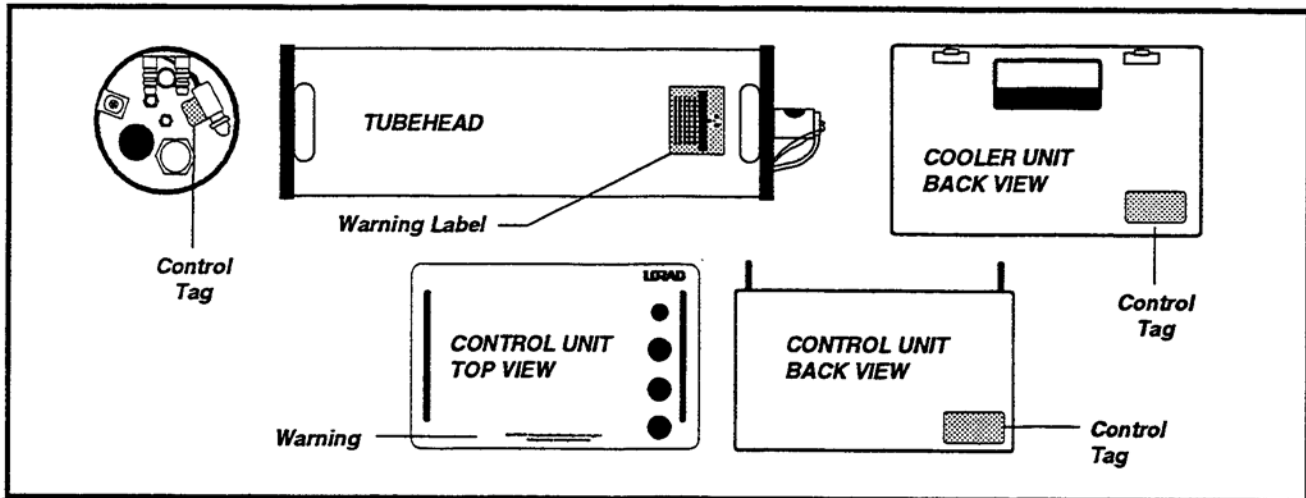


FIGURE 2-2: LOCATION OF WARNING LABELS AND CONTROL TAGS

SECTION TWO

PREPARATION FOR USE AND SHIPMENT

SPECIFICATIONS

The following tables illustrate the physical, operational, and environmental specifications for each component of the LPX-160 and LPX-160A Portable X-ray Units. Conformance with these specifications will ensure maximum system performance, and reduce the chances of mechanical breakdown and personnel hazard.

GENERAL SYSTEM SPECIFICATIONS

The following table outlines the general operating and environmental limits of the LPX-160 Series Portable X-ray Unit.

TABLE 2-1: GENERAL SYSTEM SPECIFICATIONS

Line Voltage *	100 to 130 VAC - 50/60 Hz; 20 amps maximum. 200 to 250 VAC - 50/60 Hz; 10 amps maximum.
Operating Potential	5 to 160 kV @ 0.1 to 5.0 mA.
Duty Cycle	100%
Operating Temperature Range	-30°F to 120°F (Ambient) -34°C to 49°C (Ambient)
Humidity	0 to 100% relative humidity.
Stabilization	kV and mA remain within $\pm 1\%$. Line voltage varied from 100-130/200-250 VAC.
Storage Temperature Range	-65°F to 160°F (-54°C to 71°C).

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

SECTION TWO

PREPARATION FOR USE AND SHIPMENT

GENERAL TUBE HEAD SPECIFICATIONS

The following table outlines the general operating specifications of the Tube Head Assembly.

TABLE 2-2: GENERAL TUBE HEAD SPECIFICATIONS

Physical Specifications	Water Cooled: 7.25" dia. x 28" length - 29lbs (approx) Air Cooled: 7.25" dia. x 30.5" length - 33 lbs (approx)
Anode Cooling System	Recirculating Liquid Cooling unit or Fan Forced Air.
Radiation Output	240 R/minute @ 160 kV, 5.0 mA @ 50 cm unfiltered.
Leakage Radiation	Less than 0.5 R/hour @ 1 meter from target.
Tube Pressure Sense	Monitors pressure of the SF6 gas within the Tube Head. Shuts unit down if pressure falls below 25 psi.
X-ray Tube 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.

OPTIONAL TUBE HEAD SPECIFICATIONS

Table 2-3 supplies specifications for several available Tube Head assemblies. Figure 2-3 illustrates the direction of the X-ray beam for both the 40° cone and the 360° panoramic.

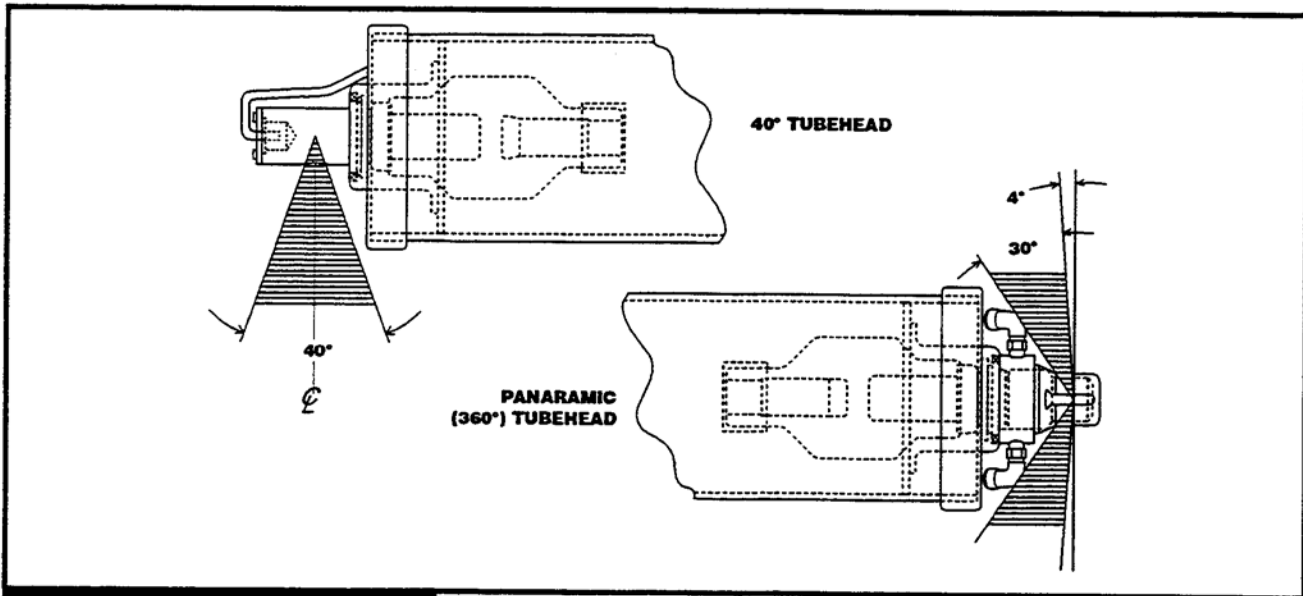


FIGURE 2-3: X-RAY BEAM PATH

TABLE 2-3: OPTIONAL TUBE HEAD SPECIFICATIONS

Tube Head 40° Cone	Air or liquid cooled models; 1.5mm Focal spots; .063 or .020 beryllium window.
Tube Head 360° Panoramic	Liquid cooled, 1.5mm focal spot, 0.6mm nickel window only.

CONTROL UNIT SPECIFICATIONS

Table 2-4 defines the physical and operating specifications of the Control Unit. Outlined are the physical dimensions, indicators, and operating controls of the unit. The controls are explained in detail in Sections 4 and 5 of this manual.

TABLE 2-4: CONTROL UNIT SPECIFICATIONS

kV Control	Analog: Continuously variable knob sets kV level between 0 & 160kV Digital: Pushbutton switches sets kV level between 0 & 160 kV in 1kV increments.
kV Indicator	Analog: Meter with deflecting needle indicator. Digital: LCD Readout on upper display.
mA Control	Analog: Continuously variable knob sets mA level between 0 & 5.0mA Digital: Pushbutton switches sets mA level between 0 and 5.0 mA in 0.1 mA increments.
mA Indicator	Analog: Meter with deflecting needle indicator. Digital: LCD Readout on upper display.
X-Ray ON Switch	Pushbutton switch with radiation symbol. Activates x-ray generation.
X-Ray OFF Switch	Red mushroom type switch terminates x-ray generation. May be depressed anytime while x-rays are being generated.
Key Lock Safety Switch	In the LOCKED OFF position prevents activation of x-ray generation. In the ON position the X-RAY ON switch is enabled.
Exposure Timer	Analog: Digital timer with pushbutton set keys. Digital: LCD readout on upper display.
Weight	35 lbs. (approximate)
Dimensions	12" W x 18" L x 12" H
Power ON Indicator	Analog: Green lamp on front panel. Digital: Yellow LED array on front panel.
X-Ray ON Indicator	Analog: Red lamp on front panel. Digital: Red LED array on front panel.
Interlock Connector	Pins A and B used for enclosure door switches; must be closed to enable the X-RAY ON switch. Pins C and D used for external warning devices

SECTION TWO

PREPARATION FOR USE AND SHIPMENT

COOLING UNIT SPECIFICATIONS

Table 2-5 defines the operating and physical specifications of the Cooling Unit.

TABLE 2-5: COOLING UNIT SPECIFICATIONS

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 "TEXACO" Soluble "D" oil.
Coolant Flow	0.5 gallons per minute @ 50 foot head.
Cooling Unit Connections	Self sealing quick disconnects.

PRE-OPERATIONAL CHECKS AND INSPECTION

The following paragraphs outline the steps to properly check and inspect the LPX-160 Series Portable X-ray unit. Before this system is set up and operated, these procedures must be performed to insure system integrity.

- Step #1** Check the Tube Head gas pressure gauge and verify that the gas pressure is within limits. If the gauge indicates Tube Head gas pressure below 50 psi (pounds per square inch) at 70°F, but is greater than 5 psi, perform the procedures for "Pressurizing the Tube Head". If Tube Head gas pressure is below 5 psi at 70°F, the Tube Head must be purged of all remaining gas, then refilled before operating the unit. The procedures for "Pressurizing" and "Refilling" the Tube Head are outlined in Section 6 of this manual.

*** CAUTION ***

DO NOT operate this unit if Tube Head Pressure is below 50 psi @ 70°F or damage to the Tube Head may occur.

*** NOTE ***

Tube Head gas pressure normally varies ± 1 psi for every 7°F increase or decrease in ambient air temperature.

- Step #2** For liquid cooled units, 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.
- Step #3** Remove the Radiator cap on the Cooling Unit (if applicable) and check that the coolant level is within 1/2" from the top of the reservoir. Add coolant solution at this time if necessary (as described in Section 6 of this manual).
- Step #4** Remove the top cover from the Control Unit perform a thorough visual inspection. Check the four connectors along the right side of the front panel for foreign material and signs of corrosion, then inspect the front panel controls for missing or broken knobs and switches.

SYSTEM SET UP PROCEDURES

Refer to Figures 3-1 and 3-2 while performing the following procedures.

Step #1 On liquid cooled units, connect the twin hose assembly between the Tube Head and the Cooling Unit. The two angled couplings attach to the fittings on the back of the Tube Head, and the couplings on the opposite end attach to the female fittings on the Cooling Unit.

For air cooled units, check that the cooling fan is firmly attached to the anode end of the Tube Head, and that the grill is free of obstruction.

*** 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.

Step #2 Install the Cooling Unit power cable (8 pin connectors) between the Control Unit and the Cooling Unit (Liquid cooled units only). The male end connects to the Control Unit and the female end connects to the Cooling Unit.

For air cooled units, install the fan power cable (8 and 4 pin connectors) between the Control Unit and the back of the Tube Head. The 8 pin end connects to the Control Unit and the 4 pin end connects to the Tube Head.

Step #3 Install the tube control cable (10 pin connectors) between the Control Unit and the Tube Head. The male end connects to the Control Unit and the female end connects to the back of the Tube Head.

Step #4 Install the line power cable between the Control Unit and an AC power outlet. The female end connects to the Control Unit and the male end connects to the AC outlet.

! Warning !

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

* NOTE *

The wall outlet must be rated either 120 VAC, 20 amps, 50/60 Hz or 230 VAC, 10 amps, 50/60Hz. Line voltage selection is automatic. For 220V input application, the male plug on the supplied power cord must be removed and replaced with one that fits the local AC receptacle, or an adapter cable can be locally manufactured. See Figure 3-3 for the correct plug termination.

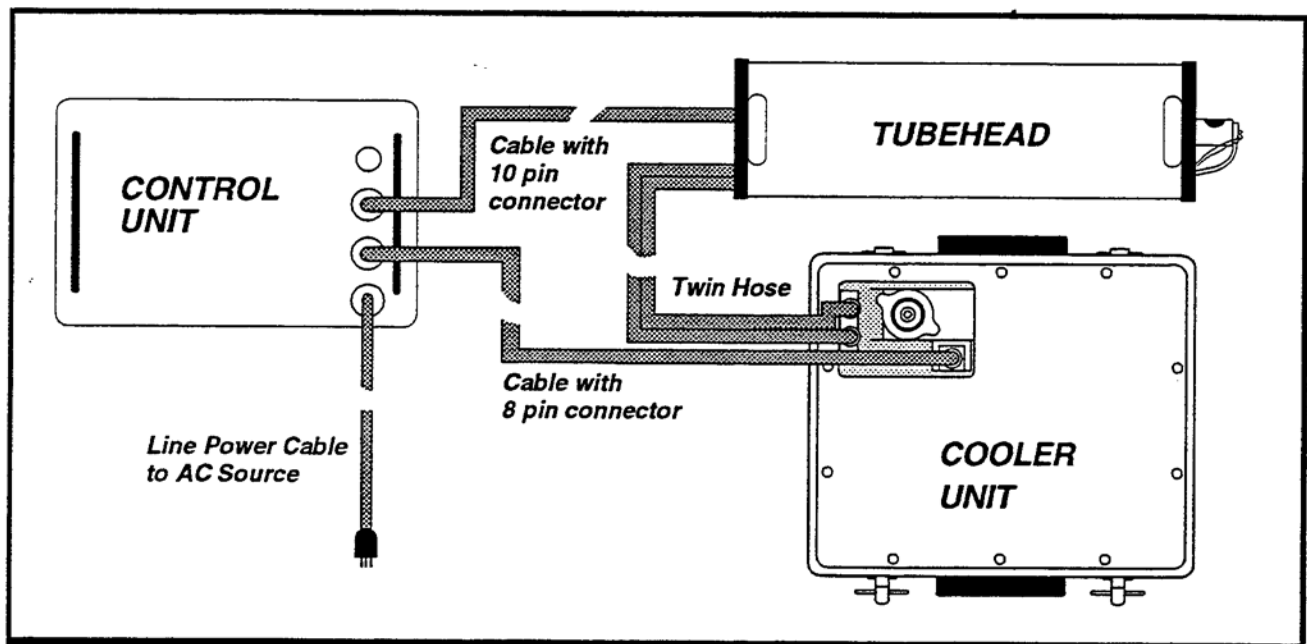


FIGURE 3-1: LPX-160 SERIES SET UP (LIQUID COOLED)

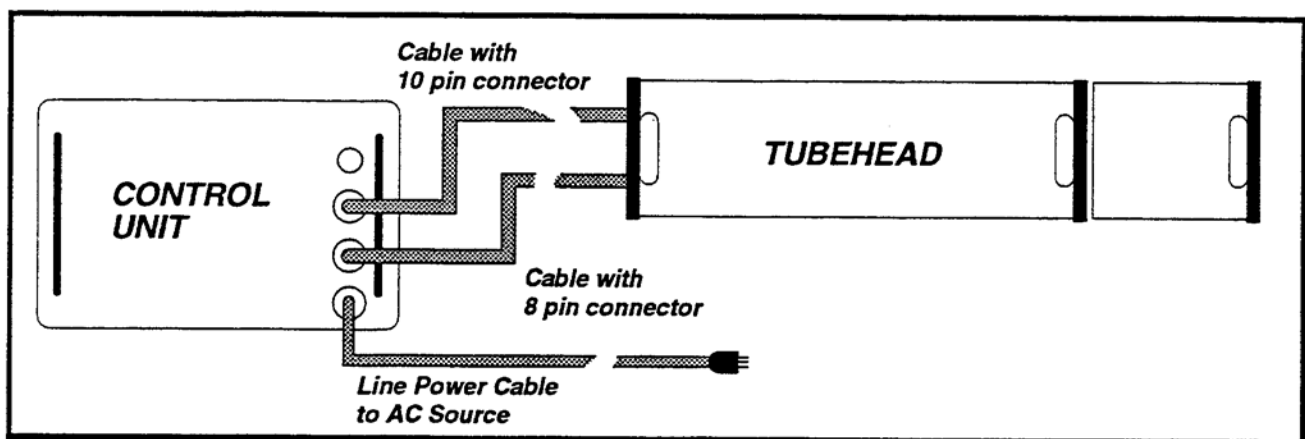


FIGURE 3-2: LPX-160 SERIES SET UP (AIR COOLED)

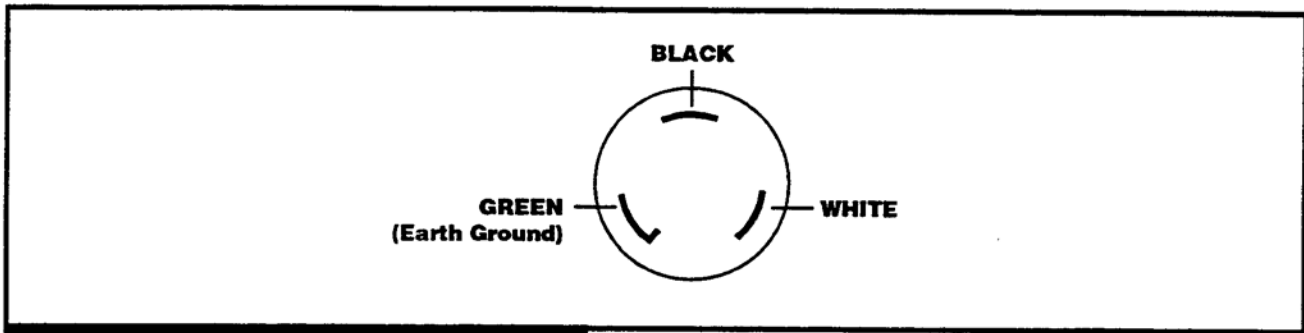


FIGURE 3-3: 220 VOLT PLUG TERMINATION

EXTERNAL INTERLOCK CONNECTIONS

The INTERLOCK connector on the front panel of the Control Unit enables x-ray enclosure doors and/or external warning devices to be interconnected with the internal safety interlock circuitry of the system.

*** NOTE ***

Pins "A" and "B" of the INTERLOCK connector must form a closed circuit in order to operate the X-Ray unit. If no external switch interlocks are incorporated, a jumper (provided) must be installed across pins "A" and "B" to form this closed circuit.

Figure 3-4 illustrates the two circuits provided for this purpose. Pins "A" and "B" are used to connect enclosure door switches. When properly attached, x-rays can only be generated when the enclosure doors housing the Tube Head are shut. Pins "C" and "D" provide a switch closure to operate warning devices such as lights, sirens, or other types of external warning signals. These signals warn all personnel that x-rays are being generated.

! WARNING !

Voltage is present at pins "A" and "B" of the INTERLOCK when the unit is powered up. Ensure power is OFF before making any external connections or while installing the jumper.

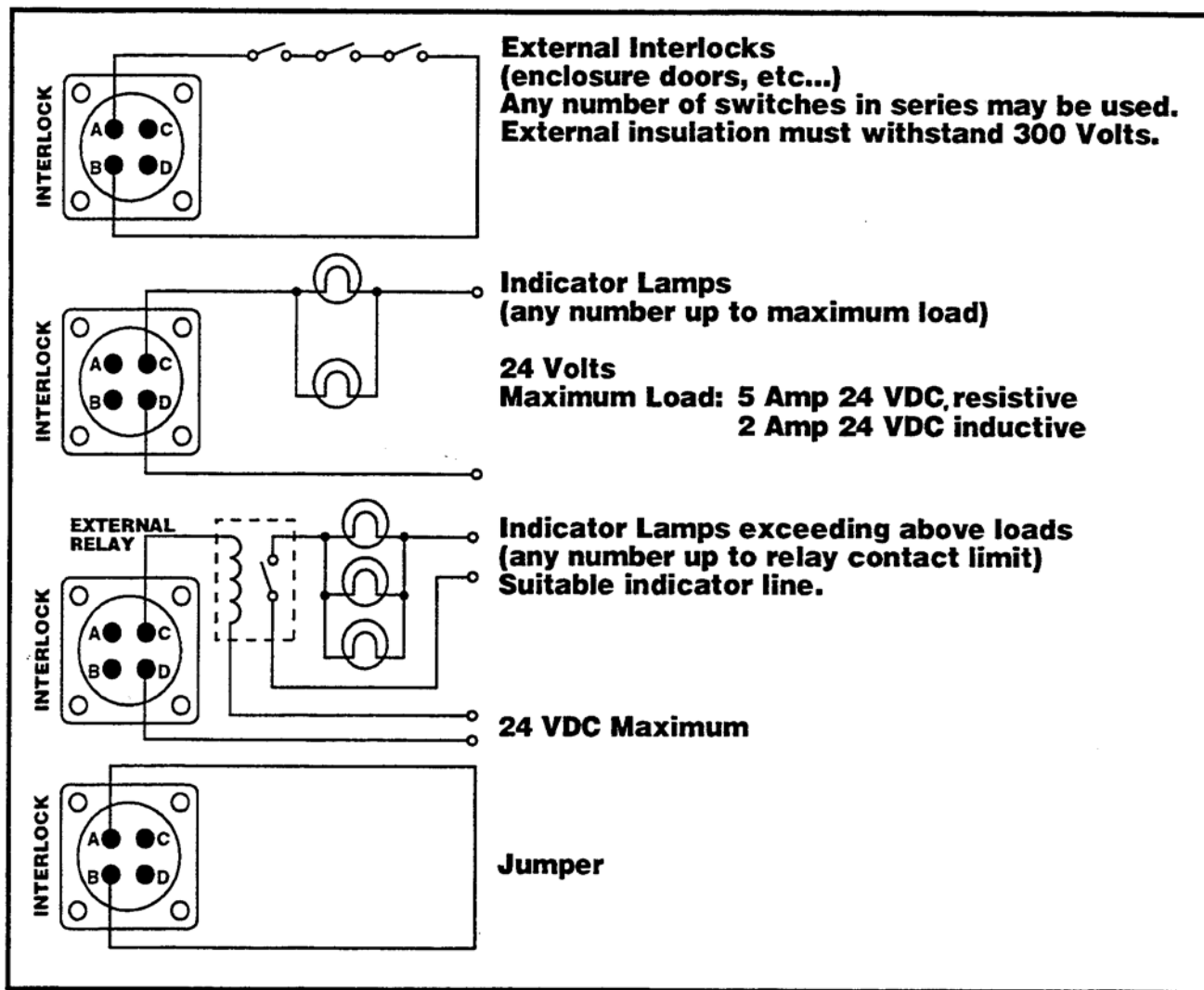


FIGURE 3-4: EXTERNAL INTERLOCK CONNECTIONS

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SECTION FOUR

LPX-160 (DIGITAL) SYSTEM OPERATION

INTRODUCTION

The following paragraphs describe the controls and switches on the control panel of the LPX-160 (Digital) Control Unit. The functions and use of these controls must be thoroughly understood before operating the x-ray unit.

CONTROL UNIT OVERVIEW

The Digital Control Unit's control panel is comprised of two liquid crystal display (LCD) screens, exposure parameter pushbutton control switches, a MAIN POWER circuit breaker, and LED indicators. Military type connectors, along the right side of the panel, are used to connect the input power cord and the system's interconnecting control cables.

THE LIQUID CRYSTAL DISPLAY SCREENS

The Top LCD (Figure 4-1)

The top LCD screen (large screen) displays two rows of exposure parameters. The top row of information displays the exposure parameters set by the operator using the front panel controls. The exposure kV is displayed on the left side of the screen, the mA is displayed near the center, and the exposure duration (TIME) is displayed on the right. The selectable exposure duration can be displayed in minutes and seconds, or in mAs.

The bottom row of information displays the actual operating levels during x-ray emission. The operating kV level is displayed on the left, directly below the set kV level. Tube current is displayed in the center of the screen, directly below the set mA level. At the right side of the screen, directly below the set exposure duration, is the time or mAs remaining or elapsed.

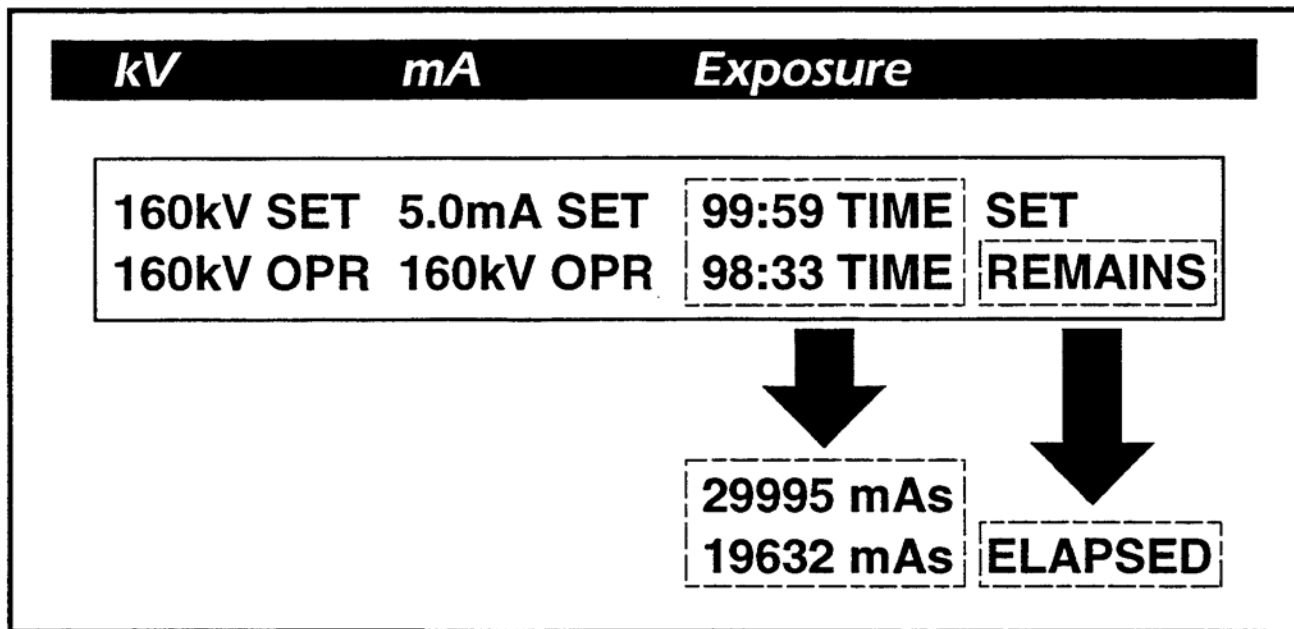


FIGURE 4-1: TOP LCD DISPLAY

SECTION FOUR

LPX-160 (DIGITAL) SYSTEM OPERATION

The Bottom LCD (Figure 4-2)

The bottom LCD screen (small screen) displays the system's operating mode, operator prompts, and any system (fault) messages. The upper left side of the screen indicates the system operation mode or one of the available automatic warm up modes. The lower left side of the screen indicates the selected warm up mode, or any system fault messages.

The right hand side of the screen indicates the current operating status of the system, or if a fault was detected, a description of the fault condition.

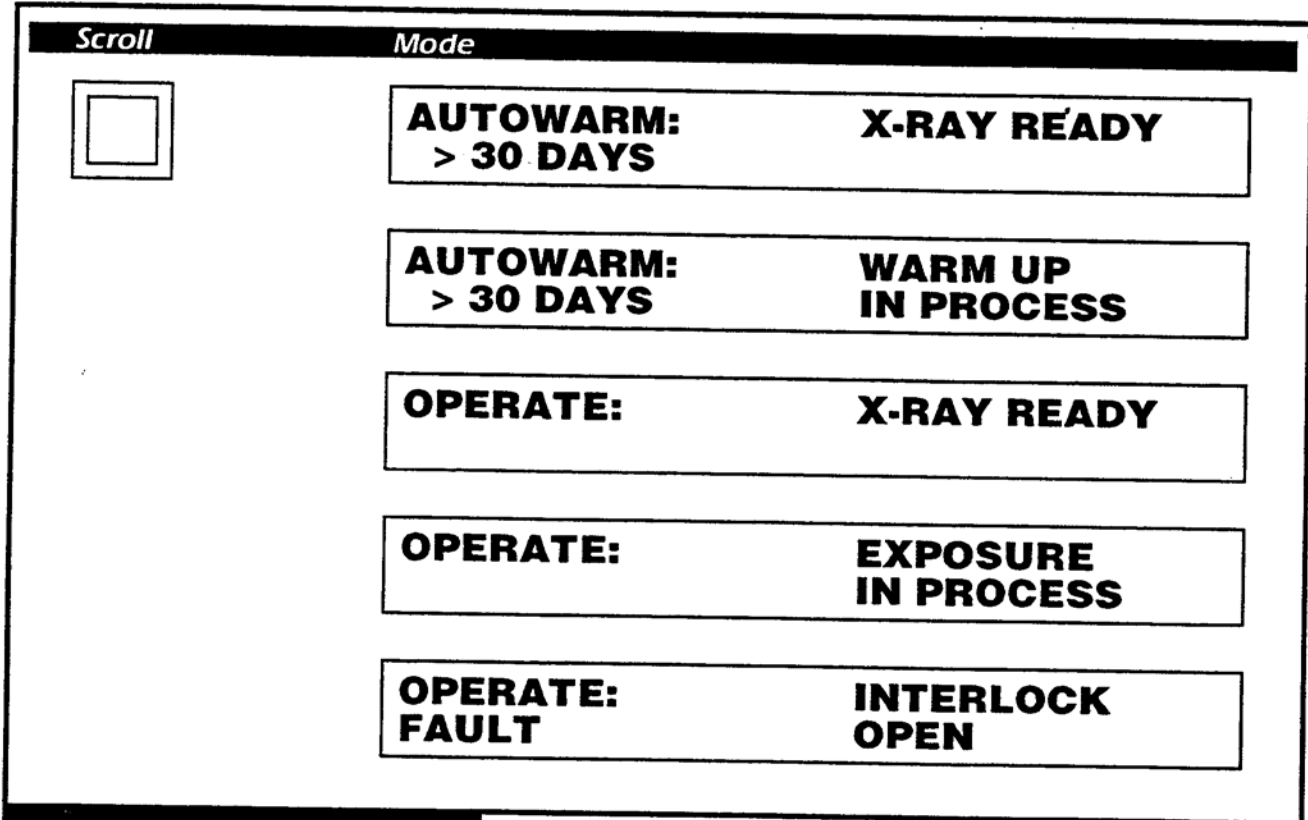


FIGURE 4-2: BOTTOM LCD DISPLAY

FRONT PANEL CONTROLS AND INDICATORS

Refer to Figure 4-3 for the location of each control and indicator while reading this section.

MAINS ON/OFF Switch (1)

The MAINS ON/OFF switch is a two position circuit breaker that applies power to the Control Unit. Placing the MAINS switch in the ON position causes line power to be applied to the Control Unit after a delay of approximately 2 seconds. During this delay the input power detection circuitry determines whether line voltage is 110 or 220, and selects the proper line circuitry. Placing the MAINS switch in the OFF position causes line power to be immediately disconnected from the system. The MAINS switch also acts as the system circuit breaker and will automatically trip off if excessive current is drawn.

MAINS ON Indicator (2)

The MAINS ON indicator is a light emitting diode (LED) array located next to the MAINS ON/OFF switch. This LED glows yellow when line power is applied to the system.

SAFETY Switch (3)

The SAFETY switch, a two position key switch, prevents unauthorized use of the X-Ray Unit. Before x-rays can be generated, the key must be inserted into the switch and rotated to the ON position. The SAFETY switch does not activate x-ray generation, but permits use of the x-ray apparatus. The Tube Head must never be approached with power applied without the SAFETY switch in the LOCKED OFF position and the keys in the possession of the operator.

kV UP/DOWN Control (4)

The kV UP/DOWN controls are pushbutton switches located near the upper left side of the control panel below the upper LCD display. These switches, identified by arrow labels, are used to set the desired exposure kV level. Pressing the UP button (▲) causes the set kV in the upper portion of the LCD window to increment by 1 kV steps, toward 160 kV. Pressing the DOWN button (▼) causes the set kV in the upper portion of the LCD window to decrement by 1 kV steps, toward 0 kV. For rapid change, press and hold the UP or DOWN button. For slow change, press and release the buttons.

These switches are active upon initial system power up, during an exposure in the OPERATE mode, and prior to an exposure provided the Exposure Counter has been reset.

mA UP/DOWN Control (5)

The mA UP/DOWN controls are pushbutton switches, located near the center of the control panel, below the upper LCD display. These switches, identified by arrow labels, are used to set the desired exposure mA level. Pressing the UP button (▲) causes the set mA in the upper portion of the LCD window to increment by 0.1 mA steps, toward 5.0 mA. Pressing the DOWN button (▼) causes the set mA in the upper portion of the LCD window to decrement by 1 mA steps, toward 0 mA. For rapid change, press and hold the UP or DOWN button. For slow change, press and release the buttons.

These switches are active upon initial system power up, during an exposure in the OPERATE mode, and prior to an exposure provided the Exposure Counter has been reset.

EXPOSURE UP/DOWN Control (6)

The EXPOSURE UP/DOWN controls are pushbutton switches, are located near the upper right side of the control panel, directly below the upper LCD display. These switches, identified by the directional arrow labels, are used to set the desired exposure time or mAs value. Pressing the UP button (▲) causes the exposure duration in the upper portion of the LCD window to rise toward the maximum exposure time of 99 minutes and 59 seconds (in the Time mode), or toward 29995 mAs (in the mAs mode). Pressing the DOWN button (▼)

causes the set exposure time or mAs value to decrease. For rapid change, press and hold the UP or DOWN button. For slow change, press and release the buttons.

These switches are active upon initial system power up and prior to an exposure provided the exposure timer has been reset.

UNITS (Time/mAs) Control (7)

The UNITS control is a pushbutton switch, located below the upper LCD display (next to the EXPOSURE UP/DOWN controls), switches between the two exposure duration modes (Time or mAs). When power is applied to the system, the exposure duration mode defaults to TIME. Pressing the UNITS button once switches the mode to mAs, and pressing it yet again switches it back to TIME.

In the TIME mode, the maximum exposure duration is 99 minutes and 59 seconds. In the mAs mode, the Control Unit monitors the operating mA and automatically controls the exposure duration to fulfill the selected number of mAs. No operator time calculations are required. This switch is active upon initial system power up, after an exposure is complete or has been interrupted, or if the exposure timer has been reset.

TIME (Elapsed/Remains) Control (8)

The TIME control is a pushbutton switch, located below the upper LCD display (next to the UNITS control) that switches the selected exposure duration mode between Count Up (Elapsed) or Count Down (Remains) mode. Selecting the Elapsed mode causes the lower line of the exposure display to begin at zero and count upward until the set exposure time or mAs value is reached. Selecting the Remains mode causes the lower line of the exposure display to begin at the set exposure time or mAs value and count down until reaching zero.

The displayed units will be in minutes/seconds or mAs depending on the mode selected. This switch is active at all times when power is applied to the system.

RESET Control (9)

The RESET control is a pushbutton switch, located next to the TIME control, resets the exposure timer. When depressed, the exposure duration (lower row) will either return to the duration set by the operator (Remains mode), or to zero (Elapsed mode). This switch is only active after the exposure has been terminated, either by reaching the set time (or mAs), or having been interrupted by pressing the STOP Button.

SCROLL Control (10)

The SCROLL control, used in conjunction with the MODE display (lower LCD), switches between the OPERATE mode and the five AUTOWARM (warm-up) modes. The OPERATE mode is selected to make radiographs after completing the proper warm up sequence (if warm up is required). One of the five AUTOWARM modes are selected to run up to the required kV level at a fixed rate when the equipment has not been used for a period of time (see "Warm Up Sequence").

X-RAY ON Control (11)

The X-RAY ON control, identified by the radiation symbol, starts x-ray generation. The SAFETY KEY SWITCH must be turned to the ON position for this switch to activate.

X-RAY ON Indicator (12)

The X-RAY ON indicator is a light emitting diode (LED) array located next to the X-RAY ON control. This LED glows red when x-rays are being generated.

X-RAY OFF Control (13)

The X-RAY OFF control (large, red pushbutton switch), near the bottom of the control panel, terminates (interrupts) the x-ray exposure. This switch can be depressed anytime during the exposure, at which time power to the x-ray tube is discontinued, the exposure counter stops, and the red X-RAY ON LED array extinguishes. The timer will continue to display the exposure time (elapsed or remaining), or the mAs value until the START button is again depressed to resume the interrupted exposure, or the RESET control is pressed to set the time for a new exposure.

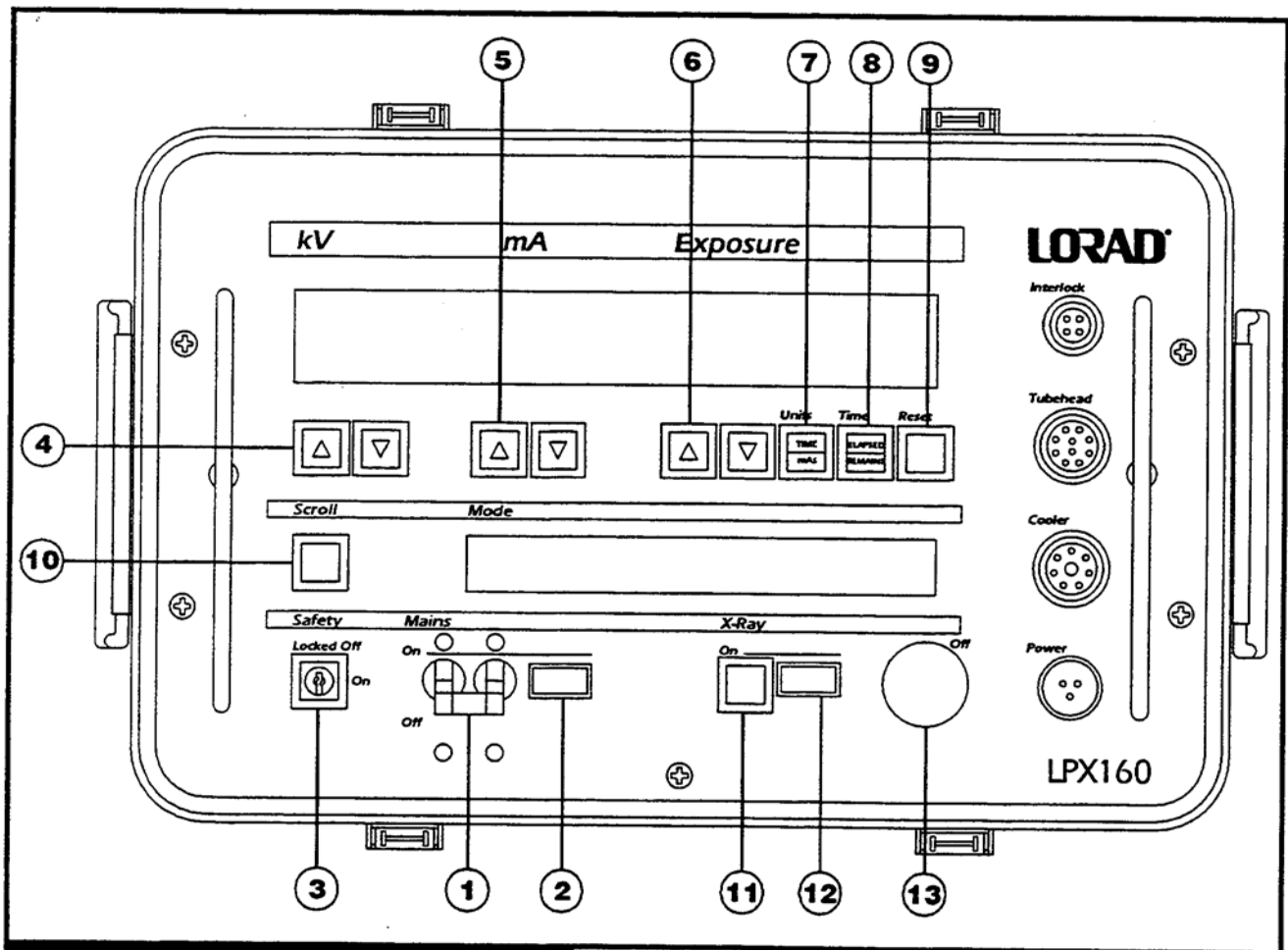


FIGURE 4-3: CONTROLS AND INDICATORS

SECTION FOUR

LPX-160 (DIGITAL) SYSTEM OPERATION

X-RAY TUBE WARM UP

The X-ray tube provided with this system has been pre-aged by the original manufacturer, and further tested and aged by LORAD. 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. The LPX-160 (Digital) has an AUTOWARM feature, which allows the operator to select and initiate one of five automatic warm-up sequences.

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 un-shielded, outdoor operating conditions, the Control Unit must be placed a considerable distance from the Tube Head. 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.

Using the Autowarm Feature

This procedure is required whenever the tube is operated above 100 kV, and four hours have elapsed since the x-ray tube was operated at the level required for the next exposure, or when operating with a new tube having less than ten hours of operation. The AUTOWARM modes automatically set the run-up level to 160 kV, but it is only necessary to run the tube to the kV level required for the next exposure. Tubes having been previously operated, but not run over 100 kV for 30 days or longer, must be treated as new tubes.

The following procedures outline the steps to properly complete the x-ray tube warm up sequence. Table 4-1 relates the tube's inactive time to the required AUTOWARM mode.

Step #1 Rotate the lead shield on the anode of the Tube Head until the window is completely blocked. This reduces the amount of x-rays emitted during the warm up sequence.

! WARNING !

Although the window is blocked, the Tube Head **MUST NOT** be approached during the warm up process. The area must be surveyed to assure adequate radiation limits. All applicable safety precautions must be observed.

Step #2 Check that all interlock connections are closed, or the jumper is installed across pins "A" and "B" of the INTERLOCK connector.

Step #3 Place the MAINS circuit breaker ON. Select the appropriate AUTOWARM mode, as outlined in the table below, by depressing the SCROLL pushbutton until the appropriate AUTOWARM mode is displayed on the lower LCD screen.

SECTION FOUR

LPX-160 (DIGITAL) SYSTEM OPERATION

! WARNING !

The system is now capable of generating x-rays.
All unauthorized personnel must be clear of the
area, and all warning devices must be activated.

TABLE 4-1: AUTOWARM Modes

MODE	DESCRIPTION
> 30 DAYS:	This mode is used when the Tube Head has not been operated at the 160 kV level within the last 30 days. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 2 minutes at that level, the kV automatically rises 5 kV. These steps are automatically repeated every 2 minutes until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.
7 - 30 DAYS:	This mode is used when the Tube Head has not been operated at the 160 kV level for at least 7 days but not more than 30 days. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 1 minute at that level, the kV automatically rises 5 kV. These steps are automatically repeated every 1 minute until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.
16 HRS. - 7 DAYS:	This mode is used when the Tube Head has not been operated at the 160 kV level for at least 16 hours but not more than 7 days. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 1 minute at that level, the kV automatically rises 10 kV. These steps are automatically repeated every 1 minute until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.
8 - 16 HOURS:	This mode is used when the Tube Head has not been operated at the 160 kV level for at least 8 hours but not more than 16 hours. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 1 minute at that level, the kV automatically rises 20 kV. These steps are automatically repeated every 1 minute until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.
4 - 8 HOURS:	This mode is used when the Tube Head has not been operated at the 160 kV level for at least 4 hours but not more than 8 hours. Upon activation, the kV level rises to 100 kV and the mA to 5.0. After 1 minute at that level, the kV automatically rises 30 kV. These steps are automatically repeated every 1 minute until 160 kV is reached. X-ray generation is then terminated and the MODE display reads: OPERATE: X-RAY READY.

SECTION FOUR

LPX-160 (DIGITAL) SYSTEM OPERATION

- Step #4** Start the AUTOWARM sequence by pressing and holding the X-RAY ON button for approximately 3 seconds, and then release it. Allow the selected AUTOWARM sequence to operate up to the kV level required for the ensuing exposure.
- Step #5** When the system increments to the next kV level, press the STOP button. The Mode Display will indicate OPERATE: X-RAY READY. If the ensuing exposure is to be operated at 160 kV, simply let the AUTOWARM mode continue (do not press the STOP button). When the sequence completes the warm-up at 160 kV, the lower LCD screen automatically displays the message OPERATE: X-RAY READY.
- Step #6** Turn the SAFETY SWITCH to the LOCKED OFF position and remove the key. Rotate the lead shield on the Tube Head's anode to expose the window. X-ray exposures at the kV level warmed up to can now be safely made.

* NOTE *

In all five AUTOWARM modes, if any tube instability is detected, as might occur with a new tube, x-ray generation is automatically stopped and the MODE window displays "FAULT ARC RESTART". The operator should then reactivate x-ray generation. The kV level will then rise to a level 20 kV below where the instability was detected and operate for two minutes. After two minutes, the kV level advances to the next highest incremental kV level on the selected warm-up schedule, and the AUTOWARM sequence continues normally from that point.

LPX-160 (DIGITAL) OPERATING PROCEDURES

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.

- Step #1** If the operator has not read the "SAFETY SUMMARY" in Section 1, and the WARNINGS outlined under "Pre-Operational Safety Precautions" in this section, do so before proceeding.

SECTION FOUR

LPX-160 (DIGITAL) SYSTEM OPERATION

- Step #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 Tube Head before power is applied to the System.

- Step #3** Make sure the SAFETY KEYSWITCH is in the LOCKED OFF position, then remove the key. Turn the MAINS switch ON. After approximately 2 seconds, the yellow MAINS LED indicator will illuminate, the Cooling Unit or fan (on air cooled units) will start, the Control Unit's cooling fan will start, and information will appear in the upper and lower LCD screens.
- Step #4** If the LPX-160 is to be operated above 100 kV and it has been more than four hours since it was last operated at that level, or if operating with a new x-ray tube, it is necessary to perform the appropriate warm-up procedure (outlined earlier in this section). If the warm-up procedure is unnecessary, proceed to Step #5.
- Step #5** Press the SCROLL pushbutton until the lower LCD display indicates "OPERATE: X-RAY READY". Set the desired kV and mA levels using the appropriate UP/DOWN controls. Set the desired exposure duration using the EXPOSURE UP/DOWN controls.
- Step #6** 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 LPX-160 is now ready to make an exposure. Press the X-RAY ON switch to begin the exposure.

! 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 run up to the maximum value it can produce at the set kV level, up to 5 mA. At no time, however, should the tube be permitted to operate above 5 mA. Lower kV settings (settings below 20kV) will not permit the tube to generate the full 5 mA.

- Step #7** 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 pushbutton. To restart an interrupted exposure, press the X-RAY ON switch.
- Step #8** 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. Press the RESET button. To repeat the exposure, re-insert the key and turn it to the ON position and press the X-RAY ON button. If the next exposure requires new parameters, press the appropriate UP/DOWN switches at this time to set in the new factors, then turn the key to the ON position and press the X-RAY ON switch.
- Step #9** If further operation is not necessary, turn the key to the LOCKED OFF position and remove it. Allow the Cooling Unit, or cooling fan (air cooled units) to operate for an additional five minutes.

*** NOTE ***

The Cooling Unit or 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.

- Step #10** After the five minute cool down period, place the MAINS circuit breaker OFF. 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.

LPX-160 (DIGITAL) FAULT MESSAGES

During operation, if a fault condition occurs, x-ray generation is automatically terminated and FAULT messages will appear in the MODE display (lower LCD). The following is a list of the fault messages that may appear and instructions on how to remedy the fault.

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.

FLOW:

Coolant flow from the Cooling Unit to the Tube Head has been interrupted. Check that the Cooling Unit is running, or that the twin coolant hose is properly attached.

TEMPERATURE/PRESSURE:

The Tube Head has overheated or the gas pressure has dropped below 25 psi. Make sure the Cooling Unit (liquid cooled units) or the cooling fan (air cooled units) is working properly. Check the gas pressure within the Tube Head. If the pressure is below 25 psi @ 70°F, perform the Re-pressurization/Re-Filling procedures in Section 6 of this manual.

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.

EXCESS kV:

This condition occurs if the drive voltage to the high voltage inverter (in the Control Unit) exceeds a factory set level. If the Excess kV fault occurs repeatedly after restart, service is necessary.

X-RAY SW. ERROR:

Upon power up the computer checks the X-RAY ON button for a short circuit and displays this message if a short is detected. X-ray generation cannot be initiated in this condition. Service is necessary.

INTRODUCTION

The following paragraphs describe the controls and switches on the control panel of the LPX-160A (Analog) Control Unit. The functions and use of these controls must be thoroughly understood before operating the x-ray unit.

Power ON/OFF CIRCUIT BREAKER (1)

The CIRCUIT BREAKER is the main power switch for the entire unit. When placed ON, AC power is applied to the Control and Cooling Units. Applying power to the system causes the timer's LED display to illuminate immediately and the green POWER ON lamp to illuminate after an approximate 2 second delay.

*** NOTE ***

The CIRCUIT BREAKER does not activate x-ray generation. X-rays can only be produced when the CIRCUIT BREAKER is on, the SAFETY SWITCH is on, and the appropriate interlock circuitry is interlocked.

Exposure Timer (2)

The exposure timer is used to set the time duration of the x-ray exposure. The timer is factory set to provide a maximum exposure time of 99 minutes and 59 seconds (example: 3030 indicates an exposure time of 30 minutes and 30 seconds). The exposure time is set by depressing the small push-buttons located on the upper (+) and lower (-) portion of the timer mechanism.

*** NOTE ***

The maximum exposure time can be changed by following the procedures in Section 6 of this manual.

After the exposure time is entered, the RESET button is pressed to initialize the timer. This places the exposure time in the TIME REMAINING digits of the LED display. Activating x-ray generation causes the illuminated digits to begin counting down toward 0000. Power to the Tube Head is discontinued when the timer reaches 0000, ending the exposure.

A different exposure duration can be set for the next exposure using the timer pushbuttons, then pressing the RESET button. If the subsequent exposure requires the same exposure duration, depress the RESET button after the exposure to return the previous exposure time to the time remaining digits.

kV CONTROL KNOB (3)

The kV CONTROL KNOB is used to set the kV level for the x-ray tube between 0 kV and 160 kV. Rotating this knob clockwise increases the kV level; rotating it counter-clockwise decreases the kV level. It is imperative that the proper warm up procedures are performed before taking exposures to prevent damage to the Tube Head. These procedures are contained in this section.

kV METER (4)

The kV Meter indicates the operating kV level during x-ray generation. Activating the X-RAY ON button causes the needle to slowly rises to the pre-set kV level. Instability is detected by monitoring fluctuations of this meter.

mA CONTROL KNOB (5)

The mA CONTROL KNOB is used to set the exposure mA level for the x-ray tube between 0 and 5.0 mA. Rotating the knob clockwise increases the mA level; rotating it counter-clockwise decreases the mA level. It is imperative that the proper warm up procedures are performed before taking exposures to prevent damage to the Tube Head. These procedures are contained in this section.

mA METER (6)

The mA Meter indicates the operating mA level during x-ray generation. Activating the X-RAY ON button causes the needle to slowly rises to the pre-set mA level. Instability is detected by monitoring fluctuations of this meter.

X-RAY ON Button (7)

The X-RAY ON button is the black push-button switch identified by the x-ray symbol. When the exposure parameters are set (kV, mA, and exposure time), depressing this button initiates x-ray generation provided the SAFETY SWITCH is ON, and pins "A" and "B" of the INTERLOCK connector are interconnected.

Pressing the X-RAY ON button causes the red X-RAY ON lamp to illuminate, the kV and mA meters to slowly ramp up to their set levels, and the exposure timer to count down toward 0000. X-ray generation can be interrupted anytime by pressing the red X-RAY OFF button.

X-RAY OFF Button (8)

The X-RAY OFF button (large, red push-button) is used to terminate (interrupt) the x-ray exposure. This button can be pressed any time during the exposure, at which time, power to the x-ray tube is discontinued, the exposure timer stops counting down, and the red X-RAY ON lamp extinguishes. The timer will continue to display the remaining exposure time until x-ray generation is resumed (by pressing the X-RAY ON button), or the timer is reset.

SAFETY SWITCH (9)

The SAFETY SWITCH is a key-type lock to prevent unauthorized use of the x-ray unit. Before x-rays can be generated, the key must be placed in the lock, and the switch rotated to the ON position. The SAFETY SWITCH does not activate x-ray generation, but permits use of the x-ray apparatus. With power applied to the system, the Tube Head must never be approached without the SAFETY SWITCH placed in the OFF position and the keys in the possession of the operator.

LED Indicators (10)

LED's along the right side of the control panel glow green to indicate adequate coolant flow, acceptable Tube Head temperature, and actuated interlock circuits.

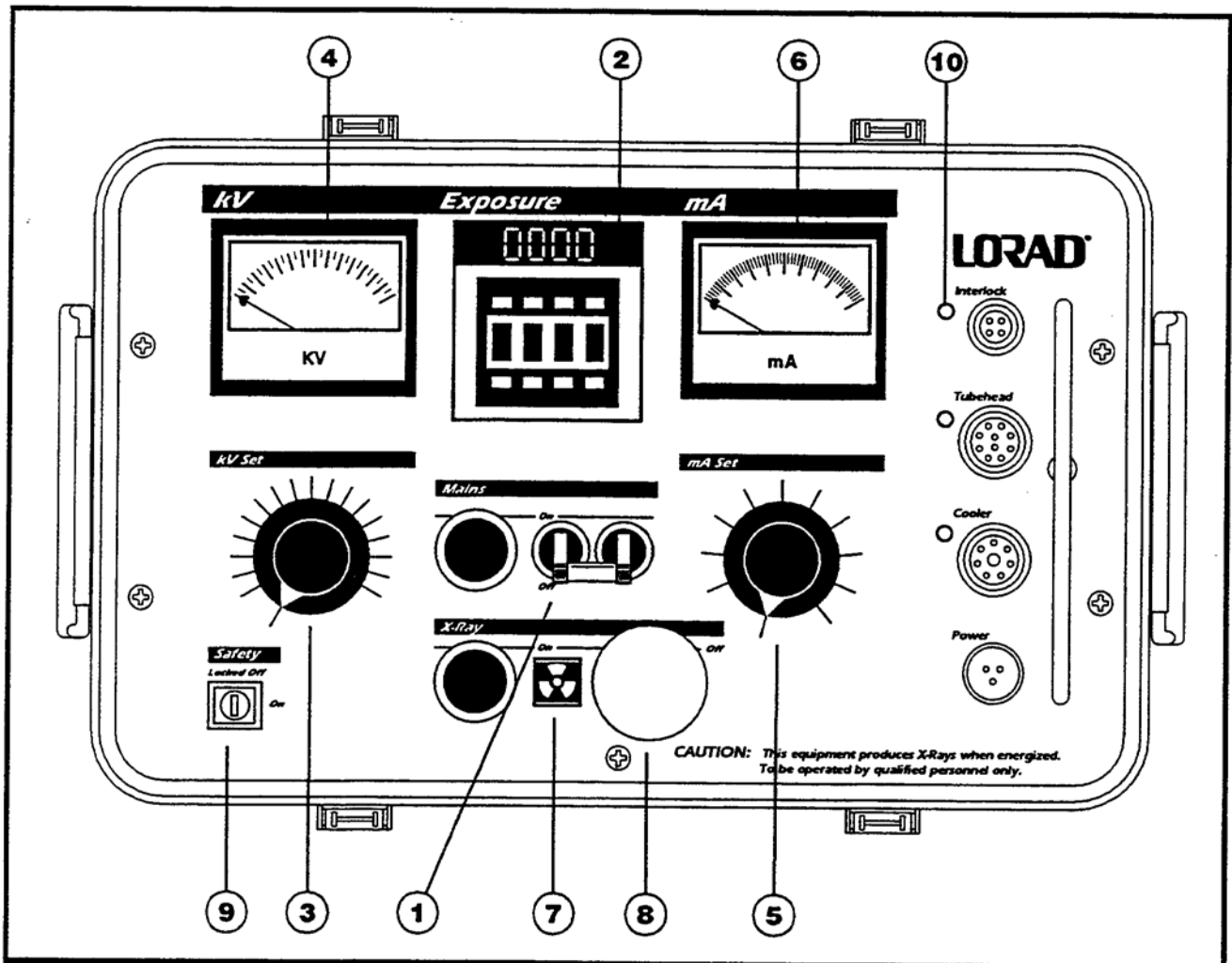


FIGURE 5-1: LPX-160A (ANALOG) CONTROLS AND INDICATORS

SECTION FIVE

LPX-160 (ANALOG) SYSTEM OPERATION

X-RAY TUBE WARM UP

The x-ray tube provided with this system has been pre-aged by the original manufacturer, and further tested and aged by LORAD. 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. This run up time is referred to as the "Warm Up Sequence" and is outlined below.

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 un-shielded, outdoor operating conditions, the Control Unit must be placed a considerable distance from the Tube Head. 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 !

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 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 !

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 Sequence

This procedure is required whenever the tube is operated above 100 kV, and four hours have elapsed since the x-ray tube was operated at the level required for the next exposure, or when operating with a new tube having less than ten hours of operation. It is only necessary to run the tube to the kV level required for a particular exposure. Tubes having been previously operated, but not run over 100 kV for 30 days or longer, must be treated as new tubes.

The following procedures outline the steps to properly complete the x-ray tube Warm Up Sequence. Table 5-1 relates the tube's inactive time to the required warm up rate, and must be used while performing the warm up sequence.

Step #1 Rotate the lead shield on the Tube Head's anode until the window is completely blocked to reduce the amount of x-rays emitted during the warm up process.

! WARNING !

Although the window is blocked, the Tube Head **MUST NOT** be approached during the warm up process. All applicable safety precautions must be observed.

Step #2 Check that all interlock connections are closed, or the jumper is installed across pins "A" and "B" of the INTERLOCK connector.

Step #3 Place the power CIRCUIT BREAKER to the ON position. To ensure enough time to complete the warm up process, set the exposure timer to 60 minutes (6000), and initialize the timing circuitry by depressing the RESET button.

SECTION FIVE

LPX-160 (ANALOG) SYSTEM OPERATION

TABLE 5-1: X-ray Tube Warm Up Rates

Time Inactive Above 100 kV	Warm Up Rate @ 5.0 mA
4 to 8 hours	Starting at 100 kV, 1 minute at every 30 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 minute at every 5 kV interval until desired kV level is attained.

Step #4 Set the kV CONTROL KNOB to 100 kV and the mA CONTROL KNOB to 5 mA as specified in Table 5-1. Insert the key into the SAFETY SWITCH and rotate it to the ON position.

! WARNING !

**The system is now capable of generating X-rays.
All unauthorized personnel must clear the area,
and all warning devices must be activated.**

Step #5 Press and hold the X-RAY ON button for approximately 3 seconds, then release it. Allow the system to operate for the time specified in Table 5-1. When time interval for this kV level has elapsed, slowly rotate the kV CONTROL KNOB to the next kV interval. Continue this process until reaching the required operating kV level.

*** NOTE ***

The system must be allowed to warm up at the operating kV level for the time interval specified in Table 5-1.

- Step #6** When the tube is warmed up through the operating kV level, the warm up sequence is complete. Press the STOP button and remove the key from the SAFETY LOCK.
- Step #7** Rotate the lead shield on the Tube Head to expose the window, and set the required exposure duration on the timer. X-ray exposures at the kV level warmed up to can now be safely made.
- Step #8** If a subsequent exposure requires a higher kV setting, the kV should be advanced at the rate specified in Table 5-1 until the desired kV level is achieved.

* NOTE *

During the Warm Up Sequence, the operator must watch the kV and mA meters. If erratic needle movements (signs of instability) are observed, reduce the kV Control 20kV below the point where instability was first observed, then, in 5kV increments every 2 minutes, increase the kV to the previous setting, then continue the Warm Up Sequence.

LPX-160A OPERATING PROCEDURES

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 procedures below.

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

- Step #1** If the operator has not read the "SAFETY SUMMARY" in Section 1, and the WARNINGS at the beginning of this section, do so before proceeding.
- Step #2** All pre-operational checks and inspections must be complete before operating this unit. Also, confirm all external interlock connections are closed, or the jumper is inserted into the INTERLOCK connector.

! WARNING !

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

- Step #3** Make sure the SAFETY SWITCH is in the OFF position and the key is removed. Place the power CIRCUIT BREAKER to the ON position. The timer's LED display will illuminate immediately; and after a 2 or 3 second delay, the green POWER ON lamp will illuminate, and the fan within the Control Unit will operate.
- Step #4** Make sure that the motor within the Cooling Unit is operating, and there are no leaks along the length of the twin hose assembly. For air cooled Tube Heads, make sure that the fan on the Tube Head's anode is turning.
- Step #5** If the x-ray tube has not been operated in the previous four hours, and is to be operated above 100 kV, or if utilizing a new tube (x-ray tubes with less than 10 hours of operation), complete the Warm Up Sequence outlined earlier. If the Warm Up Sequence is unnecessary, proceed to step #6.
- Step #6** Set the exposure timer to the desired exposure duration by depressing the (+) or (-) push buttons above and below each mechanical digit. The minutes are displayed by the two left hand digits and can be set between 0 and 99 minutes. The seconds are displayed by the two right hand digits and can be set between 0 and 59 seconds. (The above time settings assume the timer is configured to the factory's original arrangement. See Section 6 for additional timer configurations).

If the digits assigned as seconds are set to exceed 59, the additional value is disregarded. Initializing the timer (pressing RESET) causes a 5 to appear as the third digit of the LED display. The fourth digit indicates the number originally set. (Example: mechanically setting 3061 appears as 3051 on the LED display).

- Step #7** Initialize the timer by pressing the RESET button on the right side of the timer. The LED display will show the exposure duration set on the mechanical digits.

To reset the timer for subsequent exposures requiring the same exposure duration, press the RESET button before proceeding. If a different exposure time is required, the mechanical digits must be set to the new exposure time, and the RESET button pressed to initialize the timer.

* NOTE *

The timer in this x-ray unit provides several timing options. The range of the timer can be configured by following the steps outlined in Section 6 of this manual.

SECTION FIVE

LPX-160 (ANALOG) SYSTEM OPERATION

- Step #8** Set the kV and mA CONTROL KNOBS to the appropriate levels for the exposure. Position the film holder and Tube Head for the ensuing exposure. Insert the key into the SAFETY SWITCH and rotate it to the ON position. The unit is now prepared for x-ray generation.

! WARNING !

At this time, all personnel must be well clear of the hazardous x-ray area. Ensure all external warning devices are working properly before proceeding.

- Step #9** Start the exposure by pressing the X-RAY ON button and holding it down for approximately 3 seconds, then release it. The red X-RAY ON lamp will illuminate, indicating the Tube Head is energized. The mA and kV meters will gradually rise to the levels set by their respective control knobs.

! 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 run up to the maximum value it can produce at the set kV level, up to 5 mA. At no time, however, should the Tube be permitted to operate above 5 mA. Lower kV settings (settings below 20kV) will not permit the tube to generate the full 5 mA.

- Step #10** X-ray emission can be terminated any time during the exposure by pressing the red X-RAY OFF button. This causes the red X-RAY ON lamp to extinguish, the kV and mA meters to drop to 0.0, the timer to stop counting down (displaying the remaining exposure time), and the Tube Head to stop producing x-rays.

To resume x-ray generation, press the X-RAY ON button for approximately 3 seconds. The exposure will continue from the point where it was interrupted (provided the timer is not RESET).

Step #11 When the exposure is complete, the unit automatically stops generating x-rays. The timer's LED display indicates 0000, the kV and mA meters return to 0, and the red X-RAY ON lamp extinguishes. If further operation is not necessary, remove the key from the SAFETY SWITCH, turn the kV and mA controls to 0, and allow the Cooling Unit (or fan on the air cooled units) to operate for an addition five minutes.

*** CAUTION ***

The Cooling Unit or cooling fan must be allowed to operate for five minutes after the completion of the x-ray exposure before turning the unit OFF. This allows sufficient time to dissipate the heat generated at the anode during operation.

Step #12 After the five minute cool down period, place the power CIRCUIT BREAKER 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.

INTRODUCTION

The LPX-160 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 section 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 attention only when the need arises (re-pressurizing or re-filling the Tube Head).

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 weekly.

*** 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 6-1: Tube Head Checklist

Pressure Gauge	Gauge in good condition; gas pressure 50 psi @ 70°F.
Gas Valve Cap	Securely fastened to charging valve.
Twin Hose Connectors	Check for dents, nicks, or corrosion; hose couplings seat properly.
Cable Connector	Ensure all pins are straight; check for corrosion or debris; check condition of threads.
Tube Head Handles	Check for cracks or breaks.
Lead Shield	Check for cracks or dents; ensure shield rotates freely.
Tube Head Housing	Paint finish in good condition; check for dents and visible damage.

Table 6-2: Control Unit Checklist

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.
kV and mA Controls	Knobs rotate freely; check for cracked or broken knobs.
Indicator Lamps	Illuminate when activated.
Exposure Timer	(+) and (-) buttons operate; LED display illuminates; RESET button operates.
Fan	Operates when power is applied.

Table 6-3: Cooling Unit Checklist

Coolant Level	Radiator cap can be easily removed; fluid level within 1/2" from top.
Radiator *	Check for cleanliness; check for dents, cracks or damage.
Hoses *	Hose clamps firmly attached; check for cuts, cracks or dry rot.
Drive Belt *	Check for cracks or frayed areas; check for proper belt tension.
Air Filter *	Check for cracks or visible damage; check for cleanliness.
Pump Assembly *	Rotates freely; check for signs of leakage.
Motor and Fan *	Rotates freely; check for dents or cracks.

(* Equipment Covers must be removed to perform inspection.)

Table 6-4: Interconnecting Cables and Hose Checklist

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.
Hose Couplings	Couplings secured firmly to hose; check for corrosion or blockage.
Hoses	Check hoses for cracks or punctures; check for visible signs of leakage.

CLEANING THE LPX-160 SERIES X-RAY UNIT

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.

The following paragraphs describe the materials and the steps needed to clean the LPX-160 Series x-ray unit.

Required Cleaning Materials

1. Clean lint free cloths;
2. Mild detergent;
3. 1" soft bristled paint brush;
4. Electronic cleaning solution;
5. Acid brushes;
6. Low pressure air station, hose and nozzle set.

Cleaning the X-Ray Unit

! WARNING !

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

- Step #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, Control Unit, and Cooling Unit.
- Step #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.

*** CAUTION ***

DO NOT allow any water to enter the cable jackets or connectors when cleaning the equipment. Always wring out any excess water from the cloth.

- Step #3** Remove the Control and Cooling units from their respective cases by first removing the bolts from the bottom of the case, then removing the screws from the top panel. Carefully lift the entire unit out of the case. Using a low pressure air and nozzle system, blow any dirt, dust, or debris out of the unit. Insert the Control and Cooling units back into their respective cases and re-assemble.

*** NOTE ***

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

- Step #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.
- Step #5** The air filter within the Cooling Unit is washable and should be cleaned periodically. Refer to the procedures outlined under "Cooling Unit Upkeep" later in this section.

TUBE HEAD UPKEEP

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 and Re-filling 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.

Re-Pressurizing the Tube Head Assembly

This x-ray unit can be safely operated at Tube Head pressures as low as 50 psi @ 70°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 procedures below outline re-pressurizing the Tube Head to 50 psi with dry sulfur hexafluoride gas at 70°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 6-1 and 6-2 while performing these procedures.

*** CAUTION ***

DO NOT re-pressurize if Tube Head pressure has fallen below 5 psi @ 70°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. Note the differences between re-pressurizing and re-filling the Tube Head.

*** NOTE ***

A charger and maintenance kit for the Tube Head is available, and can be purchased through LORAD (see "Optional Equipment Checklist" in Section 2 of this manual).

- Step #1** Remove the protective cover from the SF₆ (sulfur hexafluoride) 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. The cylinder must be chained to a stationary post or otherwise secured against tipping.

- Step #2** Connect the SF₆ charging regulator assembly (6), or equivalent, to the SF₆ cylinder valve.

* NOTE *

The pressure regulator supplied with the optional LORAD 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 aging, and/or various ambient temperatures, this setting may need to be updated.

- Step #3** Connect the Tube Head (1) to the regulator assembly (6) using the hose (8), as shown in Figure 6-1. Leave the SF₆ cylinder closed at this time. For this procedure, hose (9), and pump (10) are not required.
- Step #4** Open the vacuum line valve (7) slightly, to purge the hose (8) of standing air. Open the SF₆ gas cylinder slightly to purge the regulator of any standing air. Now close the vacuum line valve (7), and open the SF₆ cylinder valve (3) to its fully open position (against its physical stop).
- Step #5** The Tube Head will begin filling with SF₆. When the Tube Head gauge indicates the correct pressure, close the SF₆ cylinder valve (3). To determine the correct pressure, refer to the "Pressure vs. Temperature" chart (Figure 6-2).
- Step #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.

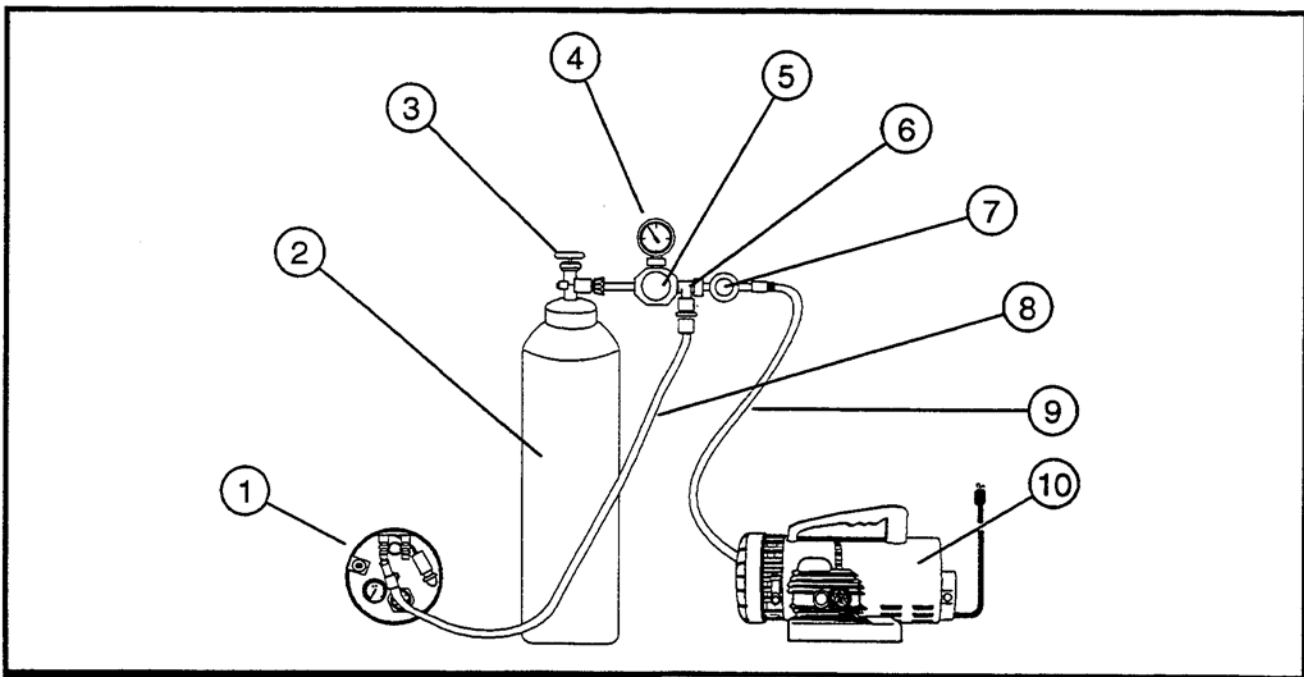


FIGURE 6-1: TUBE HEAD PRESSURIZATION SET UP

Re-Filling the Tube Head Assembly

This procedure is used when gas pressure within the Tube Head has dropped below 5 psi @ 70°F. To re-fill the Tube Head, follow the procedures outlined below while referring to Figure 6-1 and 6-2.

- Step #1** Remove the protective cover from the SF₆ (sulfur hexafluoride) 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. The cylinder must be chained to a stationary post or otherwise secured against tipping.

- Step #2** Connect the SF₆ charging regulator assembly (6), or equivalent, to the SF₆ cylinder valve.

*** NOTE ***

The pressure regulator supplied with the optional LORAD 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 aging, and/or various ambient temperatures, this setting may need to be updated.

- Step #3** Connect the vacuum pump (10) and the Tube Head (1) to the regulator assembly (6), using the hoses (8) and (9) as shown in Figure 6-1.
- Step #4** Leaving the SF₆ gas cylinder valve (3) closed, open the vacuum line (7) counter-clockwise.
- Step #5** Start the vacuum pump and allow it to run for at least 20 minutes. The final vacuum indicated on the regulator gauge should be at least 25" Hg.
- Step #6** Close the vacuum line valve (7) and turn the vacuum pump off. Open the SF₆ cylinder valve (3) to its fully open position (against its physical stop). Fill the Tube Head until the gauge indicates 25 psi, then close the cylinder valve.

Step #7 Open the vacuum valve and run the pump an additional 10 minutes. 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 6-2). When the Tube Head is at the correct pressure, close the SF₆ cylinder valve.

Step #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.

Temperature Compensation

As shown in Figure 6-2, 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. The following graph illustrates 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.

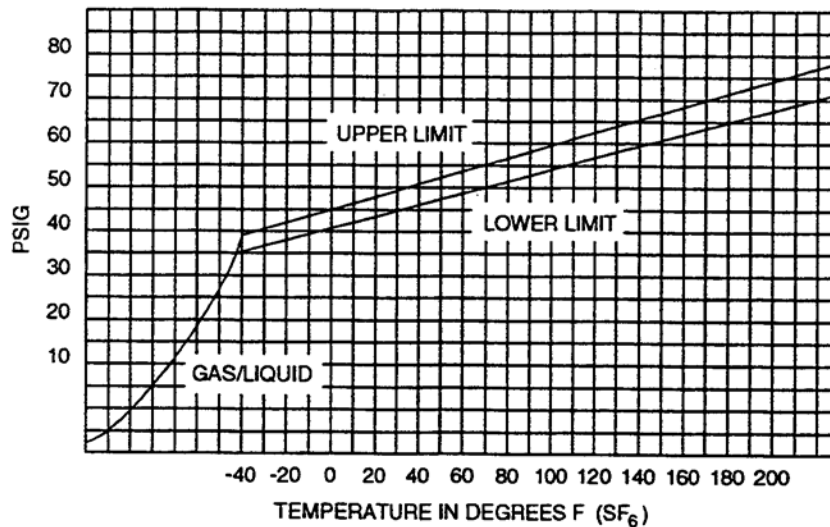


FIGURE 6-2: PRESSURE VS. TEMPERATURE CHART

COOLING UNIT UPKEEP

The following paragraphs describe the general maintenance procedures to be completed every month on the Cooling Unit. These tasks include mixing/adding coolant solution, cleaning the air filter, and cleaning the coolant filter. These procedures may need to be completed more often during times of heavy use or while operating under severe environmental conditions.

Mixing and Adding Coolant Solution

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

- Step #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.
- Step #2** In this container mix 14 parts of methyl alcohol, with 7 parts distilled water, and 1 part soluble oil (Chevron Soluble "B").
Gently agitate the container to help blend the solution.
- Step #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, coolant solution must be added.
- Step #4** Add coolant solution to the reservoir until the level is approximately 1/2" from the top, then replace the radiator cap.
- Step #5** 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. Apply power and allow the coolant to circulate through the system for approximately three minutes.
- Step #6** 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 #5.

*** CAUTION ***

The coolant container must be stored in a cool, dry area with the cap on. The container must be clearly marked, so that the contents are easily identifiable.

Cooling Unit Air Filter Cleaning

The wire mesh air filter within the Cooling Unit must be cleaned 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.

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

Coolant Filter Removal and Cleaning

The Cooling Unit contains a screen type filter housed within an in-line strainer assembly. This filter is attached to the Cooling Unit chassis. The filter must be removed, inspected, and cleaned monthly to prevent restricted coolant flow and over-heating of the anode. To remove and clean the coolant filter, follow the procedures outlined below.

- Step #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.
- Step #2** Unscrew and remove the cap nut from the strainer assembly (coolant solution can be expected 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.

- Step #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. Care must be taken while handling the filter.
- Step #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.
- Step #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.
- Step #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 coolant solution as needed.

EXPOSURE TIMER CONFIGURATION (ANALOG UNIT ONLY)

The Exposure Timer equipped with the LPX-160A has several timing options. At the factory, the Timer is pre-set to a maximum exposure period of 99 minutes and 59 seconds. Since some exposures can require longer durations, the maximum exposure time is configured by rotating a dial on the side of the Timer mechanism. To change the maximum exposure time, follow the procedures outlined below while referring to Figure 6-3.

- Step #1** Make sure power is OFF before removing the timer. Loosen the screw on the right side of the timer face (this screw is captive and cannot be detached). Grasp the timer and lift the entire assembly out of the Control Unit.
- Step #2** Locate the circuit board on the right side of the timer. Make the required dial changes, configuring the timer to meet your needs. Timing options are illustrated in Figure 6-3.
- Step #3** When the desired changes have been made, slide the timer into the Control Unit and tighten the retaining screw.

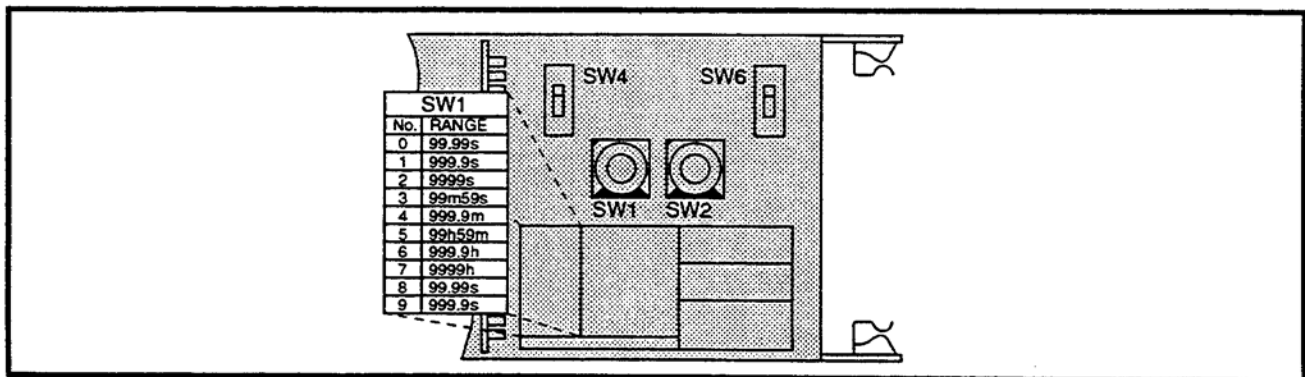


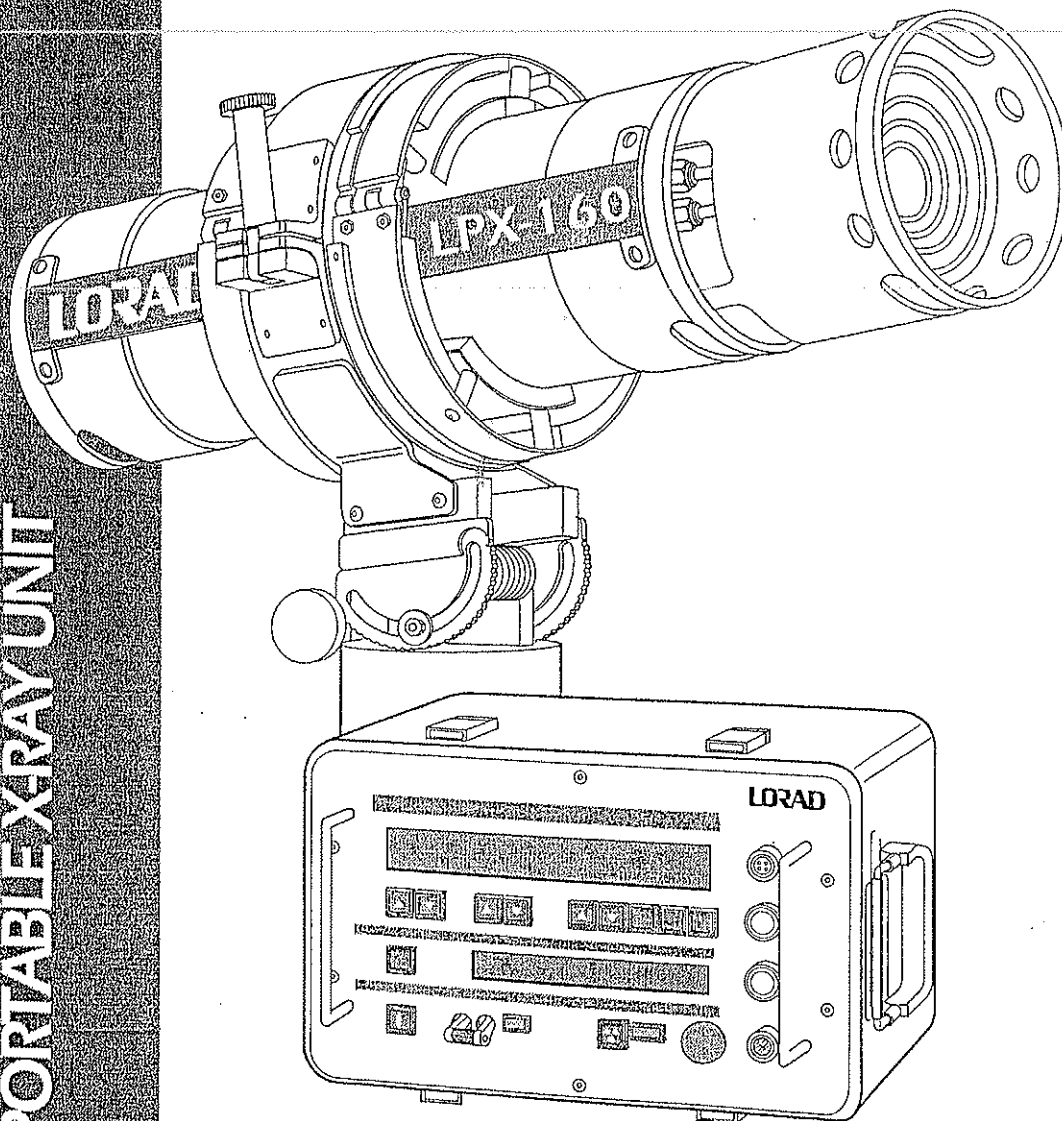
FIGURE 6-3: ALTERNATE TIMING CONFIGURATIONS (ANALOG UNIT ONLY)

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TREX Medical Corporation
Lorad Division

LPX-160 & LPX-200

DIGITAL PORTABLE XRAY UNIT



User's Manual

Exposure Library

9-500-0248

LPX-160, LPX-200 *Exposure Library*

User's Manual

9-500-0248

Revision 1

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INTRODUCTION

The Exposure Library is a time saving feature of the LPX-160 and LPX-200 systems that enables the following:

- ◆ Storage of up to 250 exposure factor combinations.
- ◆ Instant recall of stored exposure factor combinations.
- ◆ Display, upon power up, of the last used exposure factor combination

The Exposure Library has two modes of operation:

- ◆ Store Mode
- ◆ Recall Mode

The Store Mode permits the user to place exposure factor combinations (i.e., kV, mA, & Time) into a specific location in system memory. The exposure factor combination is pre-selected in the Operate Mode, and then saved with an assigned a 3-digit location - or address - in the Store Mode. Exposure factor combinations are assigned addresses within the range of 001 to 250. Note that the unit will store exposure durations in time only - not in mAs.

The Recall Mode allows selection of previously stored technique factor combinations. This mode screen shows the memory address and the pre-set exposure parameters. When selected, the exposure factors for that address become the set parameters for the x-ray procedure in the Operate Mode.

The Exposure Library feature also provides the LPX Series unit with the ability to display, upon power up, the exposure factors that were used last. These factors display in the Set Line of the top LCD when in Operate mode.

When the LPX Series unit is equipped with the Exposure Library feature, it is recommended that the user prepare the exposure library as follows:

1. Prepare a master list, or matrix, of the exposure factor combinations and addresses commonly used at your site.
2. Secure the list or matrix to the Control Unit cover or handle for quick reference.
3. Enter all desired exposure factor combinations on the matrix into the system memory using the procedures in this document.

CONTROLS

The following paragraphs describe use of the LPX Digital Panel Controls that are involved with the storing and recalling of exposure factors. All exposure factor combination selection is done with the unit in the Operate Mode. In the Store Mode, all of the Exposure Controls except the following are non-functional:

- ◆ Exposure Time (Memory) Select
- ◆ Reset/Enter

Refer to the Operator's Manual shipped with your unit for details on normal exposure controls.

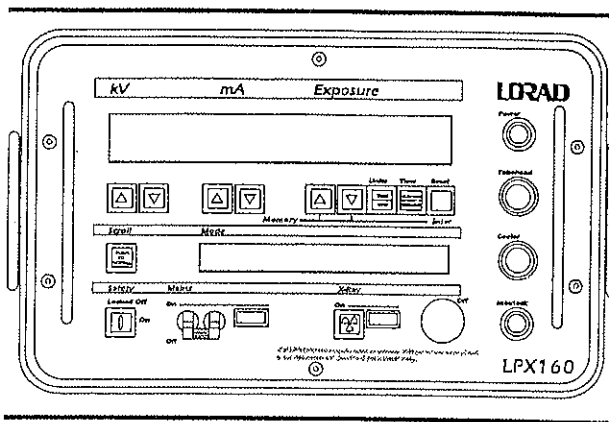


Figure 1:
The LPX Digital Control Unit

Scroll Control





Press this control to cycle through and select from the available modes of system operation:

- ◆ AutoWarm Modes (5 mode)
- ◆ Operate Mode
- ◆ Store Mode
- ◆ Recall Mode


The modes of operation specific to the Exposure Library feature are Store and Recall. Use the Store Mode to assign addresses and store exposure factor combinations. Use the Recall Mode to select an address which contains a previously stored technique factor combination.


kV Control

 Use the kV Up and Down buttons in the Operate Mode to set the desired kV level for the exposure factor combination. When a memory address is selected in the Store Mode, the set kV in the upper display will be the saved kV value for that address.


 **NOTICE . . .** The kV UP/DOWN Controls are not functional in the Store Mode.

mA Control


 Use the mA Up and Down buttons in the Operate Mode to set the desired mA level for the exposure factor combination. When a memory address is selected in the Store Mode, the set mA in the upper display will be the saved mA value for that address.


 **NOTICE . . .** The mA UP/DOWN Controls are not functional in the Store Mode.

Exposure Control


 When the unit is in the Store Mode, use these buttons to scroll through the memory addresses (001 through 250). In the Operate Mode, use these buttons to select the exposure time or mAs (see Operator's Manual for details).

Units (Time/mAs) Control

 In the Operate Mode, use this button to switch the exposure timing method between mAs or time (minutes/seconds). Note that when the Exposure Library feature is installed, the Store Mode will only save exposure timing values in minutes & seconds.

 **NOTICE . . .** The LPX Series unit will not store an mAs value.

Reset/Enter Control

 The Reset/Enter Control is a 3-function button, depending on the selected mode of system operation:

- ◆ Operate Mode: Resets the exposure (see Operator's Manual)
- ◆ Store Mode: Saves the selected address and the displayed exposure factor combination into system memory.
- ◆ Recall Mode: Selects the displayed address and sets the Operate Mode to make an exposure using the saved technique combinations for that address.


EXPOSURE LIBRARY OPERATION

The following paragraphs describe the sequences for storing and recalling exposure factor combinations.

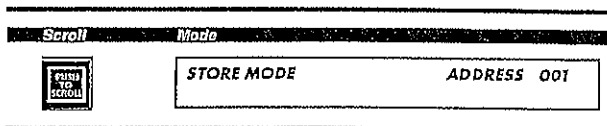
Storing Technique Combinations

Storing an exposure factor combination involves selecting a combination of exposure factors, assigning a technique address to that combination, and then saving the combination and address into system memory. The steps listed next present the recommended sequence for this procedure:

1. Perform the Power up and appropriate system Warm Up procedure following the instructions in the Operator Manual. The bottom screen will display the Operate mode, indicating that the system is ready for use.

 **NOTICE . . .** There is no need to perform any AutoWarm procedure when using the system only to store exposure factor combinations and addresses.

2. In the Operate Mode, set the desired kV and mA using the appropriate control buttons.
3. Press the Units Control to set the system for Time (minutes/seconds). Set the desired exposure time using the appropriate control buttons.
4. Press the Scroll button until the lower display shows the Store Mode (see Figure 2).
5. Press the Time controls to select a memory address (001 through 250).
6. Press the Enter button to save the exposure factor combination into memory at the selected address.



*Figure 2:
Example Screen, Store Mode*

Recalling a Stored Technique Combination

Recalling a preset exposure factor combination involves displaying the appropriate technique address, then displaying selecting the stored combination. The steps listed next present the recommended sequence:

1. Perform the Power up and appropriate system Warm Up procedure following instructions in the Operator Manual. When the Warmup cycle is complete, the lower screen will display the Operate Mode indicating that the system is ready for use.
2. Press the Scroll button until the Recall Mode screen is displayed in the lower LCD.
3. Press the Time controls to select a memory address (001 through 250). The saved exposure parameters will show below the memory address.
4. Press the Enter button to select the exposure factor combination.
5. The preset exposure factors assigned to this address will now display on the top LCD screen and the mode will switch automatically to Operate.

Changing Stored Technique Combinations

To change a factor in a stored combination, follow these steps:

1. In the Operate Mode, use the appropriate controls to select new exposure factors.
2. Access the Store Mode, then select the memory address containing the exposure factor combination to change.
3. Press Enter to store the new exposure factor combination for the selected address.

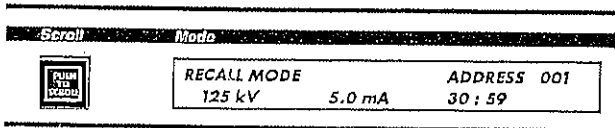


Figure 3:
Example Screen, Recall Mode

Artwork and Signature File for:

Man-01405 "ADDENDUM, LPX-160 OPS, CABINET USE"

Artwork consists of:

- Two (2) 8 ½ inch x 11 inch sheet(s) attached.

REV AUTHORED BY	DATE	HOLOGIC™	SIGNATURES ON FILE	
A. TAMBASCIO	05/18/09			
REV DRAFTED BY	DATE			
J. SHARP	05/27/09			
PROPRIETARY INFORMATION: The content of this document is the exclusive property of Hologic and may not, without prior written permission of Hologic, be reproduced, copied or used for any purpose whatsoever.	TITLE	DOCUMENT NUMBER	REV	
	ADDENDUM, LPX-160 OPS, CABINET USE	AW-03398	001	
	ARTWORK	SIZE A	SHEET 1 OF 1	

LPX-160 for Cabinet Use

This Addendum changes Revision 2 of 9-500-0077 LPX-160 Operator's Manual for use when the LPX-160 is used as a cabinet system.

A Note, which references the 21 CFR requirements when the LPX-160 is used as a cabinet system, has been added to page 3-4 of the manual. The changed page 3-4 is attached.

Put this document with your manual for future reference.

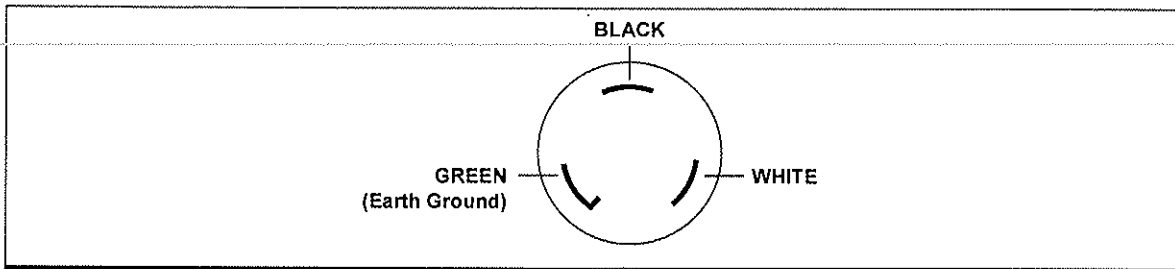


FIGURE 3-3: 220 VOLT PLUG TERMINATION

EXTERNAL INTERLOCK CONNECTIONS

NOTE

The LORAD LPX-160 is intended by its manufacturer to be used as a portable x-ray source in compliance with 21CFR Section 1020.31. When using an LPX-160 in cabinet type systems it is the user's responsibility to ensure compliance with 21CFR Section 1020.40 and other federal, state and local regulations.

The INTERLOCK connector on the front panel of the Control Unit enables x-ray enclosure doors and/or external warning devices to be interconnected with the internal safety interlock circuitry of the system.

NOTE

Pins "A" and "B" of the INTERLOCK connector must form a closed circuit in order to operate the X-Ray unit. If no external switch interlocks are incorporated, a jumper (provided) must be installed across pins "A" and "B" to form this closed circuit.

Figure 3-4 illustrates the two circuits provided for this purpose. Pins "A" and "B" are used to connect enclosure door switches. When properly attached, x-rays can only be generated when the enclosure doors housing the Tube Head are shut. Pins "C" and "D" provide a switch closure to operate warning devices such as lights, sirens, or other types of external warning signals. These signals warn all personnel that x-rays are being generated.

! WARNING !

Voltage is present at pins "A" and "B" of the INTERLOCK when the unit is powered up. Ensure power is OFF before making any external connections or while installing the jumper.

IMPORTANT SAFETY PRECAUTIONS

SAFETY

THIS POWER SUPPLY GENERATES VOLTAGES THAT ARE DANGEROUS AND MAY BE FATAL.
OBSERVE EXTREME CAUTION WHEN WORKING WITH THIS EQUIPMENT.

High voltage power supplies must always be grounded.

Do not touch connections unless the equipment is off and the Capacitance of both the load and power supply is discharged.

Allow five minutes for discharge of internal capacitance of the power supply.

Do not ground yourself or work under wet or damp conditions.



SERVICING SAFETY

Maintenance may require removing the instrument cover with the power on.

Servicing should be done by qualified personnel aware of the electrical hazards.

WARNING note in the text call attention to hazards in operation of these units that could lead to possible injury or death.

CAUTION notes in the text indicate procedures to be followed to avoid possible damage to equipment.

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This information contained in this publication is derived in part from proprietary and patent data. This information has been prepared for the express purpose of assisting operating and maintenance personnel in the efficient use of the model described herein, and publication of this information does not convey any right to reproduce it or to use it for any purpose other than in connection with installation, operation, and maintenance of the equipment described.

WICHTIGE SICHERHEITSHINWEISE

SICHERHEIT

DIESES HOCHSPANNUNGSNETZTEIL ERZEUGT LEBENSGEFÄHRLICHE HOCHSPANNUNG.
SEIN SIE SEHR VORSICHTIG BEI DER ARBEIT MIT DIESEM GERÄT.

Das Hochspannungsnetzteil muß immer geerdet sein.

Berühren Sie die Stecker des Netzteiles nur, wenn das Gerät ausgeschaltet ist und die elektrischen Kapazitäten des Netzteiles und der angeschlossenen Last entladen sind.

Die internen Kapazitäten des Hochspannungsnetzteiles benötigen ca. 5 Minuten, um sich zu entladen.

Erden Sie sich nicht, und arbeiten Sie nicht in feuchter oder nasser Umgebung.



SERVICESICHERHEIT

Notwendige Reparaturen können es erforderlich machen, den Gehäusedeckel während des Betriebes zu entfernen.

Reparaturen dürfen nur von qualifiziertem, eingewiesenem Personal ausgeführt werden.

“WARNING” im folgenden Text weist auf gefährliche Operationen hin, die zu Verletzungen oder zum Tod führen können.

“CAUTION” im folgenden Text weist auf Prozeduren hin, die genauestens befolgt werden müssen, um eventuelle Beschädigungen des Gerätes zu vermeiden.

PRECAUTIONS IMPORTANTES POUR VOTRE SECURITE

CONSIGNES DE SÉCURITÉ

CETTE ALIMENTATION GÉNÈRE DES TENSIONS QUI SONT DANGEUREUSES ET PEUVENT ÊTRE FATALES.
SOYEZ EXTRÊMEMENT VIGILANTS LORSQUE VOUS UTILISEZ CET ÉQUIPEMENT.

Les alimentations haute tension doivent toujours être mises à la masse.

Ne touchez pas les connectiques sans que l'équipement soit éteint et que la capacité à la fois de la charge et de l'alimentation soient déchargées.

Prévoyez 5 minutes pour la décharge de la capacité interne de l'alimentation.

Ne vous mettez pas à la masse, ou ne travaillez pas sous conditions mouillées ou humides.



CONSIGNES DE SÉCURITÉ EN CAS DE REPARATION

La maintenance peut nécessiter l'enlèvement du couvercle lorsque l'alimentation est encore allumée.

Les réparations doivent être effectuées par une personne qualifiée et connaissant les risques électriques.

Dans le manuel, les notes marquées « **WARNING** » attire l'attention sur les risques lors de la manipulation de ces équipements, qui peuvent entraîner de possibles blessures voire la mort.

Dans le manuel, les notes marquées « **CAUTION** » indiquent les procédures qui doivent être suivies afin d'éviter d'éventuels dommages sur l'équipement.

IMPORTANTI PRECAUZIONI DI SICUREZZA

SICUREZZA

QUESTO ALIMENTATORE GENERA TENSIONI CHE SONO PERICOLOSE E POTREBBERO ESSERE MORTALI.
PONI ESTREMA CAUTELA QUANDO OPERI CON QUESTO APPARECCHIO.

Gli alimentatori ad alta tensione devono sempre essere collegati ad un impianto di terra.

Non toccare le connessioni a meno che l'apparecchio sia stato spento e la capacità interna del carico e dell'alimentatore stesso siano scariche.

Attendere cinque minuti per permettere la scarica della capacità interna dell'alimentatore ad alta tensione.

Non mettere a terra il proprio corpo oppure operare in ambienti bagnati o saturi d'umidità.



SICUREZZA NELLA MANUTENZIONE.

Manutenzione potrebbe essere richiesta, rimuovendo la copertura con apparecchio acceso.

La manutenzione deve essere svolta da personale qualificato, coscio dei rischi elettrici.

Attenzione alle **AVVERTENZE** contenute nel manuale, che richiamano all'attenzione ai rischi quando si opera con tali unità e che potrebbero causare possibili ferite o morte.

Le note di **CAUTELA** contenute nel manuale, indicano le procedure da seguire per evitare possibili danni all'apparecchio.

To obtain information on Spellman's product warranty please visit our website at:

<http://www.spellmanhv.com/en/About/Warranty.aspx>

