Communications & Power Industries
communications & medical products division

DECLARATION of CONFORMITY

Application of Council Directive:	93/42/EEC - Medical Devices Directive
Equipment Type:	Diagnostic X-ray Equipment
Classification:	Class IIB
Trade Name/Model No.	Millenia Series X-ray Generator VZW2553RD3-01
Serial No. / Manufacture Date:	AE-AF1341E2 MAY2002
Manufacturer:	Communications & Power Industries Canada, Inc.
Manufacturer's Address:	45 River Drive, Georgetown, Ontario L7G 2J4, Canada.
Designated European Representative:	Udo Ander
Title:	Manager
Address:	CPI International Inc., German Branch, Hohenadlstrasse 31, 85737 Ismaning, Germany.
Tel:	49 89 458737 0
Conformity Assessment Procedure:	Annex II of MDD in conjunction with EN 46001
European Notified Body:	VDE, Offenbach, Germany. (#0366)

We declare that the above mentioned product series is in conformity with the essential requirements of the Council Directive concerning Medical Devices. Attestation is provided according to the Directive by means of a Technical File, and certification from the European Notified Body.

Authorised Signatory to this declaration, on behalf of the manufacturer is identified below:

Name: *Gary Spiller*
Title: *QA Manager*
Address: *45 River Drive, Georgetown, Ontario L7G 2J4, Canada.*

Signature: [signature] **Date:** 15 MAY 2002

Communications & Power Industries
communications & medical products division

CPI CANADA INC.
INSTALLATION RECORD
FAX-BACK REPORT

Please FAX-BACK this form to allow CPI to update the as-built records for this product.

FAX COVER SHEET

TO: CPI CANADA INC.
ADDRESS: 45 RIVER DRIVE, GEORGETOWN, ONTARIO, CANADA L7G 2J4
FAX NUMBER: 905-877-8320
ATTENTION: KEITH ELLIOTT, Mgr. Product Support (Telephone: 905-877-0161)

DATE OF INSTALLATION: ______________________________

LOCATION: ______________________________

COMPANY NAME: ______________________________

PHONE NUMBER: ____________________ FAX NUMBER: ____________________

SERIAL NUMBER OF UNIT: ____________________ MODEL: ____________________

TUBE TYPE: ____________________ STATOR TYPE: ____________________

AEC DEVICE: ______________________________

COMMENTS OR OBSERVATIONS REGARDING THE EQUIPMENT, THE INSTALLATION, OR THE OPERATION OF THE PRODUCT.

____

____

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____

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____

Thank you for taking the time to complete and return this form.

MF-0744A

Communications & Power Industries
communications & medical products division

Problem Report

Subject: CPI Equipment Status	Fax #: 1 – 905 – 877 - 8320
From (Company):	Fax #:
Name:	Phone #:
Date:	Model : Serial:

GENERAL QUESTIONS

1. Date event occurred?
2. Did failure / malfunction occur during a procedure?
3. Was the procedure delayed? If so how long?
4. Did the failure or malfunction result, or contribute to a serious injury to the patient or the healthcare personnel?
5. Was the patient or healthcare personnel exposed to unnecessary radiation?

1. Please explain the specific failure symptoms and your thoughts on the failure mechanism. ie. Does the problem appear in the high voltage oil tank, inverter section; DSS or cables and connectors? Is there any evidence of over heating?
2. How long has the unit been installed in this location?
3. Is the externally connected equipment the same as shown on the product description in the manual? Yes ☐ No ☐
4. What items are connected to the room interface assembly?
5. Record the last 5 error messages with times from the error log.
6. Did the supply fail during Fluoroscopic ☐ or during Radiographic ☐ exposure ? Specify the kVp ________ Time ________ mA ________
7. Prior to breakdown what was the usage?
8. Has there been any rework or modifications to the unit? Yes ☐ No ☐ If Yes, please describe:

X-RAY TUBE TYPE

1. Did the X-Ray tube arc when the unit failed? Yes ☐ No ☐
2. Were the High Voltage cables damaged:? Yes ☐ No ☐

OPERATING ENVIRONMENT

1. Is the line voltage at the installation known? Yes ☐ No ☐ If Yes, Line Voltage
2. Did the supply fail during any unusual weather conditions such as a thunderstorm? Yes ☐ No ☐
3. What is the normal ambient temperature around the equipment? ________

DROC INTERFACE ASSEMBLY 735406

CONTENTS

1.0 INTRODUCTION 2
2.0 CONNECTION OF DROC TO GENERATOR 2
3.0 INSTALLATION, PROGRAMMING, AND CALIBRATION 2
4.0 THEORY OF OPERATION 3
4.1 Generator Ready Signal 3
4.2 EIP (Exposure In Process) Signal 3
4.3 Prep Signal 3
4.4 X-Ray Signal 4
4.5 Expose Ready Signal 4
4.6 Power On Signal 4
4.7 Power Off Signal 4
4.8 Radiographic Exposure Timing 4
5.0 SPARES 4

1.0 INTRODUCTION

This supplement contains interfacing and user information for the DRC I/O board, assembly 735406-00. This board is designed to interface the Millenia generator to the DROC (Direct Radiographic Operator Console). The CPI supplied console is not used with this option; therefore portions of the standard Millenia service manual that reference the CPI console do not apply.

WARNING:	***PLEASE REFER TO THE MILLENIA GENERATOR SERVICE MANUAL AND TO THE GenWare™ INSTRUCTION GUIDE FOR SAFETY NOTICES AND WARNINGS, AND FOR PROPER USE OF THE GENERATOR AND THE GenWare™ SERVICE SOFTWARE.***

2.0 CONNECTION OF DROC TO GENERATOR

The DROC is connected to the generator via a 25 conductor D cable (DB25). One end of the cable connects to J1 on the DROC, the other end connects to J2 on the DRC I/O board in the generator. J2 is a 25 pin D type socket (female) connector, the mating end from the DROC must be a 25 pin D male connector.

3.0 INSTALLATION, PROGRAMMING, AND CALIBRATION

1. The generator should be installed as described in the Millenia service manual. Ignore references in the manual to console installation, as the generator is not shipped with a CPI supplied console.

2. Programming and calibration of the generator must be performed using a laptop computer running the GenWare™ service software. The last few pages of chapter 2, and chapter 3 of the service manual describe programming and calibration using the Millenia console. Programming and calibration using GenWare™ is detailed in the GenWare™ instruction guide, part number 740898. A brief overview relating the programming and calibration procedure in the Millenia service manual to the GenWare™ manual is given in this supplement.

3. To use GenWare™, connect a 9 pin null modem cable from the RS232 communication port on your computer to J11 on the generator CPU board. Switch on the generator and then start GenWare™. If GenWare™ fails to communicate with the generator, it will report an error and enter the demo mode of operation.

   When GenWare™ is properly communicating with the generator, the generator will stop communicating with the DROC. GenWare™ will take control of most of the generator operation. The PREP and X-RAY buttons on the DROC will still be active and should be used for all exposure functions; also the power ON / OFF buttons on the DROC will remain functional.

   To restore control to the DROC, exit GenWare™ or switch the generator OFF and then ON again.

4. Program and calibrate the generator using the Millenia service manual as a general guide. The list below relates the major programming steps in the Millenia service manual to GenWare™.

Function per Service Manual	Corresponding function in GenWare™
Tube Auto Calibration (Ch 2)	Auto Tube Calibration
Setting Time and Date (Ch 3C)	Date and Time Utility
Error Log (Ch 3C)	Error Log Utility
Statistics (Ch 3C)	Generator Statistics
Console (Ch 3C)	N/A
APR Editor (Ch 3C)	N/A
Tube Selection (Ch 3C)	Tube Setup
Generator Limits (Ch 3C)	Generator Limits
Receptor Setup (Ch 3C)	Receptor Setup
I/O Configuration (Ch 3C)	Receptor Setup
AEC Calibration (Ch 3D)	AEC Calibration
Fluoro Setup (Ch 3E)	N/A

4.0 THEORY OF OPERATION

A special DRC I/O board, assembly 735406-00, has been created to interface with the DROC. The DRC I/O board contains an additional set of inputs and outputs whose operation is fixed, based on the special requirements of the DR system. A brief description of the DRC I/O board interface signals follow.

4.1 Generator Ready Signal

The GENERATOR READY signal is an output from the generator to the DROC that is active when the generator has finished the starter boost cycle, the X-ray tube filament has been heated to its calibrated value, and the X-ray button is pressed. The GENERATOR READY signal exits on J2-8 (referenced to J2-11) on the DRC I/O board. LED DS4 indicates the status of this signal.

4.2 EIP (Exposure In Process) Signal

The EIP signal is an output from the generator to the DROC that is active during an X-ray exposure. The EIP signal exits on J2-22 (referenced to J2-11) on the DRC I/O board. LED DS3 indicates the status of this signal.

4.3 Prep Signal

The PREP signal is an input from the DROC to the generator that is activated when the PREP button is pressed. Upon receiving an active PREP signal, the generator will start the X-ray tube boost cycle and heat the filament in preparation for a radiographic exposure. The PREP signal enters the generator on J2-12 (referenced to J2-11) on the DRC I/O board. The status of the PREP signal is indicated by LED DS1.

4.4 X-Ray Signal

The X-RAY signal is an input from the DROC to the generator that is activated when the X-RAY button is pressed. Upon receiving an active X-RAY signal, the generator will activate the GENERATOR READY signal and wait for the EXPOSE READY signal to be active before taking an exposure. If the PREP button is not active and the X-RAY button is pressed, the generator will first start the rotor and heat the filament. When ready to take an exposure, the GENERATOR READY output will be activated and the generator will wait for the EXPOSE READY signal. The X-RAY signal enters the generator on J2-15 (referenced to J2-11) on the DRC I/O board. The status of the X-RAY signal is indicated by LED DS2.

4.5 Expose Ready Signal

The EXPOSE READY signal is an input from the DROC to the generator that is activated when the GENERATOR READY signal is active and the DROC is ready to receive the exposure. The EXPOSE READY signal enters the generator on J2-9 (referenced to J2-11) on the DRC I/O board. The status of the EXPOSE READY signal is indicated by LED DS5. *When the generator is controlled using GenWare™ software, the EXPOSE READY signal will not need to be active in order for an exposure to occur.*

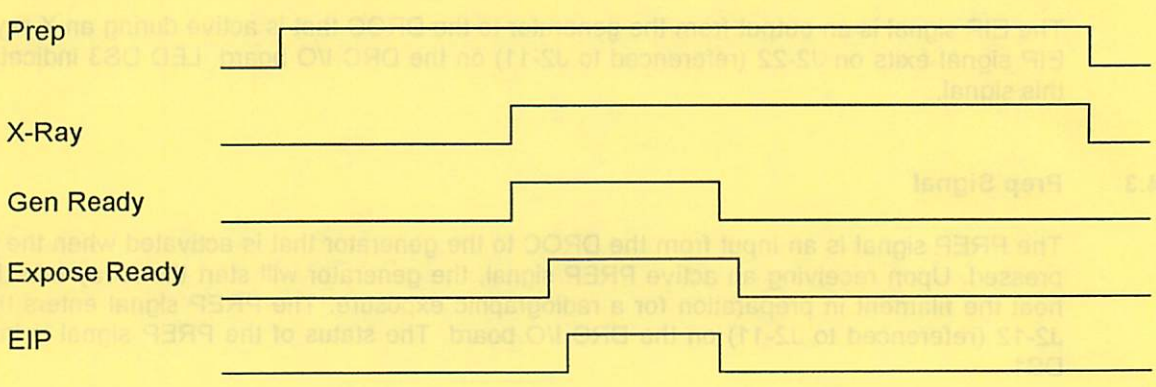
4.6 Power On Signal

The POWER ON signal is an input from the DROC to the generator that when momentarily or continuously activated, will switch ON the generator. The POWER ON signal enters the generator on J2-16 (referenced to J2-17) on the DRC I/O Board.

4.7 Power Off Signal

The POWER OFF signal is an input from the DROC to the generator that when momentarily or continuously activated, will switch OFF the generator. The POWER OFF signal enters the generator on J2-18 (referenced to J2-19) on the DRC I/O Board.

4.8 Radiographic Exposure Timing



5.0 SPARES

DESCRIPTION	PART NUMBER	SUGGESTED QTY
DRC I/O Board	00735406-00	1

POWER DISTRIBUTION KIT 735525

(INCLUDING POWER DISTRIBUTION BOARD 735520)

CONTENTS:

1.0 INTRODUCTION 2
2.0 GENERAL 2
3.0 THEORY OF OPERATION 2
4.0 CONFIRMING / SETTING THE LINE VOLTAGE TAPS 3
5.0 CONNECTIONS ON POWER DISTRIBUTION BOARD 3
6.0 SPARES 3

1.0 INTRODUCTION

This supplement contains interfacing and user information relating to the optional power distribution kit 735525. This kit includes a line adjusting autotransformer tapped 380 / 440 / 480 VAC, and a power distribution board assembly 735520-00.

HIGH VOLTAGE IS PRESENT ON THE LINE ADJUSTING TRANSFORMER, AND ON THE POWER DISTRIBUTION BOARD AT ALL TIMES THAT THE GENERATOR IS CONNECTED TO LIVE AC MAINS. TAKE ALL APPROPRIATE HIGH VOLTAGE PRECAUTIONS DURING SERVICE / ADJUSTMENTS ON THESE COMPONENTS, AND WHEN WORKING NEAR THESE COMPONENTS.

2.0 GENERAL

The line-adjusting transformer is located in the lower generator cabinet, to the right of the H.T. tank. The power distribution board is located above the line-adjusting transformer. This board contains four terminal blocks, which source 240 VAC at up to 6.0 amps in total. Refer to figure 1.

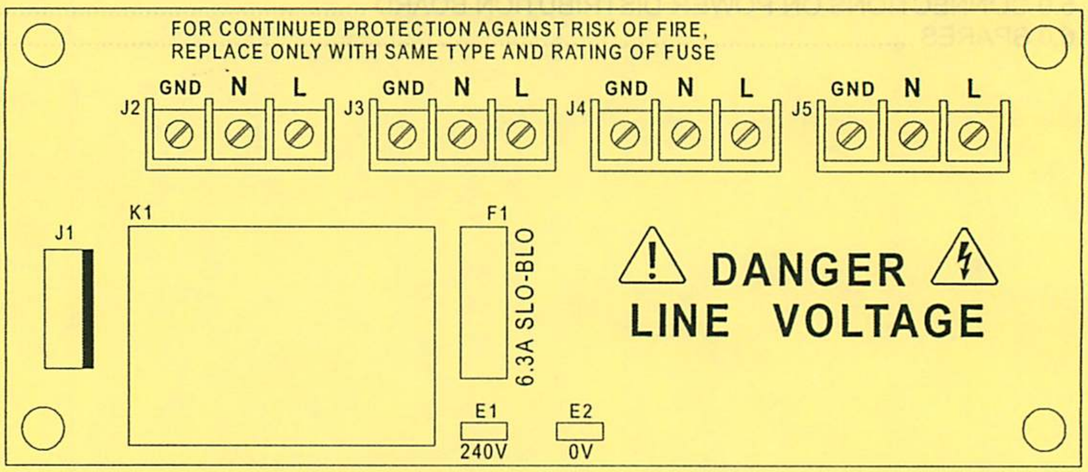


Figure 1: Power distribution board pictorial

3.0 THEORY OF OPERATION

The 3-phase AC line input is routed directly to the line-adjusting transformer. This transformer must be tapped to match the line voltage (380 / 440 / 480 VAC). The line-adjusting transformer has a separate, isolated secondary rated 240 VAC at 1.5 kVA. This 240 VAC supply is connected to E1 and E2 on the power distribution board, where it is switched by relay K1, then routed to four parallel - connected outputs at J2, J3, J4, and J5. Terminal E2 connects one side of the floating transformer winding to chassis ground via the four mounting holes on this board. GND and neutral on J2 to J5 are also connected to E2 / chassis ground.

J1 connects to terminals TB7 (ground) and TB8 (+24 VDC) on the room interface board in the upper generator cabinet. Switching the generator ON supplies 24 VDC to energize K1 on the power distribution board via J1. Auxiliary power is then available at J2, J3, J4, and J5 when K1 is energized.

4.0 CONFIRMING / SETTING THE LINE VOLTAGE TAPS

Before continuing, confirm that the line-adjusting transformer is correctly tapped for the line voltage in use. The following steps detail the procedure to do this, and to change the tap setting if required. Refer to figure 2.

1. Confirm the line voltage at the location that the generator is to be operated.
2. Switch OFF the AC line voltage at the main disconnect switch. Allow sufficient time for all capacitors in the generator to discharge. Open the lower generator door, and confirm the line tap settings per figure 2. The line tap positions are shown with asterisks (*); the large asterisk's indicate the 380 / 400 VAC taps. The figure shows the transformer tapped for 480 VAC input.
3. If the line voltage is nominally 380 / 400 VAC or 440 VAC, the line input connections must be moved to the appropriate taps. As noted in the previous step, the available tap positions are marked with asterisks in figure 2. All three phases must be tapped to the same input voltage.

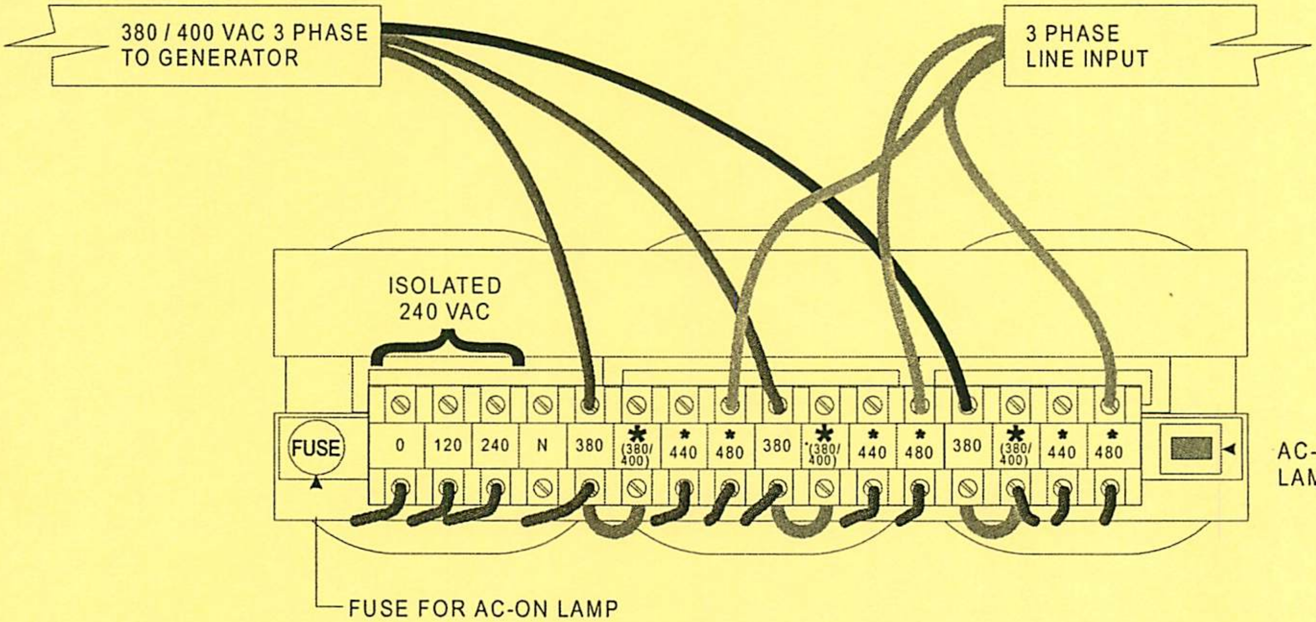


Figure 2: Line voltage taps on line adjusting transformer

5.0 CONNECTIONS ON POWER DISTRIBUTION BOARD

Connections for external 240 VAC equipment are made to J2, J3, J4, or J5 on the power distribution board. Auxiliary power will only be available when the generator is switched on. The maximum loading available is 1.5 kVA.

6.0 SPARES

The part number of the power distribution board assembly to order for spares purposes is 735520-00. The part number for the line-adjusting transformer with the 240 VAC auxiliary winding is 733543-00. This part number includes the transformer, the AC ON indicator lamp, and the fuseholder shown in figure 2. The fuse for the AC-ON lamp on the transformer is type AGC-1/4, part number 6713232500.

MILLENIA INSTALLATION & SERVICE MANUAL REVISION RECORD

MANUAL P/N:740810

ISSUE DATE: 14 May 2002 SERIAL NO: AE1341

ISSUE REVISION OF CHAPTERS / SECTIONS			FIELD UPDATES TO CHAPTER / SECTION REVISIONS					
CH/SECTION		REV	DATE	REV	DATE	REV	DATE	REV
74090300	0	A						
74090301	1	A						
74090400	1A	H						
74090401	1B	F						
74090302	1C	A						
74090402	1D	C						
74090303	1E	A						
74090304	2	G						
74090403	3	B						
74090404	3A	B						
74090305	3B	B						
74090405	3C	D						
74090406	3D	F						
74090407	3E	H						
74090408	4	H						
74090409	5	D						
74090410	6	G						
74090306	7	C						
74090307	8	H						
74090308	9	A						

SUPPLEMENTS	REV	DATE	REV	DATE	REV	DATE	REV
740917	A						
740931	B						
740941	A						

SERVICE AND INSTALLATION MANUAL

P.N. #740810

PRE-INSTALLATION 1➢

INSTALLATION AND CALIBRATION 2➢

CONFIGURATION PROGRAMMING 3➢

ACCEPTANCE TEST 4➢

TROUBLESHOOTING 5➢

REGULAR MAINTENANCE 6➢

THEORY OF OPERATION 7➢

SPARES 8➢

SCHEMATICS 9➢

The original version of this manual (Aug.21,1997) has been drafted in the English language by:
Communications & Power Industries
communications & medical products division.

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CHAPTER 1

PRE-INSTALLATION

1.0 INTRODUCTION

1.1 Purpose

This manual applies to the Millenia family of generators and provides instructions for the installation and maintenance of all models of that generator.

This chapter contains the following sections.

SECTION	TITLE
1A	Introduction
1B	Safety
1C	Preparing for installation
1D	Compatibility listing
1E	Generator layout and Major Components

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CHAPTER 1 SECTION 1A

INTRODUCTION

CONTENTS:

1A.1.0 INTRODUCTION 1A-2
1A.1.1 Purpose 1A-2
1A.2.0 GENERATOR DESCRIPTION 1A-2
1A.3.0 PHYSICAL SPECIFICATIONS 1A-3
1A.4.0 APPLICATIONS 1A-5
1A.5.0 FEATURES 1A-5
1A.6.0 ROTOR CONTROL 1A-6
1A.7.0 AUXILIARY POWER OUTPUTS 1A-6
1A.8.0 SYSTEM DOCUMENTATION 1A-6
1A.9.0 REGULATORIES AND DESIGN STANDARDS 1A-7
1A.9.1 Environmental Specifications 1A-7
1A.9.2 Applicable Standards 1A-7
1A.9.3 Electromagnetic Compatibility (EMC) 1A-8
1A.10.0 TECHNIQUE FACTORS DEFINITIONS 1A-8

1A.1.0 INTRODUCTION

1A.1.1 Purpose

This manual provides instructions for the installation and service of Millenia and Indico 100 X-ray generators. This section of the manual applies to the Millenia and Indico 100 family of X-ray generators. Some of the sections / chapters in the balance of this manual are common to Millenia and Indico 100 X-ray generators; other sections / chapters are unique to each generator series.

1A.2.0 GENERATOR DESCRIPTION

Depending on configuration and options, the generator provides the power and interfacing to operate X-ray tubes, Buckys, Rad tables, GI (gastro-intestinal) tables, remote R&F tables, tomographic devices, and digital imaging systems. The generator consists of power supply and control systems housed in the upper and lower cabinets, a control console, and an optional remote fluoro control along with the necessary interconnecting cable(s).

Major items provided are:

- X-ray generator housed in upper and lower cabinets
- Control console
- Optional remote fluoro control
- Interconnecting cable(s)
- Operator's manual
- Service and installation manual.

1A.3.0 PHYSICAL SPECIFICATIONS

Figure 1A-1 shows the outline of the Millenia series X-ray generator, control console, and remote fluoro control. Figure 1A-2 shows the Indico 100 series X-ray generator outline.

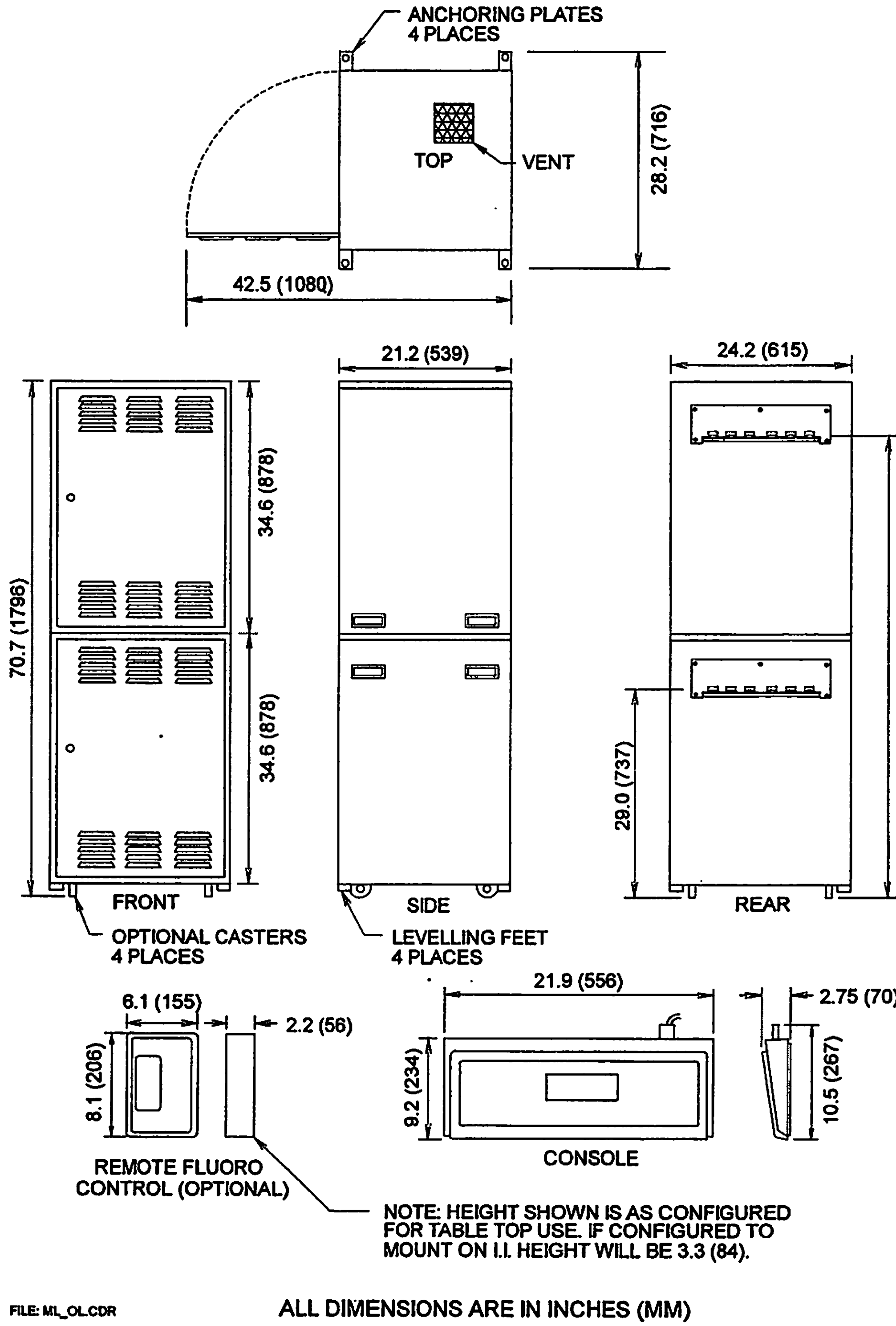

Figure 1A-1: Generator outline drawing (Millenia)

1A.3.0 PHYSICAL SPECIFICATIONS (CONT)

Figure 1A-2 shows the outline of the Indico 100 series X-ray generator.

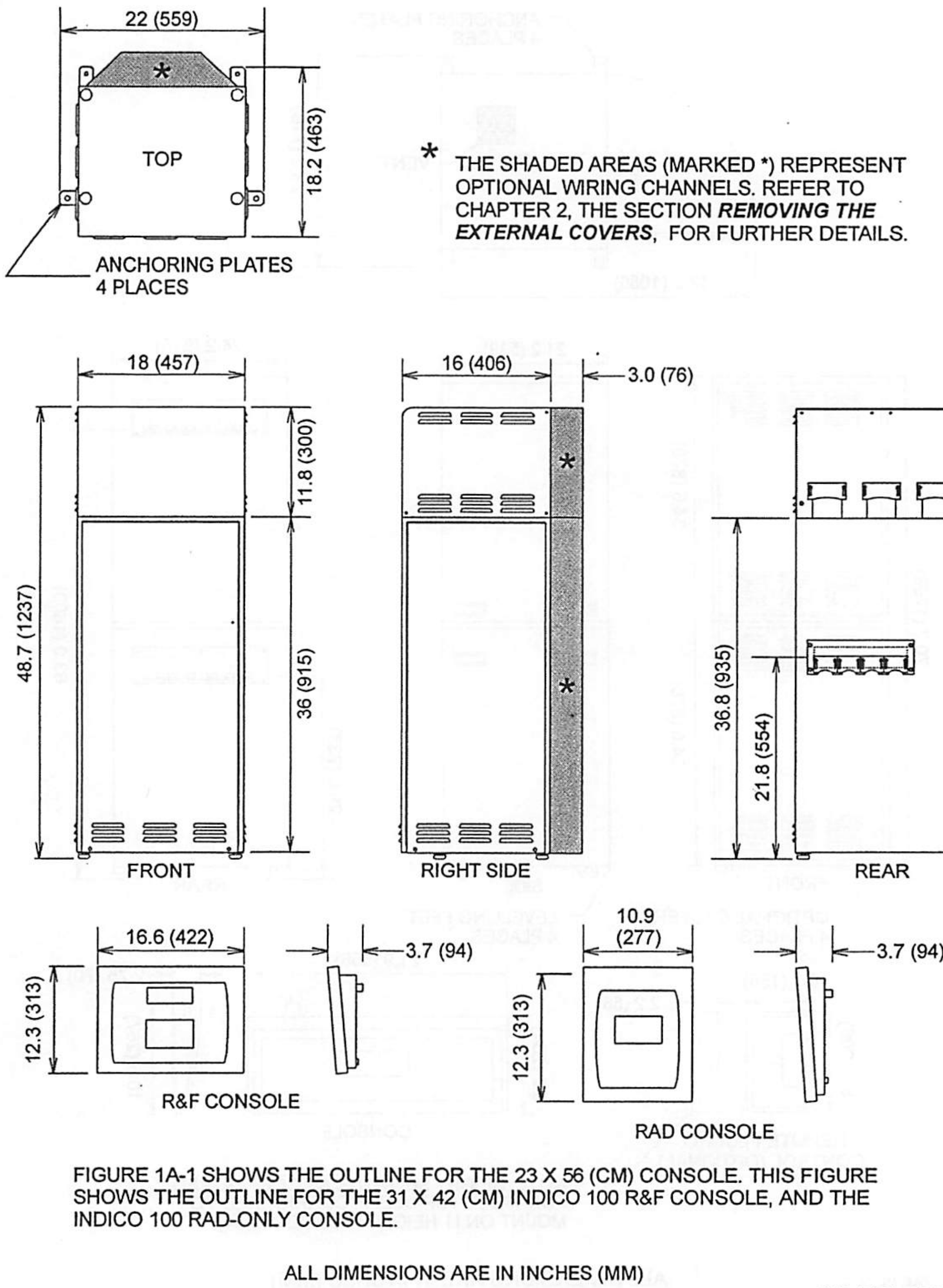

Figure 1A-2: Generator outline drawing (Indico 100)

1A.4.0 APPLICATIONS

RAD SYSTEMS:
- Bucky table, tabletop and off-table radiography.
- Vertical bucky/cassette radiography.
- Conventional tomography.

R&F SYSTEMS
- Fluoroscopic and spot film applications.
- Tomography with conventional and/or remote R&F tables.
- Optional digital compatible.
- Optional high-level fluoro for therapy simulators (Indico 100).

1A.5.0 FEATURES

- High frequency generator.
- One or two tube operation, Rad or Rad / Fluoro.
- Single or dual filament supplies.
- Low speed or dual speed X-ray tube stator supply.
- Optimal matching of X-ray tubes by PROMs.
- Repetitive self checks of generator functions, provides display of system faults and operating errors.
- Optional AEC, up to four inputs.
- Optional ABS with kVp or kVp/mA fluoro stabilizer.
- Optional remote fluoro control box for tabletop use or SFD mounting.
- Optional Dose-Area Product (DAP) display (Indico 100).
- X-ray Tube protection. The generator allows setting the following limits:
  a) Maximum mA, adjustable for each focal spot.
  b) Maximum kVp, adjustable for each X-ray tube.
  c) Maximum kW, adjustable for each focal spot.
  d) Maximum filament current limit, adjustable for large and small focal spots.
  e) Anode heat warning and anode heat alarm levels.
- Calibration features:
  a) Microprocessor design allows all calibration and programming to be performed via the Console.
  b) mA calibration is automated.
- Messages and diagnostic information: For users and service personnel, the generator console displays various messages indicating status or equipment problems. The user is prompted in case of errors.
- Error log stores last 200 errors and associated generator settings.
- Service and diagnostic information available via a laptop computer (optional).
- KVp range: Radiography 40 to 150 kVp.
  Fluoroscopy 40 to 125 kVp.
- mA range: Radiography 10 to 320 mA (30 kW), 10 to 400 mA (32 kW),
  10 to 500 mA (40 kW), 10 to 630 mA (50 kW), 10 TO 800 mA (65 kW)
  and 10 to 1000 mA (80 and 100 kW).
  Fluoroscopy 0.5 to 6.0 mA, 0.5 to 20 mA with optional high-level fluoroscopy.
- mAs range: tube dependent, max 1000 mAs.
- Time range: Radiography 1.0 to 6300 ms (Indico 100), 2.0 to 6300 ms (Millenia).
  Fluoroscopy 0 to 5 or 0 to 10 minutes.

Refer to the compatibility statement / product description (end of section 1D) for compatibility and features of this specific generator.

1A.6.0 ROTOR CONTROL

The generator will be equipped with a low speed starter, or optional dual speed starter.

DUAL SPEED STARTER

Number of tubes permissible:	Maximum of 32 tube types. Tube type is switch selectable
Current monitoring	Both stator circuits
Dual speed starter output frequency	50 or 60 Hz (low speed) 150 or 180 Hz (high speed). (Independent of line frequency)
Braking	Dynamic braking when in high speed rotation
Rotor boost time	Determined by tube selection plus incremental boost time changes from 100 to 700 msec.
Duty cycle	Not to exceed 2 high speed starts per minute.

LOW SPEED STARTER

Current monitoring	Both stator circuits
Duty cycle	Not to exceed 5 consecutive boosts, followed by a minimum 10 second wait period.

1A.7.0 AUXILIARY POWER OUTPUTS

The generator supplies the following power outputs for X-ray room equipment:

- 24 VDC, 4 Amp.
- 120 VAC, 2.5 Amp.
- 240 VAC, 1.5 Amp.

2.5 AMPS IS AVAILABLE AT 120 VAC <u>OR</u> 1.5 AMPS IS AVAILABLE AT 240 VAC, BUT BOTH ARE NOT AVAILABLE SIMULTANEOUSLY.

The above voltage sources are not compatible with:

- Collimator lamps (24 VDC 150 watts). These lamps exceed the 4 Amp rating of the 24 VDC supply.
- Fluorescent lamps. These have high starting currents and generate transients when the tube strikes.
- Some inductive loads may cause difficulties (some motors and solenoids).

1A.8.0 SYSTEM DOCUMENTATION

The Millenia and Indico 100 series of X-ray generators includes the following documentation:

- Operator's manual.
- Service and installation manual.
- Insert and application notes as required.

1A.9.0 REGULATORIES AND DESIGN STANDARDS

1A.9.1 Environmental Specifications

OPERATING	
Ambient temperature range	10 to 40 °C
Relative humidity	30 to 75%
Atmospheric pressure range	500 to 1060 hPa (375 to 795 mm Hg)
TRANSPORT AND STORAGE	
Ambient temperature range	-20 to 70 °C
Relative humidity	10 to 95%, including condensation
Atmospheric pressure range	500 to 1060 hPa (375 to 795 mm Hg)

1A.9.2 Applicable Standards

The Millenia / Indico 100 family of generators comply with the following regulatory requirements and design standards:

- FDA Center for Devices & Radiological Health (CDRH) - 21 CFR title 21 subchapter J (USA).
- Radiation Emitting Devices Act - C34 (Canada).
- Medical Device Regulations (Canada).
- EC Directive 93/42/EEC concerning Medical Devices (European Community).
- IEC 601.1, IEC 601.2.7:1998, CSA 601.1, UL2601.1
  -Type of protection against electric shock: Class I equipment.
  -Degree of protection against electric shock: Not classified.
  -Degree of protection against harmful ingress of water: Ordinary equipment.
  -Mode of operation: Continuous operation with intermittent loading (standby - exposure).
  -Equipment not suitable for use in presence of a FLAMMABLE ANESTHETIC MIXTURE WITH AIR OR WITH OXYGEN OR NITROUS OXIDE.
- IEC 601.1.2

  Immunity:

IEC1000-4-2	Electrostatic discharge
IEC1000-4-3	Radiated RF field
IEC1000-4-4	Electrical fast transient
IEC1000-4-5	Surge
IEC1000-4-6	Conducted RF immunity
IEC1000-4-8	Magnetic field immunity
IEC1000-4-11	Voltage dips, interrupts and variations

  Emission:
  EN55011 (CISPR Publications II Emission Standards, Group 1 Class A).

1A.9.3 Electromagnetic Compatibility (EMC)

In accordance with the intended use, this X-ray generator complies with the European Council Directive concerning Medical Devices. The CE marking affixed to this product signifies this. One of the harmonized standards of this Directive defines the permitted levels of electromagnetic emission from this equipment and its required immunity from the electromagnetic emissions of other devices.

It is not possible, however, to exclude with absolute certainty the possibility that other high frequency electronic equipment, which is fully compliant to the EMC regulations, will not adversely affect the operation of this generator. If the other equipment has a comparatively high level of transmission power and is in close proximity to the generator, these EMC concerns (the risk of interference) may be more pronounced. It is therefore recommended that the operation of equipment of this type such as mobile telephones, cordless microphones and other similar mobile radio equipment be restricted from the vicinity of this X-ray generator.

1A.10.0 TECHNIQUE FACTORS DEFINITIONS

- **KV:** KV peak after any initial kV overshoot.
- **TIME:** Time in milliseconds, (ms) that the high voltage (anode to cathode) is greater or equal to 75% of the desired **kV**.
- **mA:** Average Tube Beam Current (in mA) during the exposure **TIME.**
- **mAs:** milliampere-seconds (**mA** x **TIME**).

Address any questions regarding X-ray generator operation to:

Mail: Customer Support Department
Communications and Power Industries Canada Inc.
45 River Drive
Georgetown, Ontario, Canada L7G 2J4

Telephone: (905) 877-0161

Fax: (905) 877-8320
Attention: Customer Support Department

E-mail: marketing@cmp.cpii.com
Attention: Customer Support Department

CHAPTER 1 SECTION 1B

SAFETY

CONTENTS:

1B.1.0 INTRODUCTION 1B-2
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1B.5.1 Caution HV Behind Cover Label 1B-5
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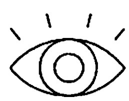
1B.1.0 INTRODUCTION

This section contains important safety warnings and safety information required for installing and servicing the generator.

1B.2.0 SAFETY AND WARNING SYMBOLS

The following advisory symbols are used on the safety warning labels, and/or on circuit boards, and/or on the operator console and the optional remote fluoro control.

	High voltage symbol used to indicate the presence of high voltage.
	Warning symbol used to indicate a potential hazard to operators, service personnel or to the equipment. It indicates a requirement to refer to the accompanying documentation for details.
	Radiation exposure symbol used on operator console. Lights to indicate that an exposure is in progress. This is accompanied by an audible tone from the console.
	Fluoro radiation exposure symbol used on operator console and on optional remote fluoro control unit. Lights to indicate that a fluoro exposure is in progress. This is accompanied by an audible tone from the console.
WARNING *THIS X-RAY UNIT MAY BE DANGEROUS TO PATIENT AND OPERATOR UNLESS SAFE EXPOSURE FACTORS AND OPERATING INSTRUCTIONS ARE OBSERVED.*	Radiation warning label on console, used in certain jurisdictions. Never allow unqualified personnel to operate the X-ray generator.

1B.3.0 SAFETY NOTICES AND WARNINGS

WARNING: ***PROPER USE AND SAFE OPERATING PRACTICES WITH RESPECT TO X-RAY GENERATORS ARE THE RESPONSIBILITY OF USERS OF SUCH GENERATORS. CPI CANADA INC. PROVIDES INFORMATION ON ITS PRODUCTS AND ASSOCIATED HAZARDS, BUT ASSUMES NO RESPONSIBILITIES FOR AFTER-SALE OPERATING AND SAFETY PRACTICES.***

THE MANUFACTURER ACCEPTS NO RESPONSIBILITY FOR ANY GENERATOR NOT MAINTAINED OR SERVICED ACCORDING TO THIS SERVICE AND INSTALLATION MANUAL, OR FOR ANY GENERATOR THAT HAS BEEN MODIFIED IN ANY WAY.

THE MANUFACTURER ALSO ASSUMES NO RESPONSIBILITY FOR X-RAY RADIATION OVEREXPOSURE OF PATIENTS OR PERSONNEL RESULTING FROM POOR OPERATING TECHNIQUES OR PROCEDURES.

SAFETY NOTICES AND WARNINGS (cont)

WARNING: ***THIS X-RAY UNIT MAY BE DANGEROUS TO PATIENT AND OPERATOR UNLESS SAFE EXPOSURE FACTORS AND OPERATING INSTRUCTIONS ARE OBSERVED.***

X-ray radiation exposure may be damaging to health, with some effects being cumulative and extending over periods of many months or even years. **Operators and service personnel should avoid any exposure to the primary beam** and take protective measures to safeguard against scatter radiation. Scatter radiation is caused by any object in the path of the primary beam and may be of equal or less intensity than the primary beam that exposes the film.

No practical design can incorporate complete protection for operators or service personnel who do not take adequate safety precautions. **Only authorized and properly trained service and operating personnel should be allowed to work with this X-ray generator equipment.** The appropriate personnel must be made aware of the inherent dangers associated with the servicing of high voltage equipment and the danger of excessive exposure to X-ray radiation during system operation.

DO NOT CONNECT UNAPPROVED EQUIPMENT TO THE REAR OF THE CONSOLE.
For the 23 X 56 (cm) console, J5 is used for the interconnect cable to the generator main cabinet, J4 is not used, J2 is a serial port for use by an external computer, and J1 is for connection of an optional printer.

For the 31 X 42 (cm) console, J5 is used for the interconnect cable to the generator main cabinet, J2 is a serial port for use by an external computer, and J13 is for connection of an external hand switch and / or foot switch.

For the Rad-only console, J3 is for connection of an external hand switch, J4 is a serial port for use by an external computer, and J8 is for the interconnect cable to the main cabinet.

INCORRECT CONNECTIONS OR USE OF UNAPPROVED EQUIPMENT MAY RESULT IN INJURY OR EQUIPMENT DAMAGE..

CAUTION: ***DO NOT EXCEED THE TUBE MAXIMUM OPERATING LIMITS. INTENDED LIFE AND RELIABILITY WILL NOT BE OBTAINED UNLESS GENERATORS ARE OPERATED WITHIN PUBLISHED SPECIFICATIONS.***

WARNING: ***HAZARDOUS VOLTAGES EXIST INSIDE THE GENERATOR WHENEVER THE MAIN POWER DISCONNECT IS SWITCHED ON. THOSE AREAS INCLUDE THE MAIN FUSEHOLDER AND ASSOCIATED CIRCUITS IN THE HV POWER SUPPLY, PORTIONS OF THE GENERATOR INTERFACE BOARD ON THE UPPER DOOR OF THE GENERATOR, AND THE TERMINALS ON THE LINE ADJUSTING TRANSFORMER IN THE LOWER GENERATOR CABINET IF FITTED***

THE CONSOLE ON/OFF SWITCH DOES NOT DISCONNECT THE MAIN POWER FROM THE ABOVE AREAS INSIDE THE GENERATOR.

THE BUS CAPACITORS, LOCATED ON THE BASE OF THE POWER SUPPLY PRESENT A SAFETY HAZARD FOR AT LEAST 5 MINUTES AFTER THE POWER HAS BEEN REMOVED FROM THE UNIT. CHECK THAT THESE CAPACITORS ARE DISCHARGED BEFORE SERVICING THE GENERATOR.

1B.4.0 SAFETY WARNING LABELS - INTRODUCTION

The safety warning label subsections define the safety labels used inside and outside the generator cabinets. Depending on configuration, your X-ray generator may contain some or all of the labels shown.

NOTE:	***THESE LABELS AND WARNINGS ARE LOCATED TO ALERT SERVICE PERSONNEL THAT SERIOUS INJURY WILL RESULT IF THE HAZARD IDENTIFIED IS IGNORED.***

NOTE:	***DUE TO THE DIVERSITY OF GENERATOR MODELS, THE EQUIPMENT MAY NOT BE EXACTLY AS SHOWN.***

WARNING:	***SWITCH OFF THE MAIN POWER DISCONNECT AND ALLOW SUFFICIENT TIME FOR ALL CAPACITORS TO DISCHARGE BEFORE REMOVING ANY COVERS OR OPENING ANY SERVICE DOOR.***

WARNING:	***IF ANY BARRIERS OR COVERS MUST BE REMOVED FOR SERVICE, TAKE ALL REQUIRED PRECAUTIONS WITH RESPECT TO THE HAZARD(S) AND IMMEDIATELY REPLACE THE BARRIERS/COVERS WHEN THE NEED FOR REMOVAL IS COMPLETED.***

REPLACE ALL FUSES IN THIS GENERATOR WITH THE SAME TYPE AND RATING.

This information is provided to help you establish safe operating conditions for both you and your CPI X-ray generator. Do not operate this X-ray generator except in accordance with these precautions, and any additional information provided by the X-ray generator manufacturer and/or competent safety authorities.

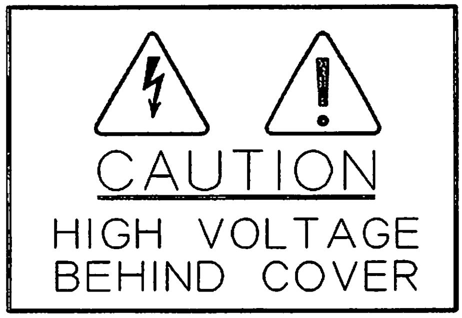
1B.4.1 Safety Warning Labels - Organization

The safety warning label information is organized into three subsections:

- Safety labels/notices common to Millenia and Indico 100
- Safety notices unique to Millenia
- Safety notices unique to Indico 100

1B.5.0 SAFETY LABELS / NOTICES COMMON TO MILLENIA AND INDICO 100

1B.5.1 Caution HV Behind Cover Label



MILLENIA: This label is attached to a cover over the main power contactor. This area will have mains voltage applied as long as the main disconnect is switched on.

MILLENIA: This label is attached to a cover over the resonant circuit and low speed starter components if a low speed starter is fitted. The resonant components (resonant capacitors etc) may be energized for 5 minutes after the console is switched off, or the main disconnect is switched off.
If a low speed starter is fitted, the associated components will have up to 240 VAC applied when the console is switched on.

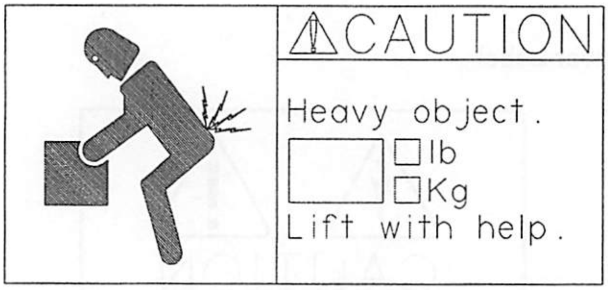
MILLENIA: This label is attached to each of the access panels on the rear of the generator. The high voltage hazards behind these panels is similar to that behind the upper and lower entrance doors, see 1B.7.4.

MILLENIA: This label is attached to a cover over the line adjusting transformer (if fitted). The terminals on the transformer will have mains voltage applied as long as the main disconnect is switched on. If access to the transformer connections is needed, SWITCH OFF THE MAIN DISCONNECT FIRST.

INDICO 100: This label is attached to a cover over the inverter board(s). The inverter assembly is connected to the main DC bus and will have high voltage applied at all times that the generator is switched on. This assembly will remain energized for 5 minutes after the generator is switched off, or the main disconnect is switched off.

INDICO 100: This label is attached to a cover over the main input fuses on the power input board. This area will have mains voltage applied as long as the main disconnect is switched on.

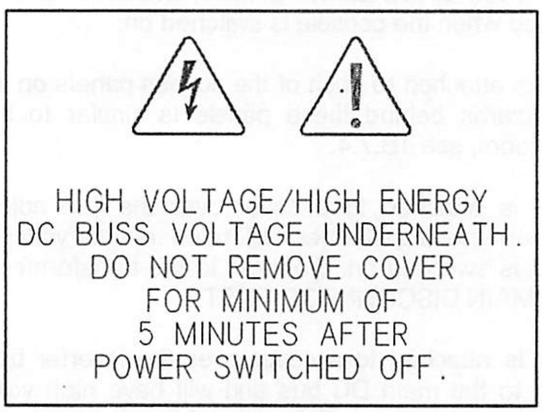
1B.5.2 Weight Label



MILLENIA: This label is attached to the upper and lower generator cabinets and to the HT oil tank and states the approximate weight of each of the generator sections and of the HT oil tank. This label cautions against attempting to lift those assemblies without proper assistance.

INDICO 100: This label is attached to the lower generator cabinet and to the HT oil tank and states the approximate weight of the lower generator cabinet and of the HT oil tank. This label cautions against attempting to lift those assemblies without proper assistance.

1B.5.3 DC Bus Label



MILLENIA: This label is attached to a cover over the DC bus capacitors. These capacitors will hold a lethal charge for 5 minutes after the console is switched off, or the main disconnect is switched off. Do not remove the cover for a minimum of 5 minutes after the power has been switched off.

INDICO 100: This label is attached to the removable panels on the lower (power supply) cabinet. The internal capacitors will hold a lethal charge for 5 minutes after the console is switched off, or the main disconnect is switched off. Do not remove the cover for a minimum of 5 minutes after the power has been switched off.

WARNING: ***WAIT A MINIMUM OF 5 MINUTES AFTER THE INPUT MAINS POWER HAS BEEN REMOVED BEFORE REMOVING ANY COVERS OR ACCESS PANELS. ONCE THE COVER(S) / PANEL(S) ARE REMOVED CHECK THAT THE VOLTAGE ACROSS THE DC BUS CAPACITORS IS LESS THAN 48 VDC BEFORE SERVICING.***

1B.5.4 Console CPU Board / Console Board

For 23 X 56 (cm) consoles:
HIGH VOLTAGE HAZARD: Approximately 400 VAC is present on this board in the area of U32 and J10. This voltage is used to light the backlight for the LCD display assembly in the console.

For 31 X 42 (cm) Indico 100 R&F consoles:
HIGH VOLTAGE HAZARD IF U40 IS FITTED: U40 is a high voltage source for the fluorescent backlight on the LCD display. Approximately 400 VAC is present on this board in the area of U40 and J10 if U40 is fitted. On LED backlight versions of the LCD display, high voltage source U40 is not fitted and no high voltage is present in this area.

For Indico 100 Rad-only consoles:
HIGH VOLTAGE HAZARD: Approximately 400 VAC is present on this board in the area of T1, C36, and J5. This is a high voltage source for the fluorescent backlight on the LCD display.
FUSE RATING:
F1: 1.6A 250V

1B.5.5 Generator Interface Board

This symbol is printed on the generator interface board in the high volage (mains) area.
HIGH VOLTAGE HAZARD: Components within the dashed line on the board have high voltage applied at all times that the main disconnect is switched ON. These components are live EVEN WITH THE CONSOLE SWITCHED OFF.

This symbol is printed on the generator interface board near fuses F1 to F6.
FUSE RATINGS:
F1: 1.6A 250V slow blow
F2, F5: 2.5A 250V slow blow
F3, F4: 5A 250V slow blow
F6: 2A 250 V slow blow

1B.5.6 Room Interface Board

This symbol is printed on the room interface board near the 110/220 VAC terminal blocks.
HIGH VOLTAGE HAZARD: 110/220 VAC may be present on this board at all times that the AC mains to the generator is switched on.

1B.5.7 AEC Board

This symbol is printed on some versions of AEC board with a high voltage power supply for a PMT or ion chamber.
HIGH VOLTAGE HAZARD: Depending on the AEC board type, up to approximately 1000 VDC may be present on the AEC board at all times that the generator is switched on.

1B.5.8 Power Input Board

Power input boards for single phase 240 VAC generators are fitted with several high power resistors that operate at temperatures sufficient to cause skin burn. Ensure that these resistors have cooled sufficiently after the power has been switched off before servicing.

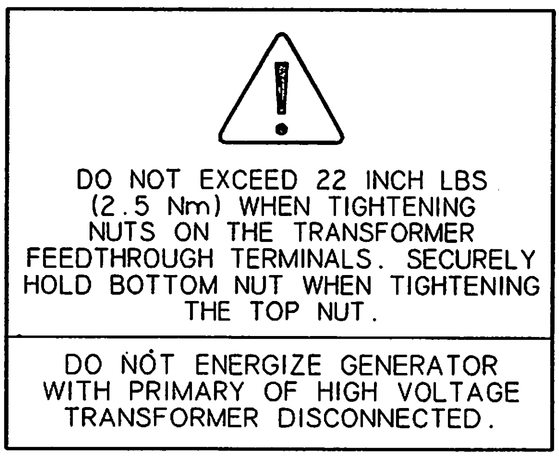
1B.5.9 Dual Speed Starter Board

This symbol is printed on the dual speed starter board if fitted.
HIGH VOLTAGE HAZARD: Approximately 600 VDC is present on this board. This voltage is supplied from the DC bus capacitors in the HF power supply. USE EXTREME CAUTION WHEN SERVICING, this voltage and current combination is lethal. Ensure that the DC bus capacitors are fully discharged before servicing as these capacitors will hold a lethal charge for 5 minutes AFTER THE EQUIPMENT IS SWITCHED OFF.

WARNING:	***COMPONENTS BEHIND VARIOUS COVERS, AS NOTED IN THIS SECTION, REMAIN LIVE EVEN WITH THE OPERATOR CONSOLE SWITCHED OFF. THE ONLY WAY TO REMOVE POWER FROM THESE AREAS IS TO SWITCH OFF THE MAIN DISCONNECT.***

1B.6.0 SAFETY LABELS / NOTICES UNIQUE TO MILLENIA

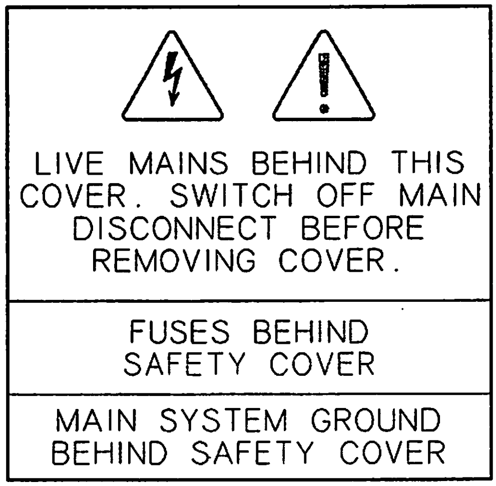
1B.6.1 HT Tank - Transformer Terminals Label



This label indicates that if the power supply inverter leads that attach to the high tension transformer primary terminals are not connected the generator must not be energized.

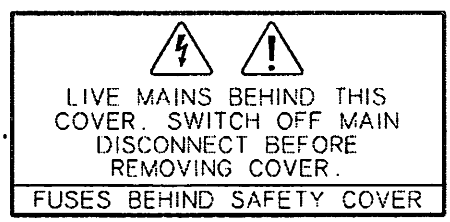
This label also cautions against over tightening the nuts on the transformer feedthrough terminals mentioned in the above paragraph.

1B.6.2 Live Mains / Fuses / Ground Label



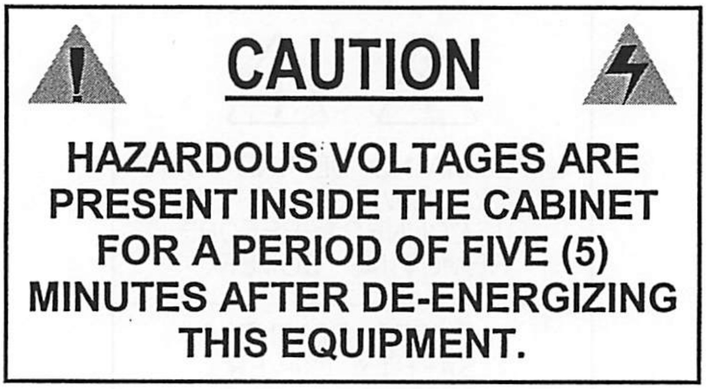
This label is attached to a cover over the main fuseblock and fuses. This area will have mains voltage applied as long as the main disconnect is switched on. The main system ground is also located behind this cover.

1B.6.3 Live Mains / Fuses Label



This label is attached to a cover over the fuseblock and fuses for the room interface transformer. This area will have mains voltage applied as long as the main disconnect is switched on.

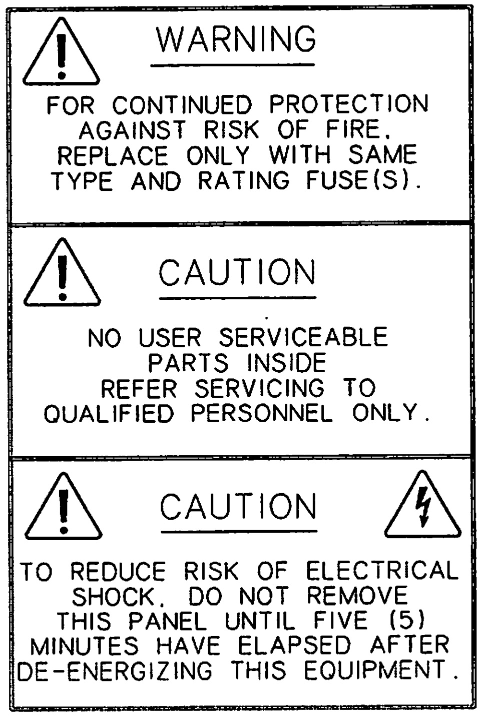
1B.6.4 Caution - Hazardous Voltages Label



This label is attached to the main access doors on the generator. ***Wait a minimum of five minutes after the main power has been removed from the generator before opening the cabinet doors.*** This will allow for internal capacitors to discharge to a safe level.

The upper door provides access to the HV power supply driver section, room interface board and associated control circuits. The lower door allows access to the HT transformer, dual speed starter chassis if fitted, line adjusting transformer if fitted, and access to the tube stator connections and thermal switch connections. Additionally, the grounding location for the X-ray tube housing is located in this area. Hazards associated with each area within are outlined in the relevant sections of this chapter.

1B.6.5 Warning / Caution / Caution Label



This label is attached to a cover over the dual speed starter assembly (if fitted). DC bus voltage is present behind this panel, see 1B.5.9.

Ensure that the generator has been turned OFF for five minutes before removing the cover or disconnecting the DC supply.

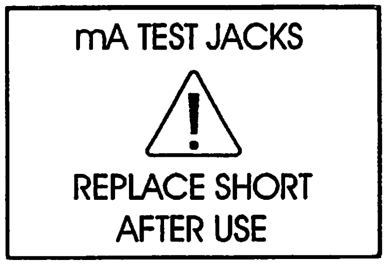
Replace fuses with the same type and rating, refer to spares list (chapter 8) for details.

1B.6.6 Tank Vent Label

This label is attached to the HT tank clamping bracket on generator models equipped with an HT tank vent screw. This screw must be loosened to allow venting of the HT tank before use of the generator when the tank is so equipped.

The screw must be fully tightened to prevent insulating oil spills or leaks from the HT tank during transportation or shipping.

1B.6.7 mA Test Jacks Label



This label is attached to the top of the HT tank on generator models equipped with mA test jacks. A similar warning is printed on tank lid boards using this connector, see 1B.7.8 below for details.

1B.6.8 mA test Jacks

This symbol is printed on tank lid boards with mA/mAs test jacks.
Replace the shorting jumper immediately after use. Do not attempt exposures without either the shorting jumper in place, or an approved mA/mAs measuring device properly connected.

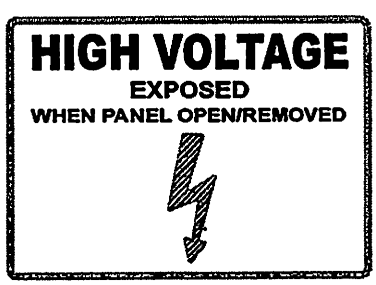
The warning "CAUTION: 48V MAX" printed on some tank lid boards does not apply in Millenia generator applications.

1B.6.9 F3 (Auxiliary Power Fuseblock)

This symbol is on a label under the fuseholder for F3 (to the right of the HF power supply).
FUSE RATING: 3A 500V slow blow.
This fuse is only used if the generator is fitted with the neutral block option.

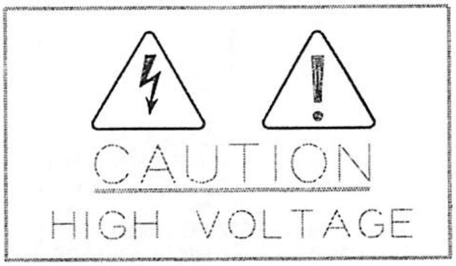
1B.7.0 SAFETY LABELS / NOTICES UNIQUE TO INDICO 100

1B.7.1 Caution HV Exposed Label



This label is attached to the removable panels on the lower (power supply) cabinet. High voltage is present within this cabinet at all times that the mains power is switched on.

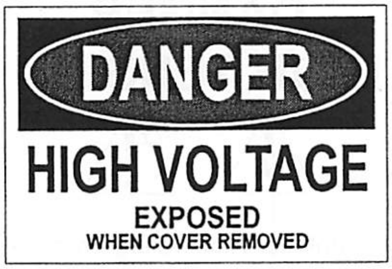
1B.7.2 Caution HV Label



This label is attached to the power input board, and to the resonant board assembly. The input power board has line voltage components attached that will be live at all times that the main disconnect is switched on. This includes the input fuses, main line contactor, mains rectifier and associated components.

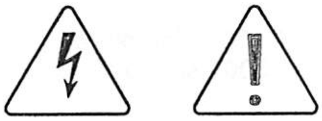
The resonant board assembly has components that may be energized at all times that the generator is on. These components may retain their charge for 5 minutes after the console is switched off, or the main disconnect is switched off.

1B.7.3 Danger HV Label



This label is attached to the primary terminals on the HT oil tank. These terminals may be energized at all times that the generator is switched on, and for 5 minutes after the console or the main disconnect is switched off.

1B.7.4 High Voltage Warning Label



This label is attached to the inverter board(s) and to the low speed starter assembly if fitted. The inverter assembly is connected to the main DC bus and will have high voltage applied at all times that the generator is switched on. This assembly will remain energized for 5 minutes after the generator is switched off, or the main disconnect is off.

Components on the low speed starter assembly will have 240 VAC applied when the console is switched on.

1B.7.5 HT Tank - Transformer Terminals

DO NOT EXCEED 2.1 N.m
(18 INCH.LBS) WHEN TIGHTENING
THE NUTS ON THE TANK LID

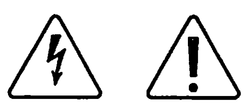
DO NOT ENERGIZE GENERATOR
WITH PRIMARY OF HIGH VOLTAGE
TRANSFORMER DISCONNECTED

This notice is printed on the HT oil tank lid and indicates that if the power supply inverter leads that attach to the high tension transformer primary terminals are not connected the generator must not be energized.

This notice also cautions against over tightening the nuts on the transformer feedthrough terminals mentioned in the above paragraph.

1B.7.6 Danger High Tension

DANGER
HIGH TENSION



This notice is printed on the HT oil tank lid. High voltage may be present at the primary terminals on the tank lid board, at the output high voltage connectors, and at the mA/mAs measuring jacks if the shorting link is opened for mA/mAs measurements.

1B.7.7 F1 (Primary of Auxiliary Transformer)

This symbol is on a label above the fuse holder for F1 (to the left of the main input fuses on the power input board).
FUSE RATING:
Single phase generators: 3A 250V slow blow.
Three phase generators: 2A 500V slow blow.

CHAPTER 1 SECTION 1C

PREPARING FOR INSTALLATION

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1C.1.0 INTRODUCTION

The following items must be considered before installing your generator:

- Power level of your generator.
- Power line requirements.
- Ground requirements.
- Physical placement of the generator.
- Environmental requirements for the generator.
- Cable runs from the generator to all room components: tables, buckys, X-ray tubes etc.

1C.2.0 GENERATOR POWER REQUIREMENTS

1C.2.1 30 kW Single Phase

Line Voltage	240 VAC ± 10%, 1Ø
Line Frequency	50/60 Hz
Momentary Current	190 Amps
Standby Current	10 Amps
Momentary Power Consumption	46kVa (for 30 kW exposure)

1C.2.2 30 kW Three Phase

Line Voltage	400 VAC ± 10%, 3Ø 480 VAC ± 10%, 3Ø with optional line adjusting transformer
Line Frequency	50/60 Hz
Momentary Current	80 Amps/phase at 400 VAC 65 Amps/phase at 480 VAC
Standby Current	10 Amps (1 phase only) at 400 VAC 10 Amps (1 phase only) at 480 VAC
Momentary Power Consumption	48 kVa (for 30 kW exposure)

1C.2.3 50 kW Three Phase

Line Voltage	400 VAC ± 10%, 3Ø 480 VAC ± 10%, 3Ø with optional line adjusting transformer
Line Frequency	50/60 Hz
Momentary Current	120 Amps/phase at 400 VAC 100 Amps/phase at 480 VAC
Standby Current	10 Amps (1 phase only) at 400 VAC 10 Amps (1 phase only) at 480 VAC
Momentary Power Consumption	85 kVa (for 50 kW exposure)

1C.2.4 65 kW Three Phase

Line Voltage	400 VAC ± 10%, 3Ø 480 VAC ± 10%, 3Ø with optional line adjusting transformer
Line Frequency	50/60 Hz
Momentary Current	150 Amps/phase at 400 VAC 120 Amps/phase at 480 VAC
Standby Current	10 Amps (1 phase only) at 400 VAC 10 Amps (1 phase only) at 480 VAC
Momentary Power Consumption	100 kVa (for 65 kW exposure)

1C.2.5 80 kW Three Phase

Line Voltage	400 VAC ± 10%, 3Ø 480 VAC ± 10%, 3Ø with optional line adjusting transformer
Line Frequency	50/60 Hz
Momentary Current	175 Amps/phase at 400 VAC 140 Amps/phase at 480 VAC
Standby Current	10 Amps (1 phase only) at 400 VAC 10 Amps (1 phase only) at 480 VAC
Momentary Power Consumption	120 kVa (for 80 kW exposure)

1C.2.6 Service Disconnect (All Models)

30 kW 240 VAC 1Ø generator:	100 Amp/single phase recommended
30 kW 400/480 VAC 3Ø generators:	60 Amp/three phase recommended
All 50, 65 and 80 kW generators:	100 Amp/three phase recommended

1C.3.0 POWER LINE REQUIREMENTS

The following table defines the room power requirements for the generators.

NOTE: ***THE FOLLOWING ARE TYPICAL VALUES AND ARE DEPENDENT ON CURRENT REQUIREMENTS AND LENGTH OF CABLE RUN***

Final selection of wire and disconnects must meet the requirements of the local electrical codes and is usually determined by hospital/contractor engineering.

AC Mains Cable Size To Main Disconnect (AWG and mm^2)					Disconnect to Generator (15 ft/5 m max)	Momentary Line Current	Service Rating	Distribution Transformer Rating	Ground Wire Size	Apparent Mains Resistance
Series	50 ft (15 m)	100 ft (30 m)	150 ft (45 m)	200 ft (60 m)						
350 1Ø GENERATOR										
240 VAC	#0000 (120 mm^2)	250MCM (150 mm^2)	300MCM (175 mm^2)	350MCM (200 mm^2)	#4 (25 mm^2)	190 A	100 A	45 kVa	#4 (25 mm^2)	0.05 Ω
350 3Ø GENERATOR										
400 VAC	#4 (25 mm^2)	#3 (30 mm^2)	#2 (35 mm^2)	#0 (50 mm^2)	#6 (15 mm^2)	80 A	60 A	45 kVa	#4 (25 mm^2)	0.25 Ω
480 VAC	#4 (25 mm^2)	#3 (30 mm^2)	#2 (35 mm^2)	#0 (50 mm^2)	#6 (15 mm^2)	65 A	60 A	45 kVa	#4 (25 mm^2)	0.40 Ω
650 GENERATOR										
400 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	120 A	100 A	70 kVa	#4 (25 mm^2)	0.15 Ω
480 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	100 A	100 A	70 kVa	#4 (25 mm^2)	0.22 Ω
850 GENERATOR										
400 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	150 A	100 A	85 kVa	#4 (25 mm^2)	0.12 Ω
480 VAC	#2 (35 mm^2)	#0 (50 mm^2)	#000 (95 mm^2)	#0000 (120 mm^2)	#6 (15 mm^2)	120 A	100 A	85 kVa	#4 (25 mm^2)	0.18 Ω
1050 GENERATOR										
400 VAC	#2 (35 mm^2)	#00 (70 mm^2)	#0000 (120 mm^2)	250MCM (150 mm^2)	#6 (15 mm^2)	175 A	100 A	100 kVa	#4 (25 mm^2)	0.10 Ω
480 VAC	#2 (35 mm^2)	#00 (70 mm^2)	#0000 (120 mm^2)	250MCM (150 mm^2)	#6 (15 mm^2)	140 A	100 A	100 kVa	#4 (25 mm^2)	0.15 Ω

1C.3.0 POWER LINE REQUIREMENTS (cont)

- All wiring and grounding should be in compliance with the national electrical code or equivalent.
- All wiring must be copper.
- For all installations, a separate copper ground cable #4 AWG (25 mm^2) is required from the building distribution ground to the ground terminal located inside the main disconnect switch fuse block.
- The disconnect switch shall be located within reach of the operator.

1C.4.0 GROUND REQUIREMENTS.

- A suitable flexible copper cable #6 AWG (15 mm^2) or larger must be supplied (usually part of the line cable) to connect from the disconnect switch to the main ground of the generator, located adjacent to the main fuseblock in the upper generator cabinet.
- A copper ground cable, #10 AWG (6 mm^2) or greater, from each X-ray tube's housing to be connected to the H.T. transformer's ground stud (located at the top of the HT transformer).
- If a neutral line is provided with the system under no circumstances is it to be used for ground purposes. The ground must carry fault currents only.

1C.5.0 OUTLINE DRAWINGS

1C.5.1 Generator Outline

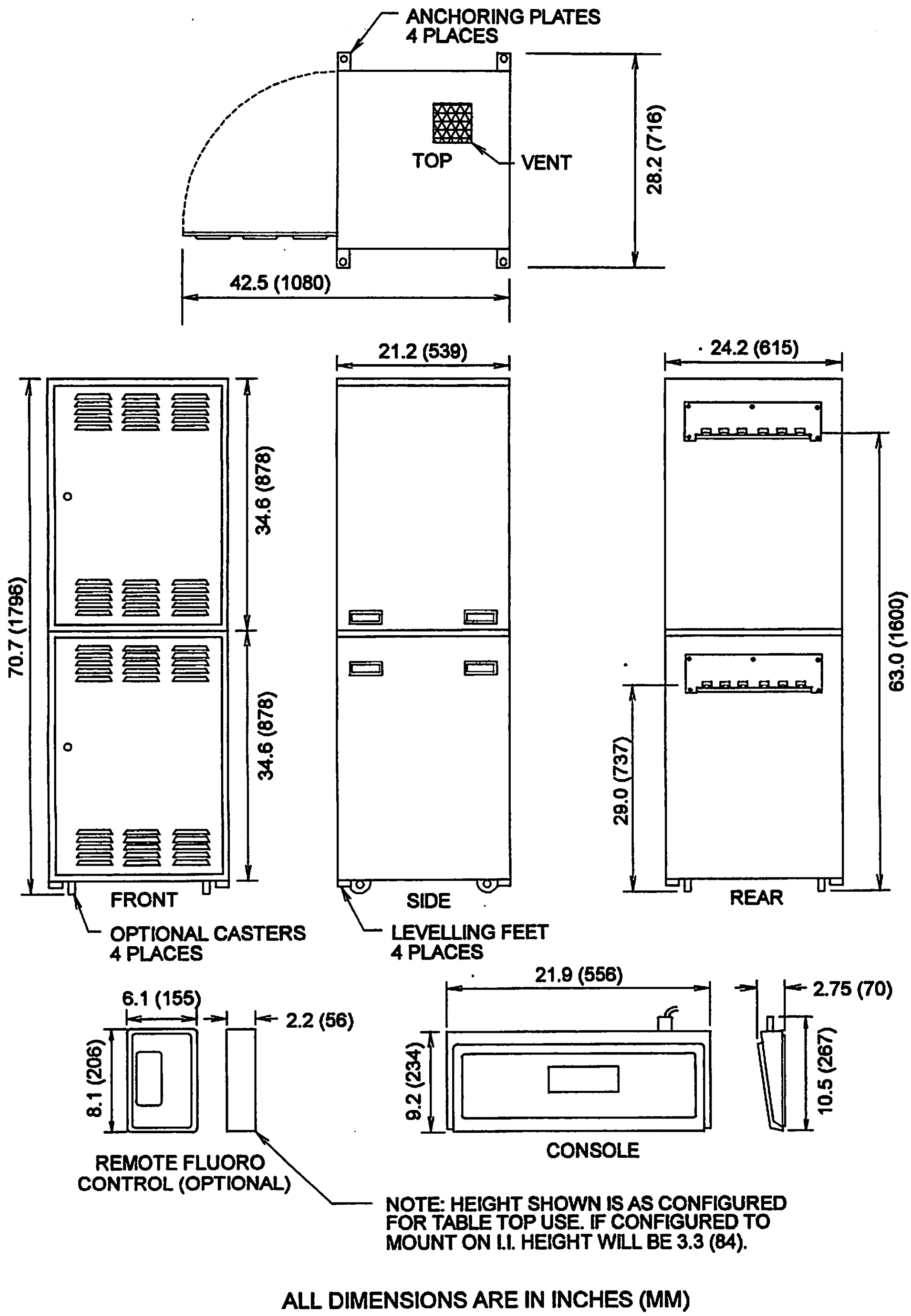

Figure 1C-1: Generator, control console, and remote fluor control outline

1C.5.2 Generator Shipping Containers: Dimensions

The generator may be split and shipped in two "2 piece packs" (figure 1C-2). If this is the case, the generator upper cabinet assembly will be shipped in one of the packs, and the lower cabinet assembly will be shipped in a second similar pack.

Alternately, both upper and lower sections of the generator may be combined and shipped in a single "1 piece pack" (figure 1C-3). Which method is chosen will depend on shipping method and destination.

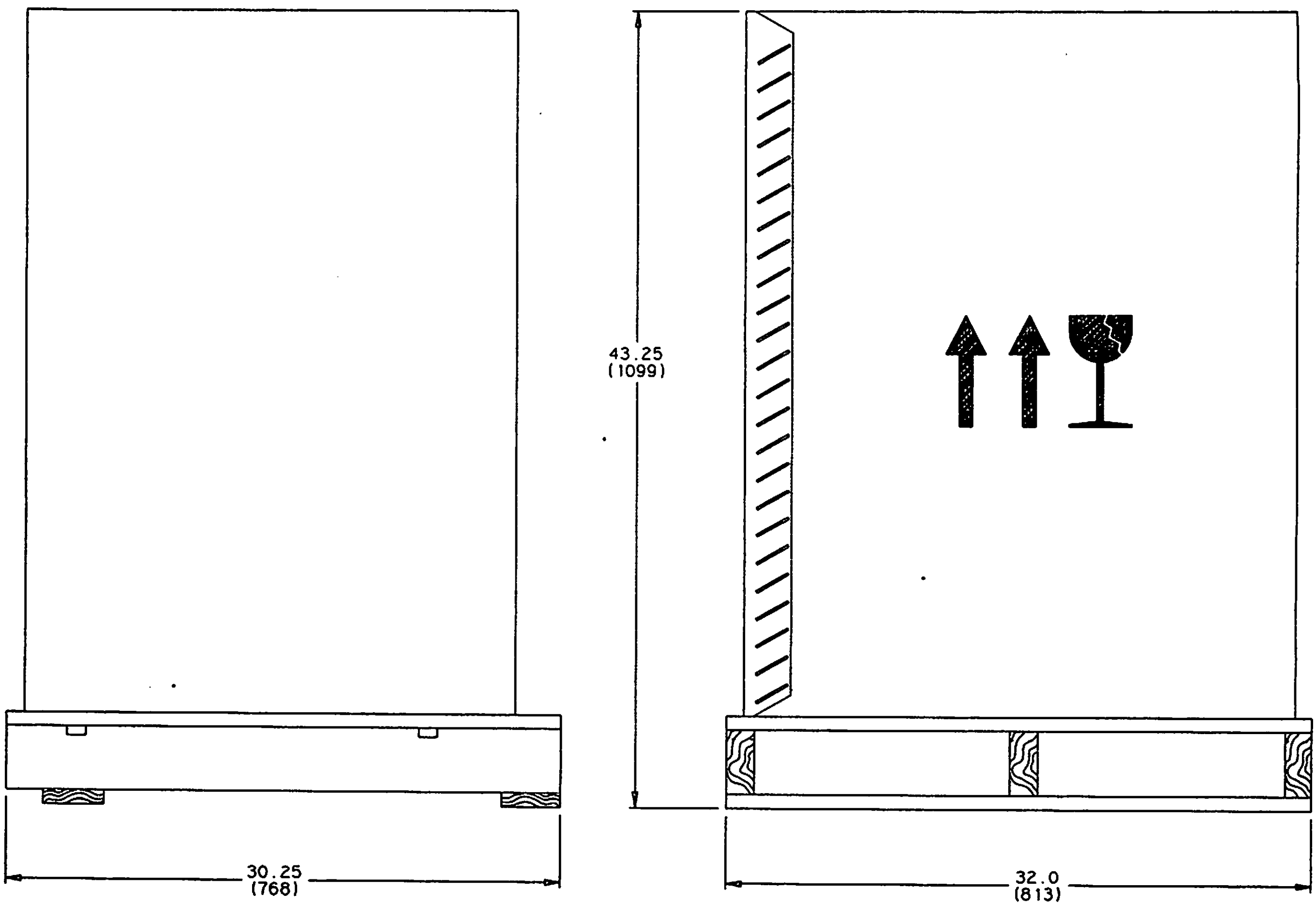

Figure 1C-2: Generator shipping containers (2 piece pack)

1C.5.2 Generator Shipping Containers: Dimensions (cont)

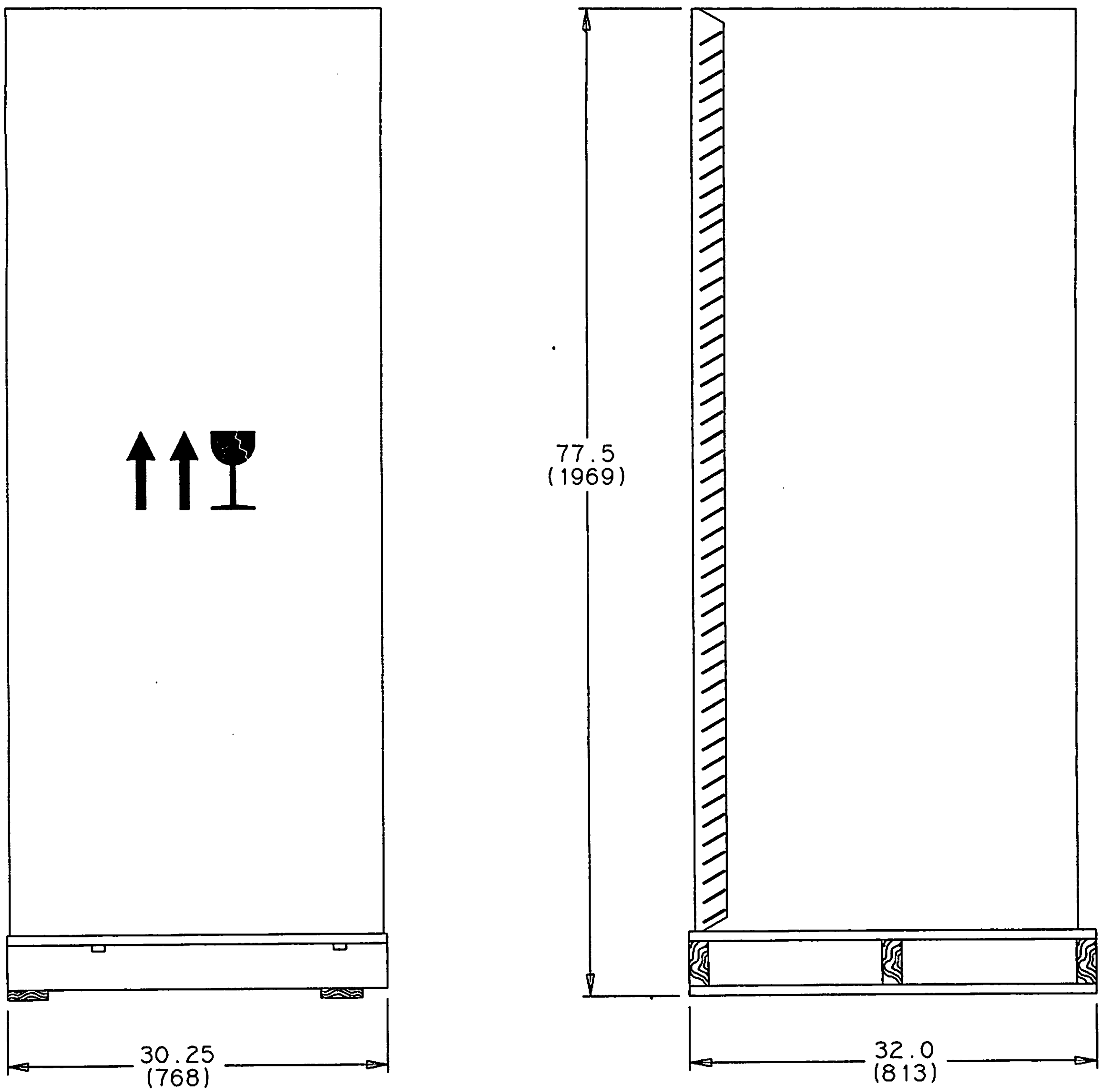

Figure 1C-3: Generator shipping container (1 piece pack)

1C.6.0 LOCATING THE GENERATOR CABINET AND CONTROLLER.

The generator cabinet is self standing and does not need to be supported. However, the installation should meet the following requirements:

- The floor must be flat and level.
- The floor must be capable of supporting a load of approximately 540 lbs (245 Kg).
- The generator installation area must be clean and free of dirt or debris.
- If required, the generator may be anchored to the floor via the anchoring plates. See figure 1C-4.
- Sufficient room must be provided to allow access to the rear panels for installation and clearance for door opening and servicing from the front. See Figure 1C-5.
- A cable conduit should be provided from the control console to the generator cabinet to allow routing of the control cable if required. Allow for a 2 inch conduit. See figure 1C-6.

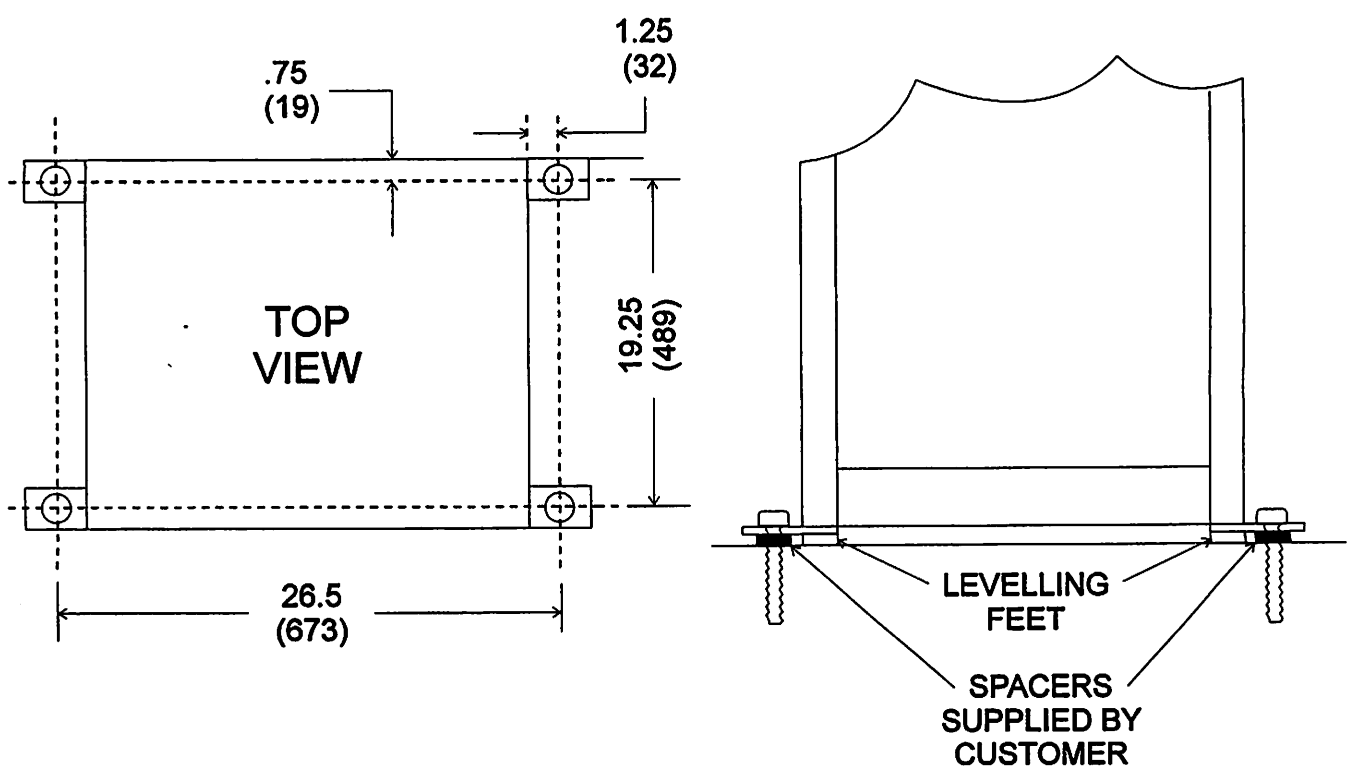

Figure 1C-4: Anchoring plates for securing the generator

1C.6.1 Locating The Equipment In The X-Ray Room.

Figure 1C-5 shows recommended clearances around the generator. Figure 1C-6 shows recommended clearances for through-the-wall cable routing.

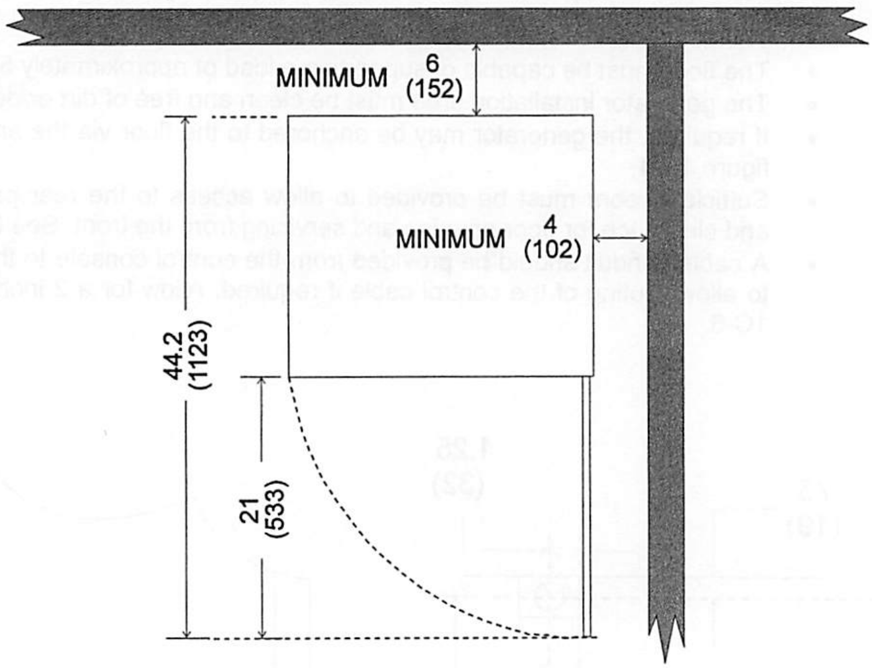

Figure 1C-5: Generator clearances

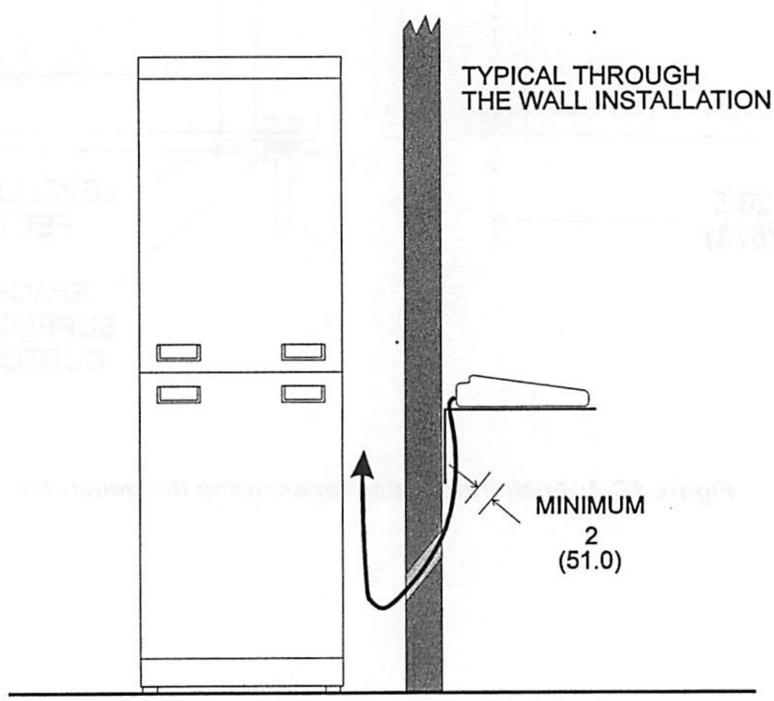

Figure 1C-6: Typical through the wall installation

1C.6.2 Seismic Centers For The Millenia Cabinet

Figure 1C-7 shows the seismic center location for generators without the line adjusting transformer, figure 1C-8 is for units with optional line adjusting transformer.

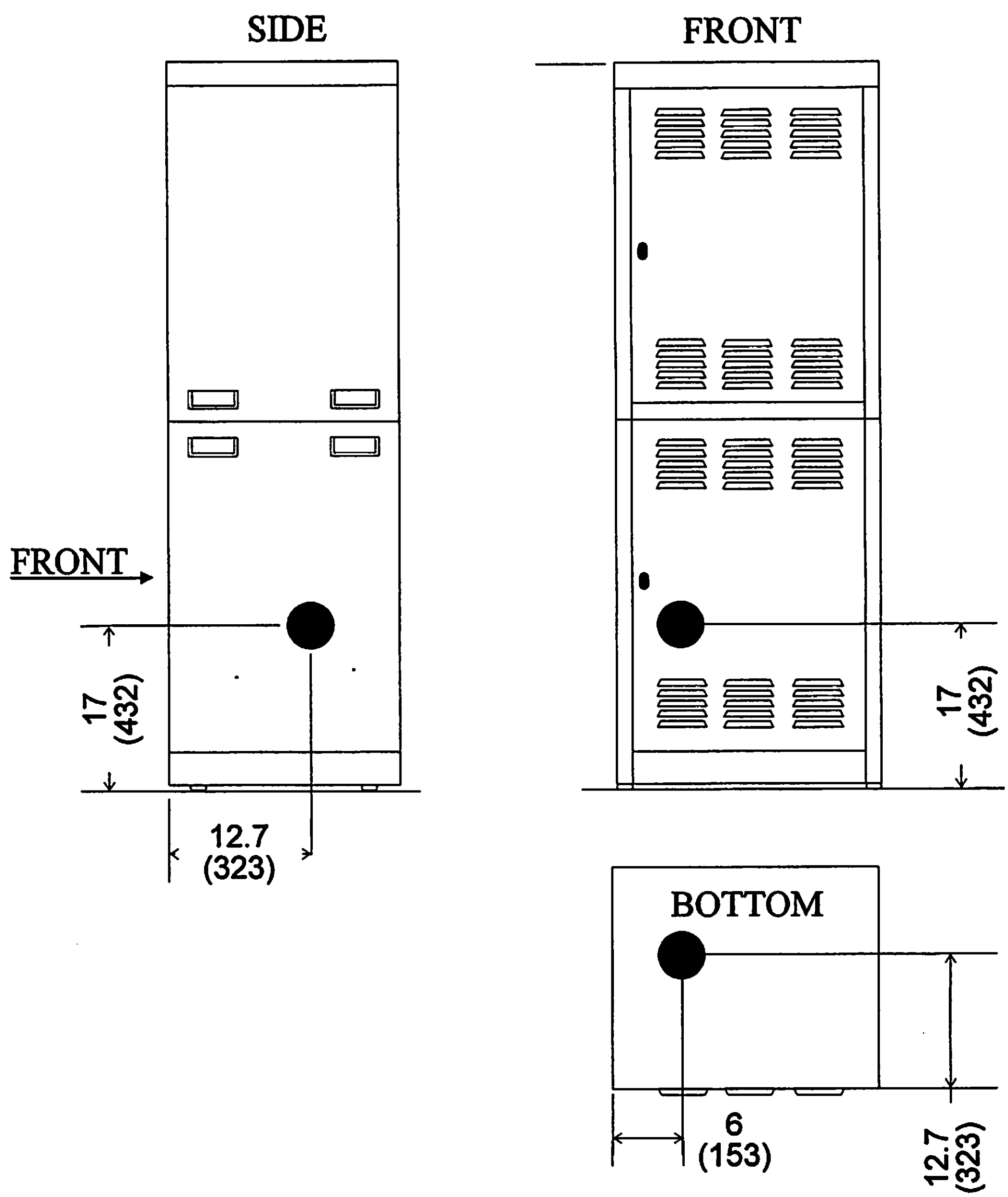

Figure 1C-7: Location of seismic centers (units without line adjusting transformer)

1C.6.2 Seismic Centers For The Millenia Cabinet (cont)

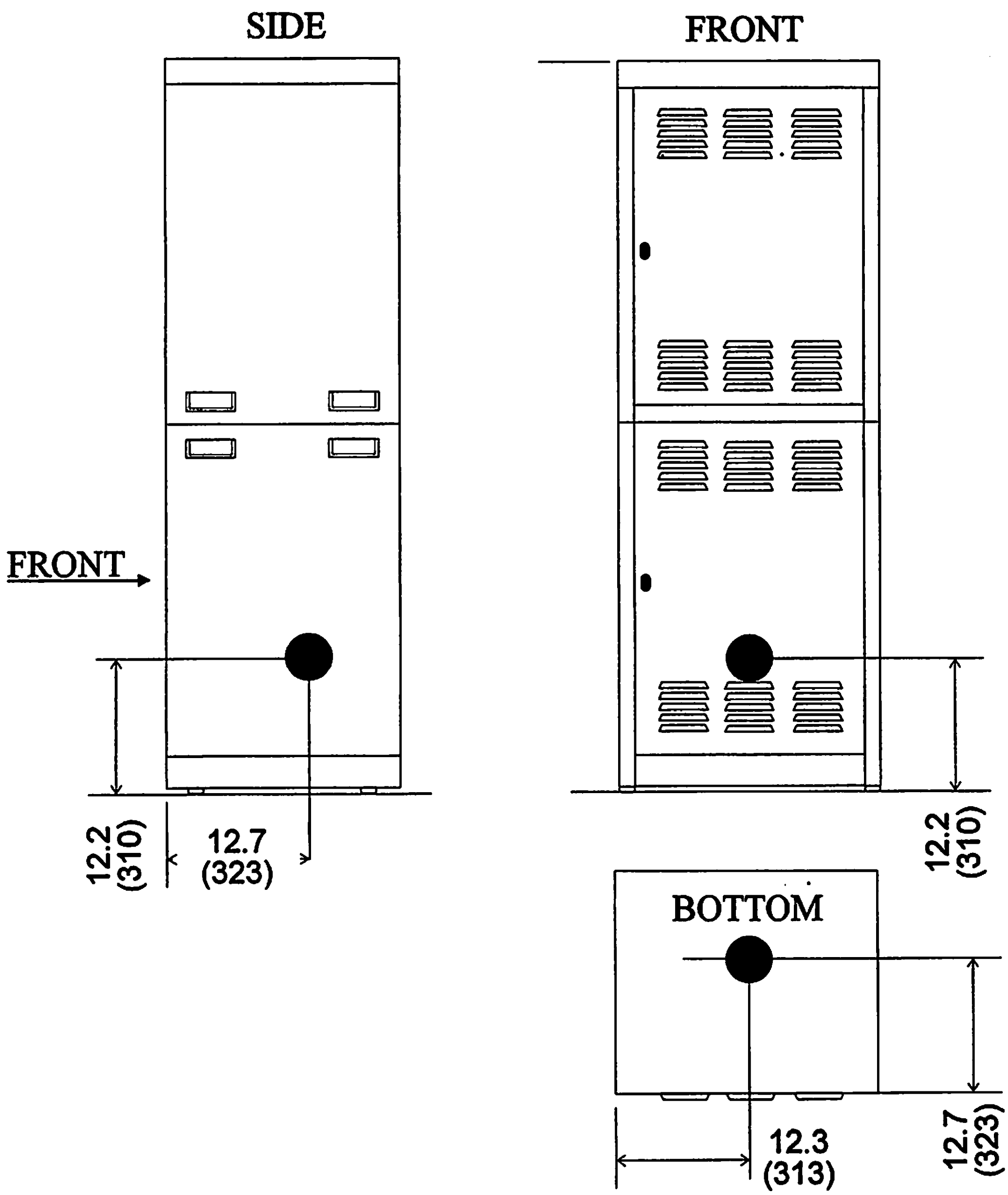

Figure 1C-8: Location of seismic centers (units with line adjusting transformer)

1C.7.0 ENVIRONMENTAL REQUIREMENTS

Listed below are ventilation requirements for the Millenia series generator:

- Unrestricted air flow must be provided at the front of the cabinet.
- Do not allow storage on top of the cabinet.
- Typical heat output 4000 BTU/hr (fluoro operation).
- Control console heat output is negligible (150 BTU/hr)

1C.8.0 CABLES SUPPLIED WITH THE MILLENIA GENERATOR

Figure 1C-9 shows the cabling supplied with the generator:

- The cable supplied for the console is a 15 conductor cable with a standard length of 50 ft. (15 m).
- The cable supplied for the optional remote fluoro control is a 9 conductor cable with a standard length of 50 ft. (15 m).

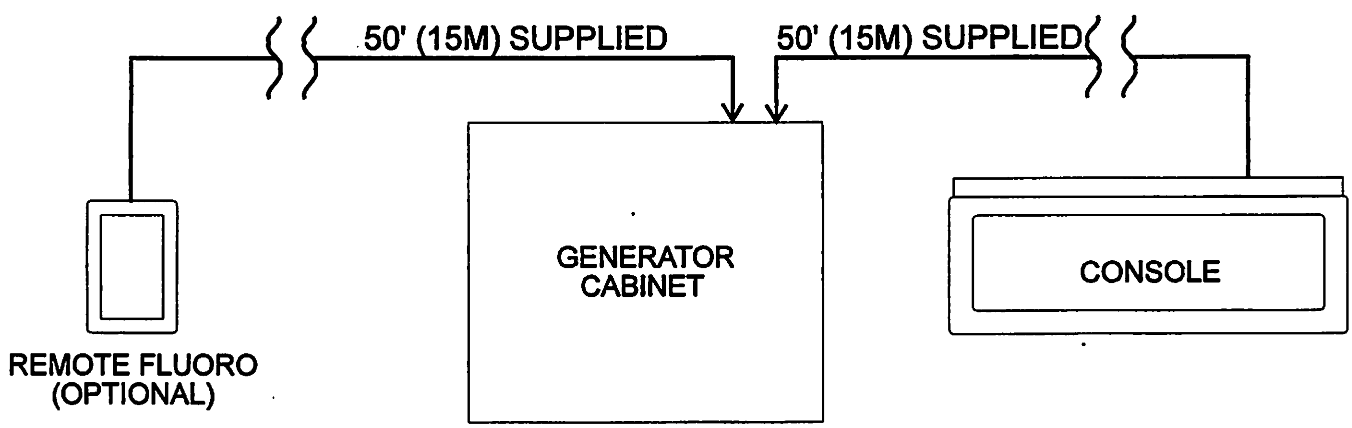

Figure 1C-9: Cabling supplied with generator

1C.9.0 PRE-INSTALLATION CHECK LISTS

The following checklists are provided to help the installer during a pre-installation site visit, prior to installing the generator:

- Site logistics
- Installation equipment

1C.9.1 Site Logistics

Before starting the generator installation, review the following checklist for site logistics.

CHECK √	DESCRIPTION
	Is there an unloading area to transport the generator from the delivery truck to the inside of the building?
	If the installation is not on the same floor as the delivery entrance, is there an elevator available?
	Are all halls and doorways large enough to allow the generator to pass through?
	Is there a transport dolly or similar device to move the Generator? It must have a minimum rating of 600 lb. (275 Kg.)
	Do any regulatory bodies need to be notified prior to installation?
	If movers are required, have arrangements for time and equipment been completed?

1C.9.2 Installation Equipment

The following is a checklist of recommended tools and test equipment for installation and calibration of the generator.

CHECK √	DESCRIPTION
	General handtools for installation: wrenches, nut drivers, assortment of screwdrivers, pliers, etc.
	If the generator is to be anchored to the floor, suitable hardware and drilling equipment must be available
	A supply of connectors for wiring: lugs, caps, line splices etc.
	A calibrated DVM which indicates true RMS voltages
	Dual trace memory oscilloscope with a minimum 20 MHz bandwidth; appropriate leads, probes, etc.
	Device for measuring true kVp and mA (mAs). This may be a Dynalyzer equivalent or a non-invasive system such as the Keithly TRIAD system.
	A calibrated radiation meter with detectors that will allow for R/min and uR type measurements (or uGy and Gy/min).
	A strobe or reed type tachometer to verify that the anode is rotating up to speed.
	A sufficient selection of patient absorbers to allow AEC and ABS calibration. A suggested selection would be 3/4 inch Al (quantity 2); 1 mm of Cu (quantity 8), Water in containers 5.0. 10.0, 15.0 cm thickness.
	Test phantoms to verify the imaging system with the generator.

CHAPTER 1

SECTION 1D

COMPATIBILITY LISTING

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1D.2.2 Stators....1D-2
1D.2.3 AEC Devices....1D-2
1D.2.4 ABS Pickups....1D-2
1D.2.5 Tomographic Tables....1D-2
1D.2.6 Digital Interfaces (R&F Generators)....1D-2
1D.2.7 DAP (Dose Area Product)....1D-3
1D.2.8 Options....1D-3
1D.3.0 X-RAY TUBE DATA....1D-3
1D.4.0 COMPATIBILITY STATEMENT / PRODUCT DESCRIPTION....1D-4

1D.1.0 INTRODUCTION

This section details external equipment that is compatible with your specific generator, and lists options that are included in that generator.

1D.2.0 COMPATIBLE DEVICES AND OPTIONS

The Millenia and Indico 100 family of generators may be factory or user configured to be compatible with various external devices. Certain features must be factory configured, others are user configurable. Please refer to chapter 2 and 3 of this manual and / or consult the factory for further specifics.

1D.2.1 X-Ray Tubes

Various makes and models of inserts and housings are supported.

CAUTION:	*PLEASE ENSURE THAT THE X-RAY TUBE INSERT IS AS STATED ON THE COMPATIBILITY STATEMENT / PRODUCT DESCRIPTION.* *IF THE HOUSING HAS BEEN RELOADED WITH ANOTHER INSERT TYPE, CALIBRATION MAY BE SERIOUSLY AFFECTED AND MAY CAUSE TUBE DAMAGE.*

1D.2.2 Stators

Various types / impedances of stators are supported.

1D.2.3 AEC Devices

The Millenia / Indico 100 family of X-ray generators may be configured to be compatible with various AEC devices (ionization, solid state or PMT) via the optional AEC board. Refer to the compatibility statement / product description at the end of this section for AEC device compatibility of this specific generator.

1D.2.4 ABS Pickups

Various ABS pickups (light diode, composite video, PMT, etc) are supported on R&F generators depending on configuration. Refer to the compatibility statement / product description at the end of this section, and chapter 3E.

1D.2.5 Tomographic Tables

Various. Please note that the generator is used as a backup timer ONLY in tomography.
AEC is NOT available for tomography.

1D.2.6 Digital Interfaces (R&F Generators)

The generator may be configured to be compatible with various digital imaging systems. Refer to the compatibility statement / product description at the end of this section.

1D.2.7 DAP (Dose Area Product)

A DAP (Dose-Area Product) meter is available as an option on Indico 100 X-ray generators. Refer to chapter 3F for details.

1D.2.8 Options

Major options include AEC board, DAP (Indico 100 only), remote fluoro control unit, dual speed starter, line adjusting transformer, and two tube HT transformer.

NOTE: ***REFER TO THE COMPATIBILITY STATEMENT / PRODUCT DESCRIPTION AT THE END OF THIS SECTION FOR COMPATIBILITY OF THIS SPECIFIC GENERATOR.***

1D.3.0 X-RAY TUBE DATA

PLEASE INSERT THE TUBE RATING CHARTS FOR THE X-RAY TUBES USED WITH THIS GENERATOR.

TUBE #1	
HOUSING (MAKE / MODEL):	
INSERT (MAKE / MODEL):	
SERIAL #:	
STATOR TYPE:	

TUBE #2	
HOUSING (MAKE / MODEL):	
INSERT (MAKE / MODEL):	
SERIAL #:	
STATOR TYPE:	

1D.4.0 COMPATIBILITY STATEMENT / PRODUCT DESCRIPTION

The compatibility statement / product description for this generator follows this page.

CUSTOMER PRODUCT DESCRIPTION X-RAY SYSTEMS
DETAILED PRODUCT/COMPATIBILITY DESCRIPTION

CUSTOMER: N/A	PRODUCT TYPE: VZW2553RD3 CONFIG TAB: -01 REV: C

PRODUCT DEFINITION

DATE: 21-FEB-00

TOP ASSEMBLY P/N: 733287-59

MILLENIA ☒

100 KHZ ☐

PRODUCT SUMMARY: 1050 RAD, 1 Tube, 1 Fil, DSS, AEC, Non-ABS, Digital Imaging

REF SPECIFICATION: VZW2553

MAXIMUM KV: 150

LANGUAGE: English

H.V. GENERATOR P/N: N/A

CONSOLE P/N: N/A

FIRMWARE (SOFTWARE) SET P/N: N/A

GENERATOR CPU BOARD P/N: N/A

INSTALLATION/SERVICE MANUAL P/N: 740810-00

MANUAL SUPPLEMENT P/N: 740931-00
740941-00

OPERATOR'S MANUAL P/N: 740811-00

COMPATIBILITY:

COMPATIBLE X-RAY TUBES

INSERT & HOUSING:

DUNLEE PX1436 (0.6/1.2)

STATOR TYPE: Standard "R" Type

OTHER STATOR: N/A

COMPATIBLE AEC DEVICE:

NO OF AEC PICKUPS: 2

MAKE: A.I.D. Ion Chamber, 3 Fields

UNIVERSAL BRD ☐ DEDICATED BRD ☒

REMARKS: N/A

COMPATIBLE TOMOGRAPH DEVICE:

MAKE: N/A

TYPE: Two Bucky RAD Table

MODEL: N/A

REMARKS: N/A

CUSTOMER PRODUCT DESCRIPTION X-RAY SYSTEMS
DETAILED PRODUCT/COMPATIBILITY DESCRIPTION

CUSTOMER: N/A	PRODUCT TYPE: VZW2553RD3 CONFIG TAB: -01 REV: C

COMPATIBILITY CONT):

COMPATIBLE ABS PICKUP: N/A

OPTIONS

LINE MAINS VOLTAGE: 480 VAC 3 Phase

X-RAY TUBE STATIONS 1: ☒ 2: ☐ **STARTER LOW SPD:** ☐ **DUAL SPD:** ☒

FILAMENT SUPPLY(S) 1: ☒ 2: ☐

SERIAL PORT COM 1: RS232 ☒ RS422 ☐ **SERIAL PORT COM 2:** Yes

SERIAL PORT COM 3: Yes **SERIAL PORT COM 4:** Yes

FLUORO REM CONTROL(R/F SYSTEMS ONLY): No **ABS (R/F SYSTEMS ONLY):** No

PULSE FLUORO: N/A

DIGITAL INTERFACE TYPE: N/A

120/240 VAC 300VA FOR IMAGE RECEPTOR POWER: Per Millenia Spec

24VDC @ 4A FOR IMAGE RECEPTOR POWER: Per Millenia Spec

NEUTRAL BLOCK OPTION: No

LINE ADJUSTING TRANSFORMER: Yes

ROOM INTERFACE CONNECTIONS: Via Room I/O Board

REMARKS/SPECIAL INSTRUCTIONS:
DIGITAL INTERFACE - DRC I/O BOARD

CHAPTER 1

SECTION 1E

GENERATOR LAYOUT AND MAJOR COMPONENTS

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1E.2.2 High Frequency Power Supply 1E-3
1E.2.3 Console Assembly 1E-4
1E.2.4 Remote Fluoro Control 1E-5
1E.2.5 Dual Speed Starter EPROM location 1E-5
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1E.1.0 INTRODUCTION

This section contains generator layout drawings and figures which identify the major generator components and PWB Assemblies.

This section also shows the location and correct orientation of the power EPROM (located on the generator CPU board, the console EPROM (located on the console CPU board), and the dual speed starter EPROM (located on the dual speed starter board if the dual speed starter option is used). Refer to the applicable figures to ensure correct EPROM placement and orientation should EPROM replacement be necessary.

1E.2.0 MAJOR COMPONENT LAYOUT

1E.2.1 Generator Cabinet Assembly

Figure 1E-1 illustrates the generator cabinet and its major components. Located within the cabinet are the following major assemblies:

- Auxiliary power supply
- Generator control circuits
- Room interface for the X-ray system
- Low speed starter or optional dual speed starter
- High frequency inverter
- H.T. transformer
- Optional AEC board (automatic exposure control)
- Optional line adjusting transformer (for 480 VAC units)

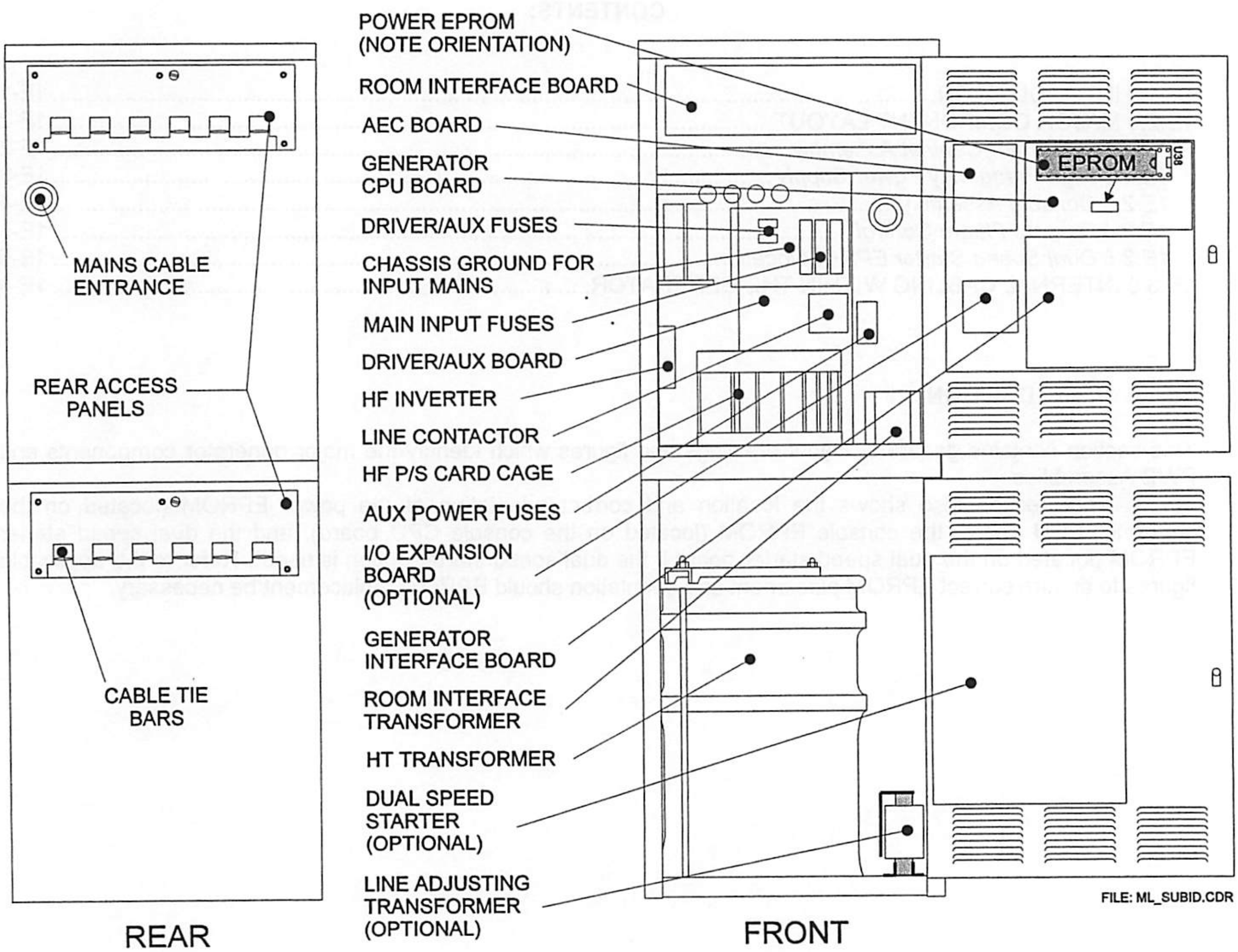


Figure 1E-1: Major generator subassemblies & power EPROM location

1E.2.2 High Frequency Power Supply

Figure 1E-2 shows the general layout of the HF power supply driver assembly.

NOTE:	***DUE TO THE DIVERSITY OF GENERATOR MODELS, THE DRIVER DETAILS MAY NOT BE EXACTLY AS SHOWN.***

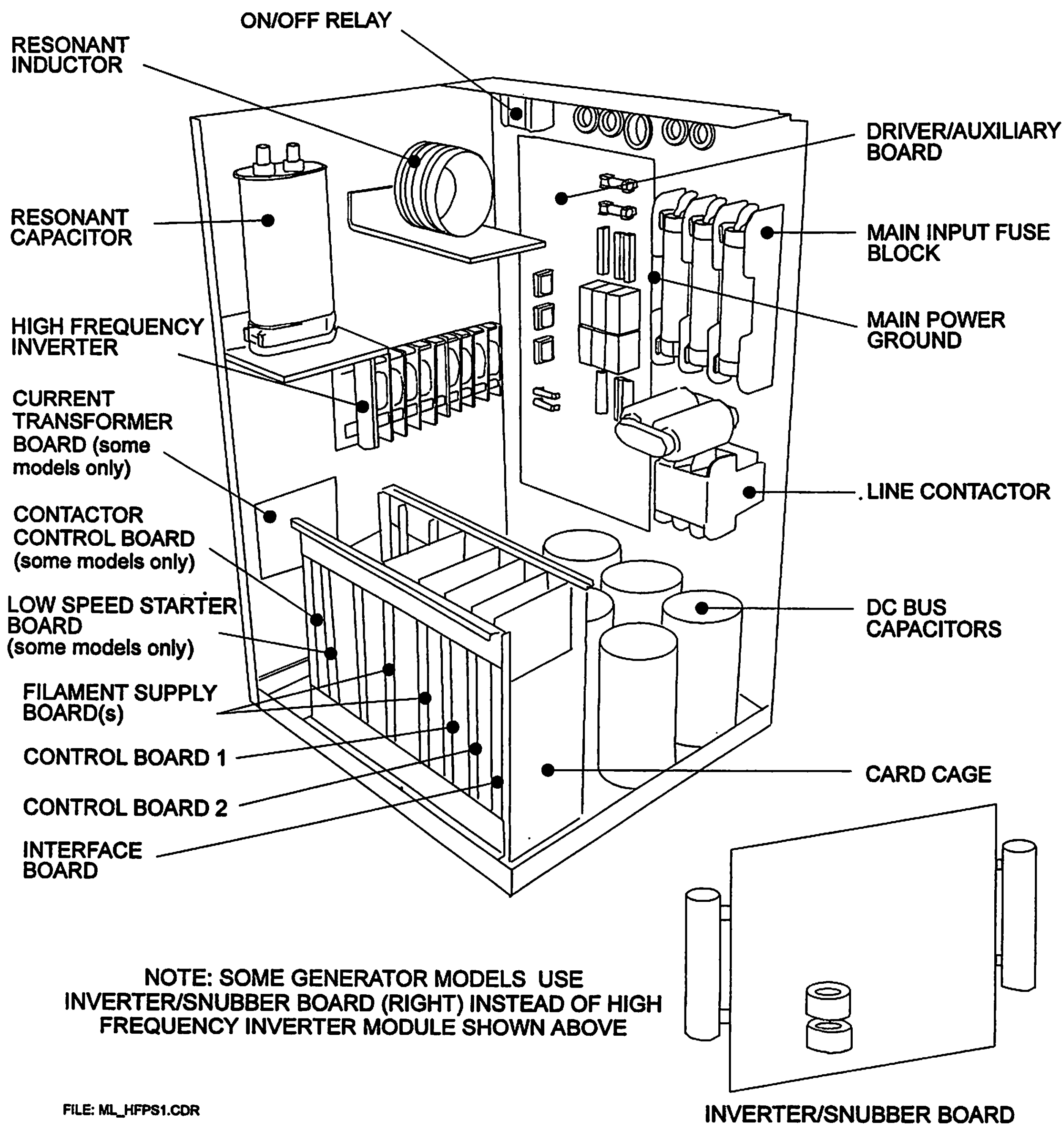
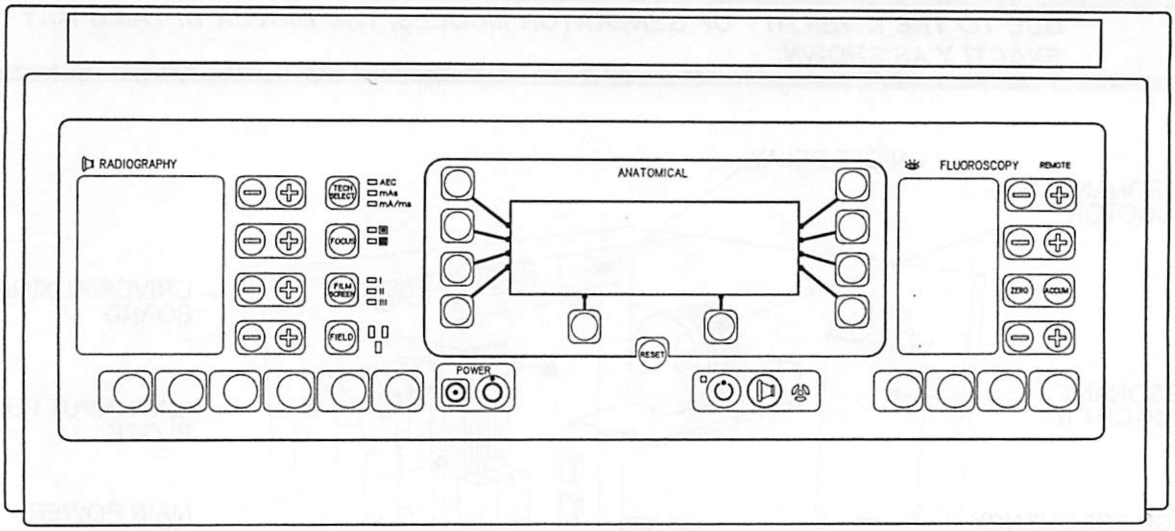


Figure 1E-2: High frequency power supply (driver)

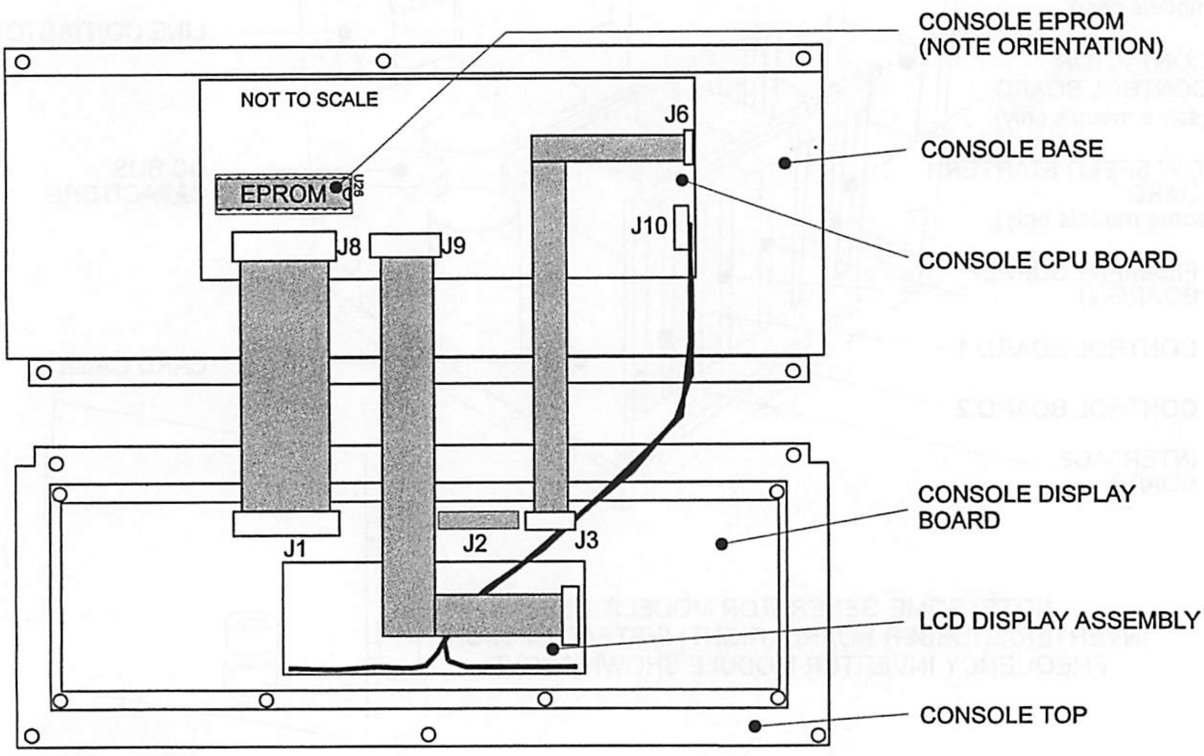
1E.2.3 Console Assembly

Figure 1E-3 is an overview of a typical R&F console assembly, figure 1E-4 is an internal view showing the major components and cabling in the console assembly.



FILE: ML_CON1.CDR

Figure 1E-3: Console top view (typical R&F generator)

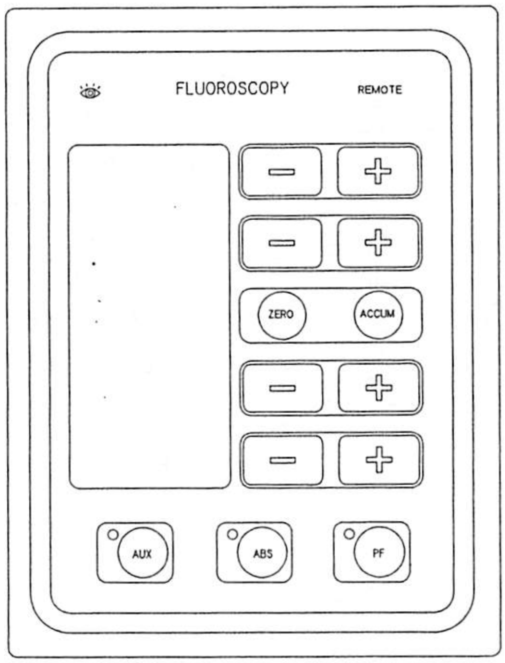


FILE: ML_CON2.CDR

Figure 1E-4: Console internal view including EPROM location

1E.2.4 Remote Fluoro Control

Figure 1E-5 is an overview of the optional remote fluoro control for the Millenia generators. This allows operation of fluoro functions from a location other than the main console.



FILE: ML_RFCTR.CDR

Figure 1E-5: Remote fluoro control unit overview

1E.2.5 Dual Speed Starter EPROM location

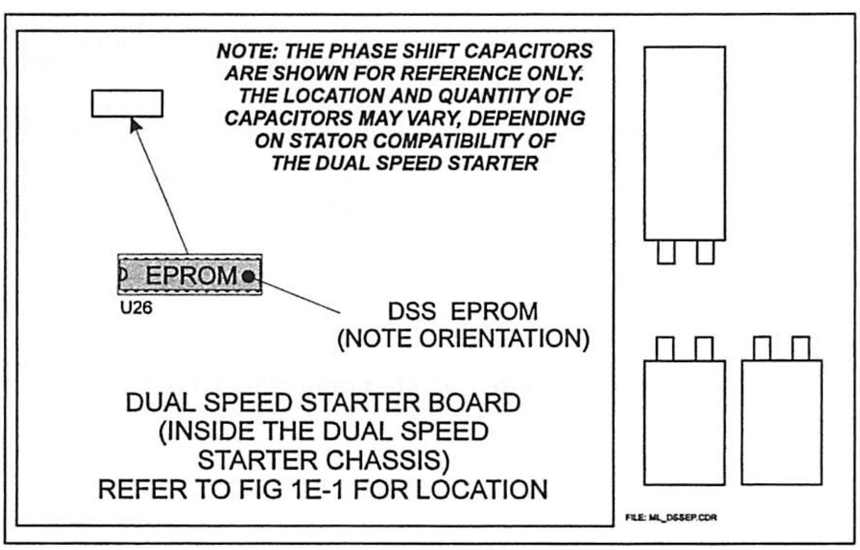


Figure 1E-6: EPROM location inside the dual speed starter

1E.3.0 INTERNAL CABLING WITHIN THE GENERATOR

Figure 1E-7 shows the main interconnecting cables within the generator.

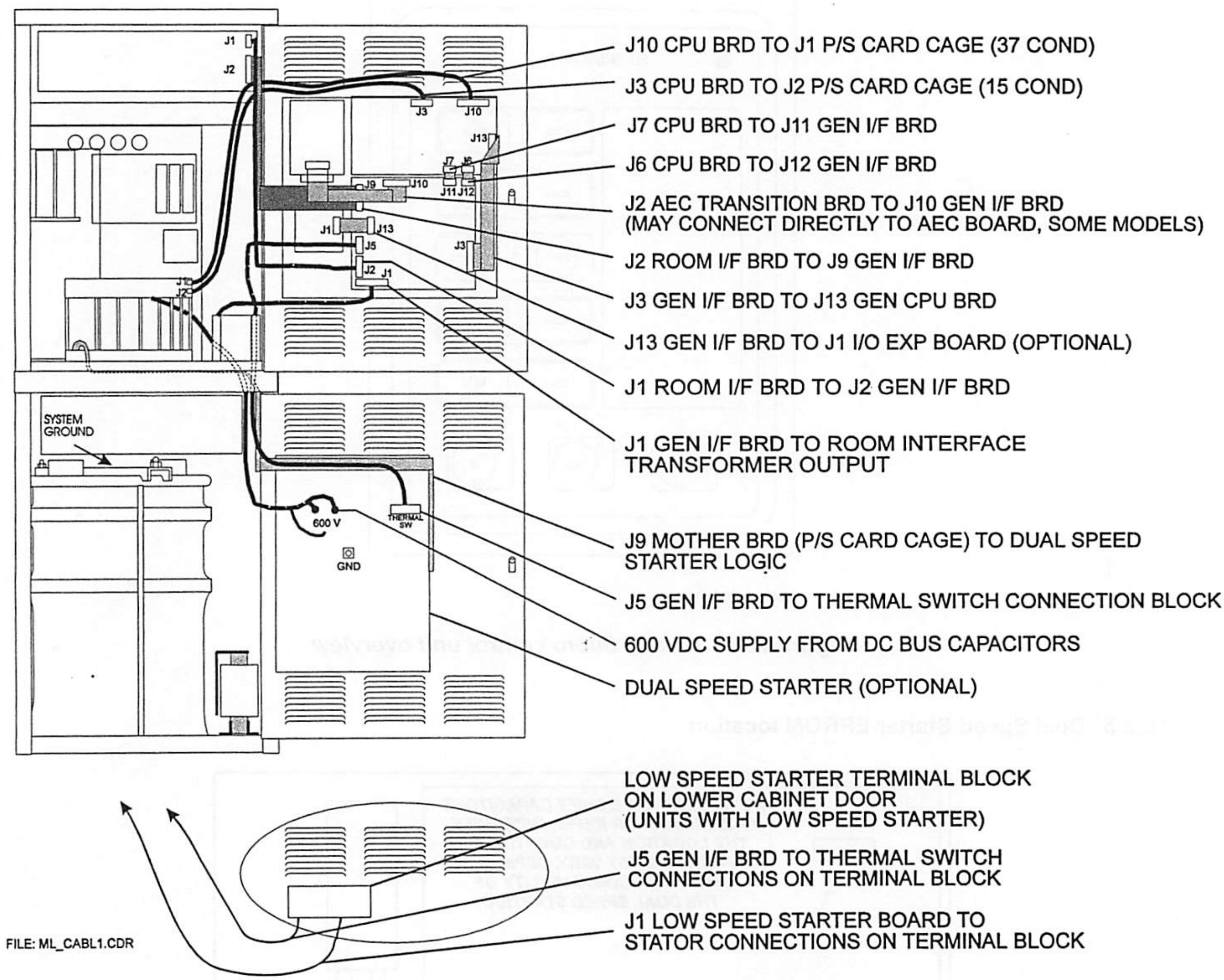


Figure 1E-7: Internal interconnecting cables

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INSTALLATION

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2.1.0 INTRODUCTION

This chapter contains instructions for unpacking, positioning, and cabling the Millenia series of generators to allow initial operation and calibration. The instructions in this chapter allows the installation engineer to:

- Install the generator and control console.
- Install the optional remote fluoro control.
- Connect power.
- Calibrate one or two X-ray tube(s), depending on the generator model, ***without*** completing the room interface connections. This allows for simpler installation and troubleshooting on the generator itself.

2.2.0 RECEIVING

WARNING:	***THE MILLENIA GENERATOR CONSISTS OF THE FOLLOWING ITEMS: UPPER AND LOWER CABINETS EITHER FACTORY ASSEMBLED OR SHIPPED IN TWO SEPARATE SECTIONS, THE CONTROL CONSOLE, AND OPTIONAL REMOTE FLUORO CONTROL.*** ***THE COMPLETE CABINET ASSEMBLY WEIGHS APPROXIMATELY 500 POUNDS (225 KG) IN ITS SHIPPING PACKAGE OR APPROXIMATELY 600 POUNDS (271 KG) WITH THE LINE ADJUSTING TRANSFORMER.*** ***WHEN SHIPPED AS SEPARATE ASSEMBLIES THE TOP CABINET WEIGHS APPROXIMATELY 200 POUNDS (90 KG) AND THE BOTTOM CABINET WEIGHS APPROXIMATELY 300 POUNDS (136 KG), OR 400 POUNDS (180 KG) WITH THE LINE ADJUSTING TRANSFORMER.*** ***THE OIL TANK IS LOCATED IN THE BOTTOM CABINET. THIS CABINET MAY ALSO CONTAIN THE LINE ADJUSTING TRANSFORMER (OPTIONAL). ONE PERSON SHOULD NOT ATTEMPT TO LIFT OR MOVE THESE ASSEMBLIES WITHOUT ADEQUATE ASSISTANCE OR PROPER EQUIPMENT.***

2.2.1 Major Shipping Assemblies

Refer to figure 1A-1 (chapter 1, section 1A). This shows the upper and lower generator cabinets fully assembled, along with the control console and optional remote fluoro control unit.

2.3.0 REMOVAL FROM PACK

1. Inspect the pack for evidence of shipping damage. If there is evidence of shipping damage, note this in the event that a damage claim is justified.

2. Remove the cardboard outer pack(s).

CAUTION: ***OPEN THE CARDBOARD PACK(S) CAREFULLY. SHARP TOOLS MAY DAMAGE THE CONTENTS.***

3. Remove the cabinet(s) from the shipping skid(s).

4. Set aside the cardboard pack(s) and skid(s). Open up the two cabinet doors with the 4 mm hex wrench located in the envelope attached to the door.

5. Inspect for shipping damage. Check the oil tank shipping pack to verify that there have been no oil leaks.

6. Remove and unpack the control console, the optional remote fluoro control if used, and the optional handswitch kit if included, and check for any damage. These items are packed in the lower generator cabinet, or may be packed in a separate carton.

7. Remove and unpack the manuals and any other paperwork that may be packed with the generator.

8. Keep the shipping containers. In case of shipping damage, place the unit(s) back in its shipping pack and notify the carrier and the customer support group at CPI Canada Inc.

2.4.0 MAJOR COMPONENT LAYOUT

Refer to chapter 1, section 1E for major component identification and layout.

2.5.0 GENERATOR CABINET ASSEMBLY

Use this procedure only for generators shipped in two separate sections. For generators shipped assembled, go to 2.7.0 EQUIPMENT PLACEMENT.

1. Position the lower generator cabinet as close to its final location as possible. The upper cabinet should be placed conveniently close by. Allow sufficient working area around the two cabinets for cabling etc.

2. Remove the following items from the hardware bag fastened to the upper generator cabinet floor:

   - One hex wrench for the bolts that hold the cabinet together (5/16", 8 mm)
   - qty 4 socket head cap bolts
   - qty 4 washers
   - Qty 4 lock washers

3. Place the upper cabinet on top of the lower cabinet and align the index dimples. See Figure 2-1.

CAUTION:	***TO PREVENT INJURY THIS ASSEMBLY MUST BE PERFORMED BY TWO PEOPLE. LIFT THE UPPER CABINET BY THE SIDE HANDLES.***

4. When the upper cabinet is properly positioned on the lower cabinet, open the lower cabinet doors and install the hardware from step 2 at the four corners of the cabinets as per figure 2-1. Tighten the bolts fully. Deposit the hex wrench in the hardware bag and place safely inside the generator cabinet such that it will be available in the future if needed.

5 Adjust the leveling feet to allow the doors to open freely. The final leveling will be completed when the generator is placed in its final location.

2.5.0 Generator Cabinet Assembly (cont)

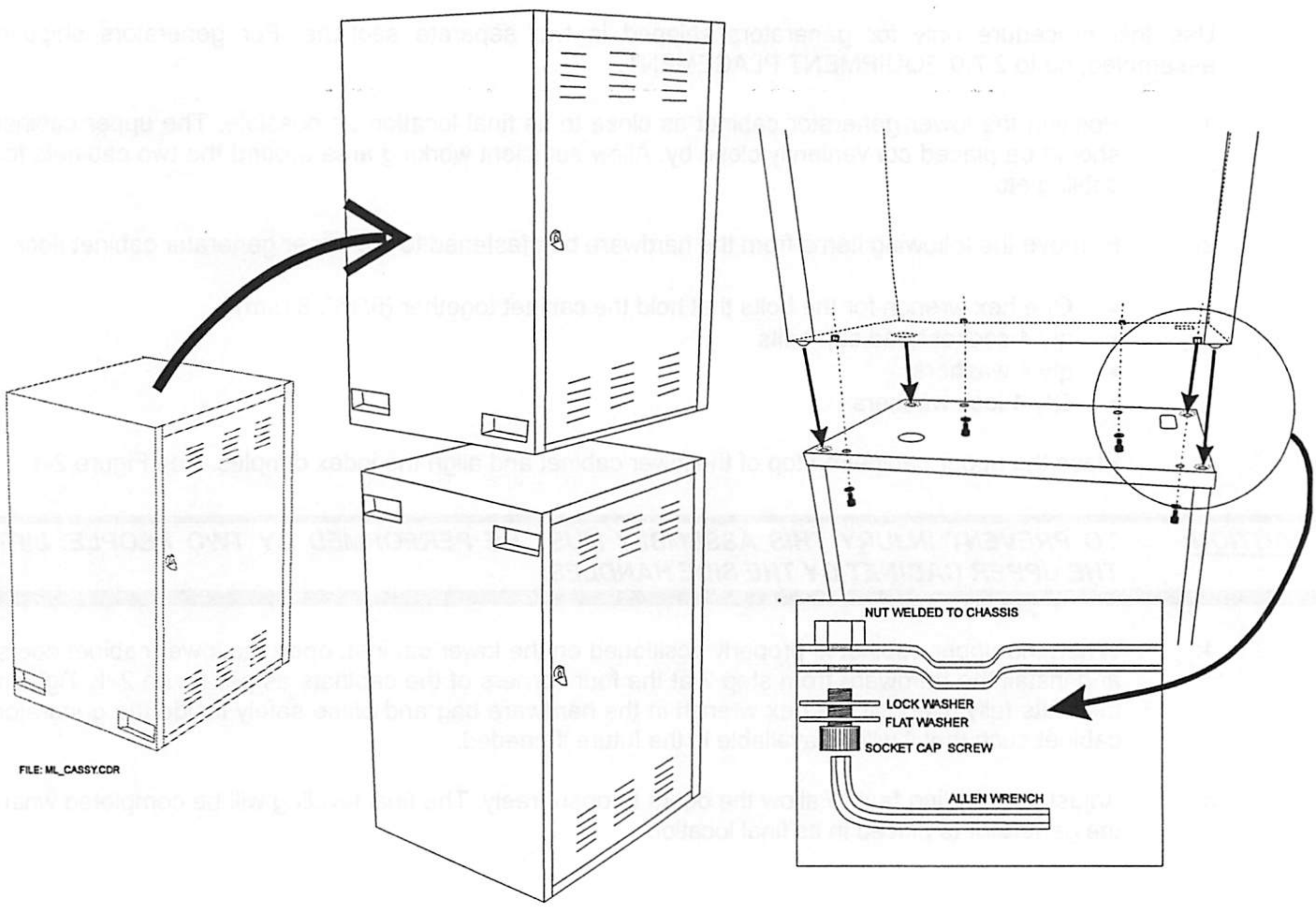


Figure 2-1: Generator cabinet assembly.

CAUTION: ***THE UPPER CABINET ASSEMBLY WEIGHTS APPROXIMATELY 125 LBS (57 Kg).***

2.6.0 INTERNAL WIRING OF THE GENERATOR

2.6.1 Line Adjusting Transformer

Use this procedure only for units with the line adjusting transformer (480 VAC units). For generators without the line adjusting transformer, go to 2.6.2

1. Locate the transformer cable harness assembly, temporarily bundled adjacent to the line adjusting transformer in the lower cabinet.

2. Undo the cable harness assembly, carefully laying out the cable set.
   Note the two pairs of cables: **RED** are the primary ***480 VAC*** input cables, **BLACK** are the ***380 VAC*** output cables.

   Refer to figure 2-2

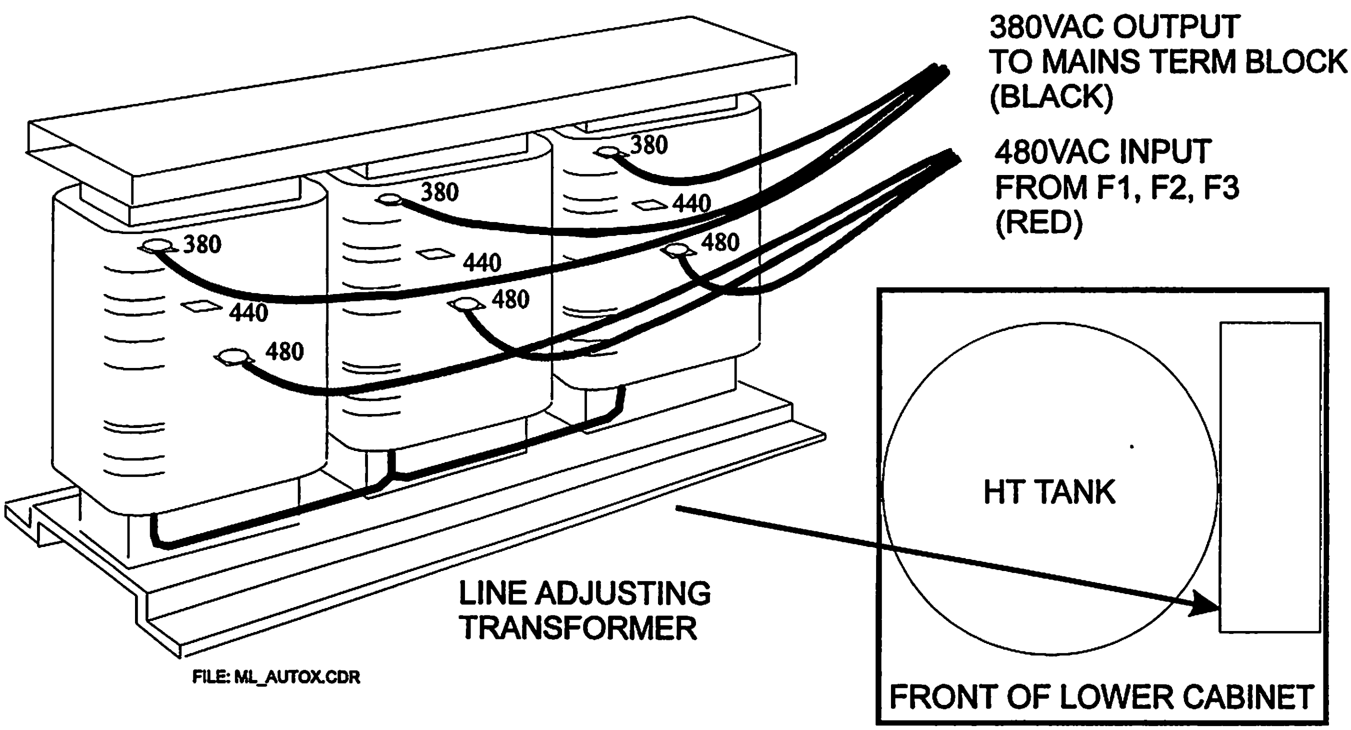


Figure 2-2: Line adjusting transformer

2.6.1 Line Adjusting Transformer (cont)

Refer to figure 2-3:

1. Pass the **BLACK** cable set up through the access hole located at the right rear side of the generator cabinets.
2. Connect the black wires (transformer output) to the terminal strip located near the line contactor on the HF power supply. The three wires may be connected to any of the three terminals.
3. Tighten the wires in the terminal strip.
4. Pass the **RED** cable set up through the same access hole located at the right rear side of the cabinet.
5. Temporarily remove the safety cover from the main fuses.
6. Connect the red wires to the bottom of the main line fuses, note that the red wires have different lengths to reach the appropriate fuse terminal.
7. Tighten the wires in the fuse block connectors. Secure the cable assembly in the cabinet and be sure there is no strain on the terminal connections. Re-attach the safety cover that was removed in step 5.

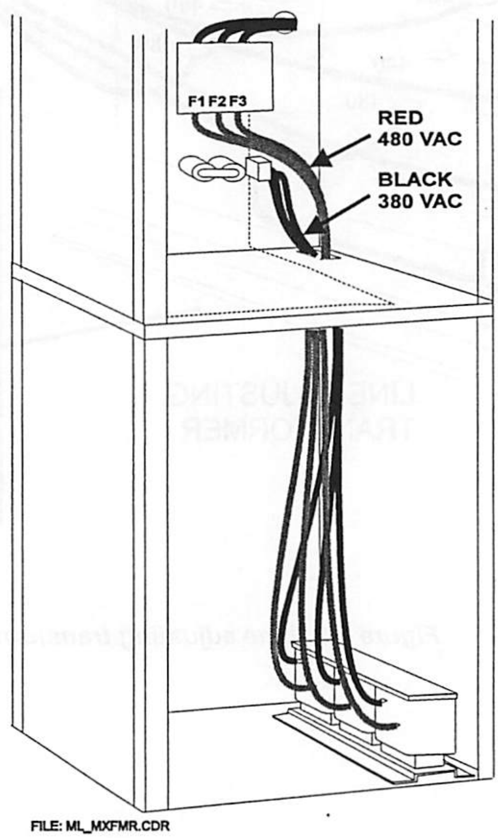


Figure 2-3: Line adjusting transformer wiring.

2.6.2 High Tension Transformer Wiring

1. Locate and unwind the high tension transformer cables. These are temporarily bundled in the upper cabinet at the side of the HV power supply. This harness assembly consists of the following cables:
   - HT primary cable (twisted heavy black wires with ring lugs).
   - KV/mA feed back cable (shielded cable with 5 pin connector)
   - Filament transformer cable (two sets of twisted wires, with a 7 pin connector).
   - HT switch and feedback cable (**2 tube units only**). This is a cable assembly consisting of a single pair of twisted wires plus a group of 3 wires all terminated with a 9 pin connector.
   - Main green/yellow ground wire from HF driver.
   - A separate green/yellow ground wire bundled along with this cable set.

2. Pass these cables from the upper cabinet to the lower cabinet via the opening at the right rear of the cabinets.

3. Connect the cables to the connectors on the tank lid board. Your generator will use one of four versions of tank lid boards, verify your tank lid board type per figures 2-6A, 2-6B, 2-6C or 2-6D. The cable assembly with the 5 pin connector must connect to the 5 pin connector on the board, similarly for the 7 pin and 9 pin connectors. The number of pins noted defines the designated CONNECTOR SIZE. In some cases pins have been removed to allow for proper voltage separation, therefore the actual pin count may be less.
   The two HT primary leads must connect to the high current threaded feedthrough connectors on the tank lid board. Refer to the note below and figures 2-4 and 2-5 before making these connections (only one of the two feedthrough connectors is shown in figure 2-4).

⚠ Do not over tighten the primary cables (22 in. lb./2.5 Nm maximum torque) as overtightening may damage the feedthrough terminals.
In order to prevent the threaded insert from turning when loosening or tightening the top nut, securely hold the bottom nut using an appropriate wrench.

4. Verify that all plugs are correctly installed onto the connectors.

5. Connect the following two ground wires to the X-ray tube housing grounding stud on the HT tank lid (see figure 2-5):
   * The free end of the ground wire from the HF driver
   * One end of the separate ground wire identified as being part of the cable bundle in step 1.

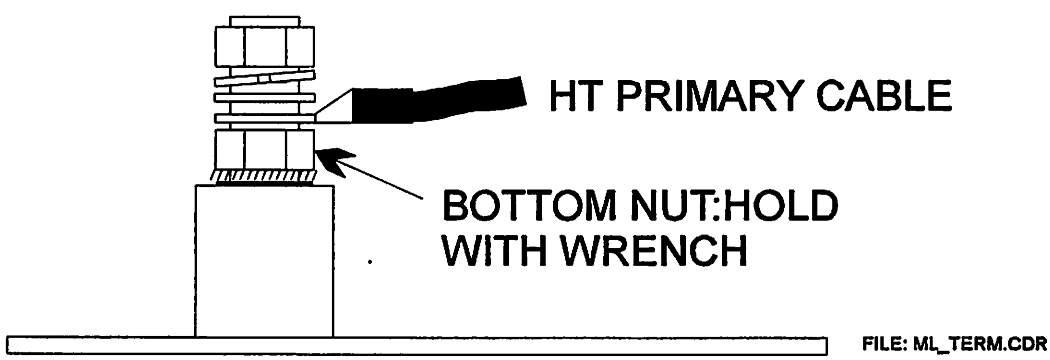
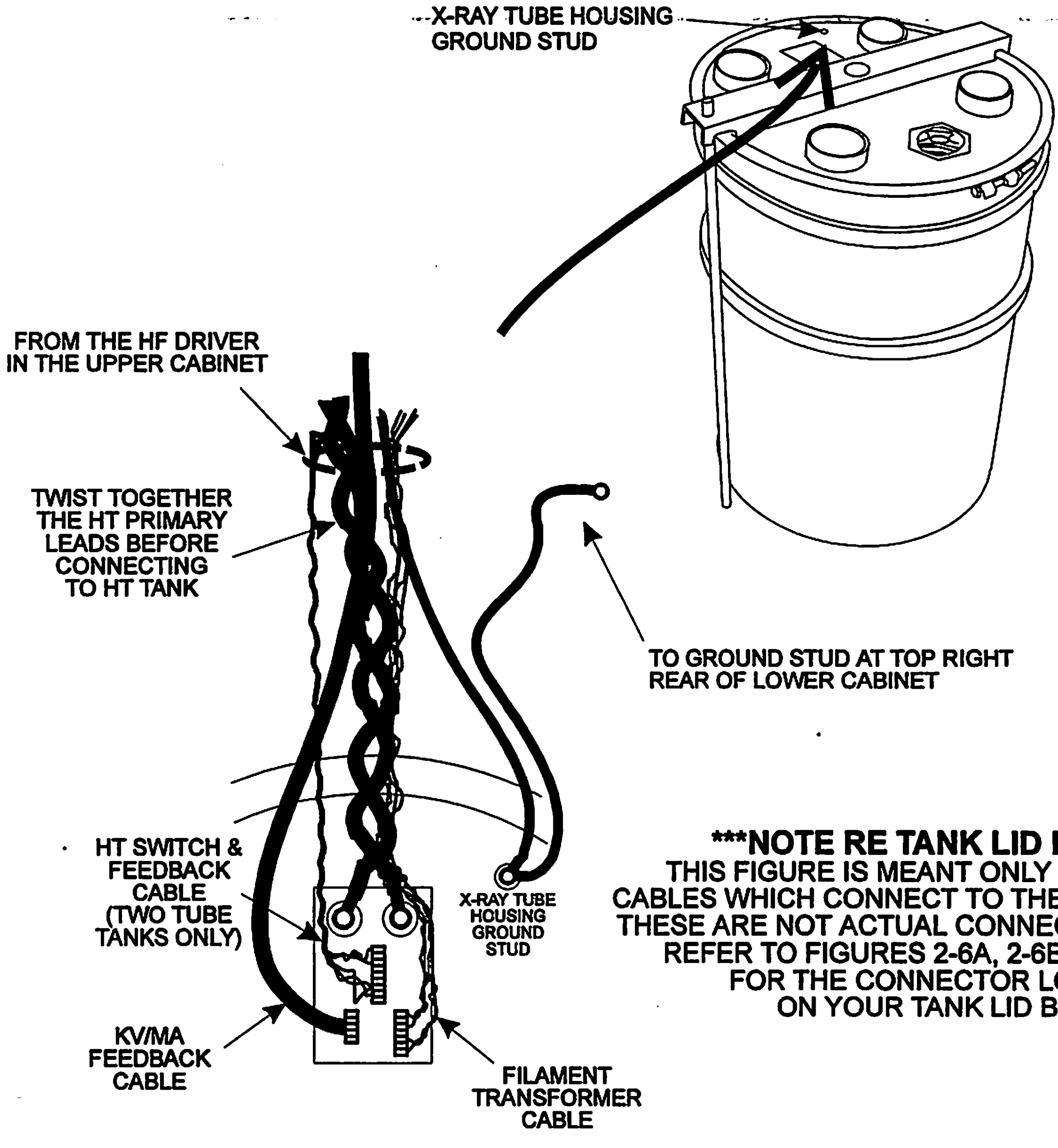


Figure 2-4: HT primary wiring.

2.6.2 High Tension Transformer Wiring (cont)



*****NOTE RE TANK LID BOARD*****
THIS FIGURE IS MEANT ONLY TO SHOW THE CABLES WHICH CONNECT TO THE TANK LID BOARD. THESE ARE NOT ACTUAL CONNECTOR LOCATIONS. REFER TO FIGURES 2-6A, 2-6B, 2-6C OR 2-6D FOR THE CONNECTOR LOCATIONS ON YOUR TANK LID BOARD

FILE: M1_OT1.CDR

Figure 2-5: HT transformer wiring.

2.6.2 High Tension Transformer Wiring (cont)

HT tank lid board styles:

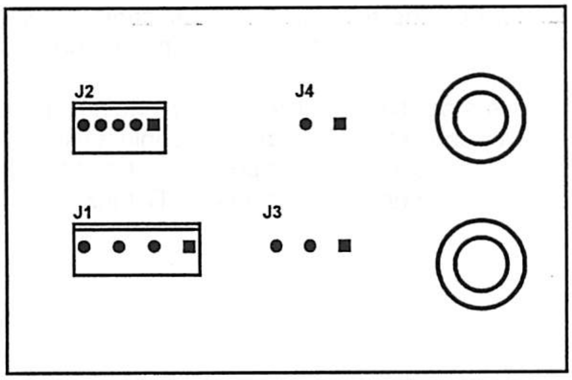


Figure 2-6A

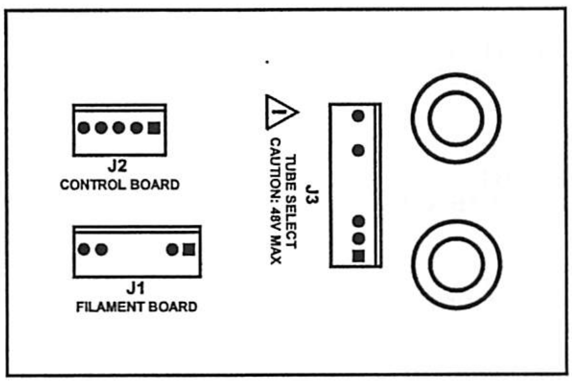


Figure 2-6B

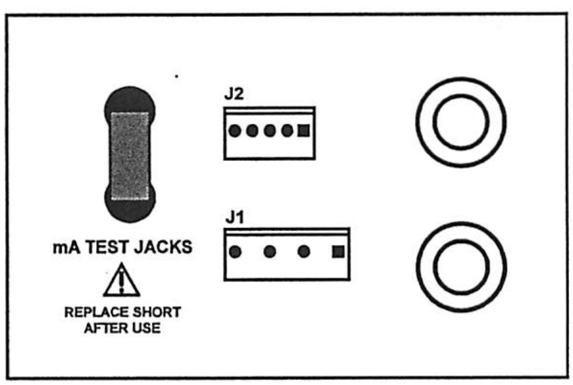


Figure 2-6C

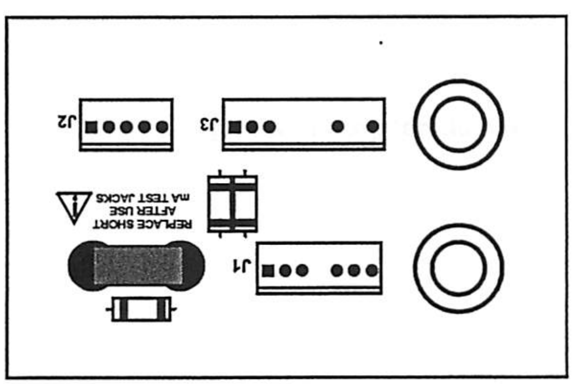


Figure 2-6D

FILE: ML_TBRDS.CDR

2.6.3 Cabinet Ground Wiring

1. Connect the free end of the ground wire from step 5 of section 2.6.2 to the ground stud located on the ceiling of the lower cabinet near the right rear side. Connect the ground wire leading from the upper cabinet ground stud (located on the floor of the upper cabinet behind the room interface transformer) to the ground stud on the ceiling of the lower cabinet along with the HT transformer ground wire. Tighten all grounds securely.

   Refer to figure 2-7 for this step. Note that the upper cabinet ground stud will have one ground wire connecting to the lower cabinet, and the bottom cabinet will have TWO ground wires, that is one end of the ground wire connecting to the upper cabinet and the other end of the ground wire connecting to the X-ray tube housing ground stud on the HT tank.

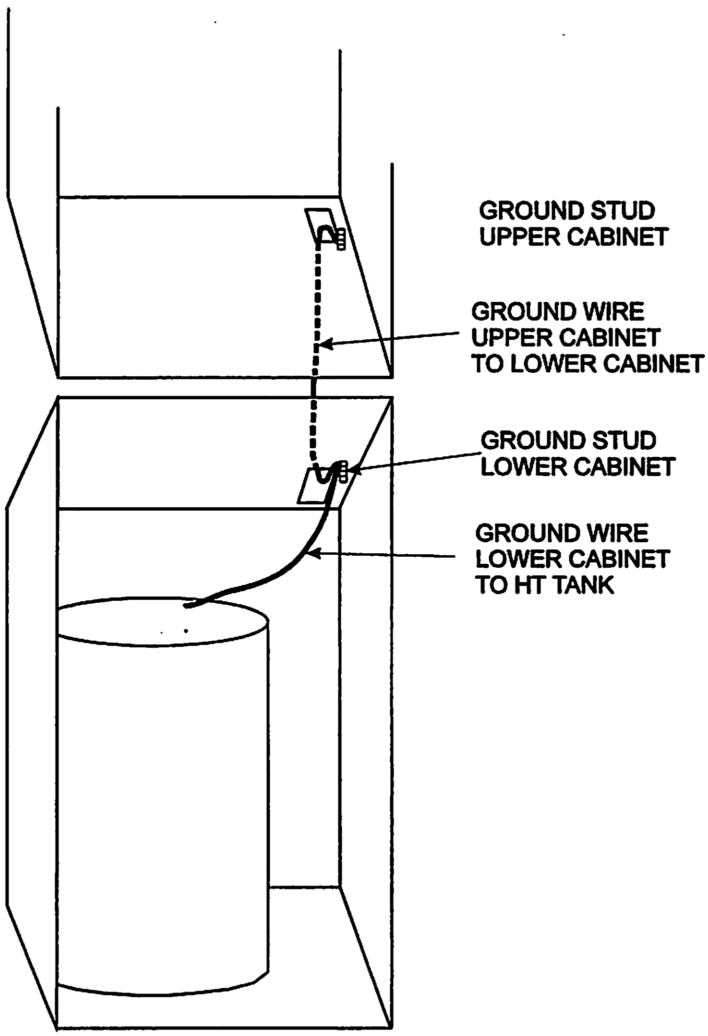


Figure 2-7: Cabinet ground wiring

2.6.4 Low Speed Starter Wiring

Refer to figure 2-8. This section applies only to units fitted with low speed starter.

1. Unbundle the cable assembly connected to the low speed starter terminal block. This cable bundle is secured in the lower cabinet for shipping.
2. Temporarily remove the Plexiglas safety barrier from the front of the HF power supply.
3. Route the two cable assemblies through the appropriate cutouts in the two cabinets as per figure 2-8, securing the cables as required using existing "P" clips and/or supplied tie wraps.
4. Connect the free ends of the two cable assemblies: The thermal switch cable from the low speed starter terminal block connects to J5 of the generator interface board. The stator power cable from the low speed starter terminal block connects to J1 of the low speed starter board.
5. Re-install the Plexiglas safety barrier that was removed in step 2. The low speed starter cable must pass through the slot near the bottom of the barrier.

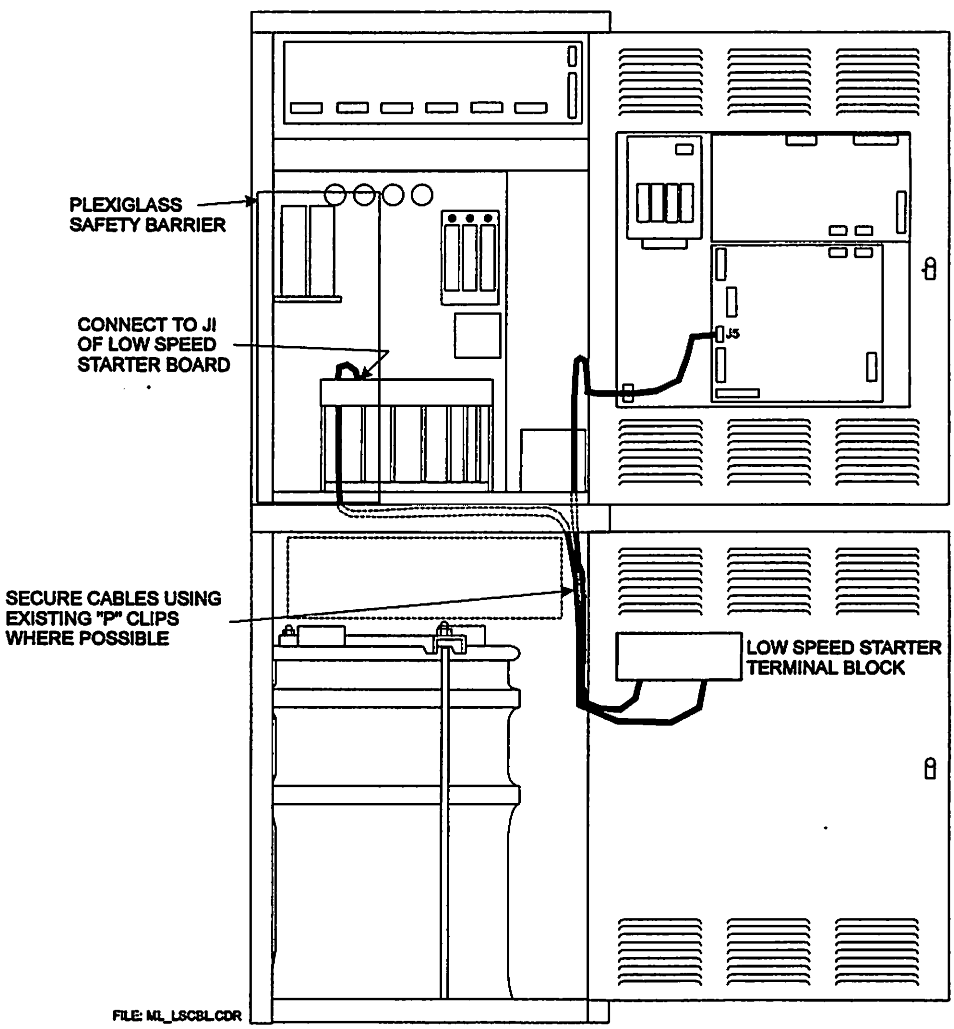


Figure 2-8: Low speed starter wiring

2.6.5 Dual Speed Starter Wiring

Refer to figure 2-9. This section applies only to units fitted with dual speed starter.

1. Untie the two cable assemblies connected to the dual speed starter. These cable assemblies are secured in place during shipping in the lower generator cabinet.

2. Route the 20 conductor DSS logic cable from the dual speed starter along the ceiling of the lower cabinet and up through the access hole in front of the power supply card cage. Then pass the end of the ribbon cable through the HF power supply card cage as shown in figure 2-9.
   Plug this cable into J9 on the backplane board located at the bottom of the card cage. J9 is on the left side of the backplane board, this connector is polarized such that the mating connector can only plug in one way. Take care not to damage any nearby components.

3. Route the X-ray tube thermal switch cable assembly through the appropriate cutouts in the two cabinets as per figure 2-9. Connect to J5 on the generator interface board.

4. Route the 600 VDC supply cable (connected to the HF power supply in the upper cabinet) through the cutouts near the rear right of the two generator cabinets down to the dual speed starter. Connect as follows:
   - Connect the red wire to the **600 VDC RED +** push-on connector at the upper left front of the dual speed starter.
   - Connect the black wire to the **600 VDC BLK** - push-on connector at the upper left front of the dual speed starter.
   - Connect the two ground wires (one is black, one has green/yellow sleeving) to the ground stud on the dual speed starter below the 600 VDC supply terminals.

5. Dress and secure the above cables as required using existing "P" clips and/or supplied tie wraps.

2.6.5 Dual Speed Starter Wiring (cont)

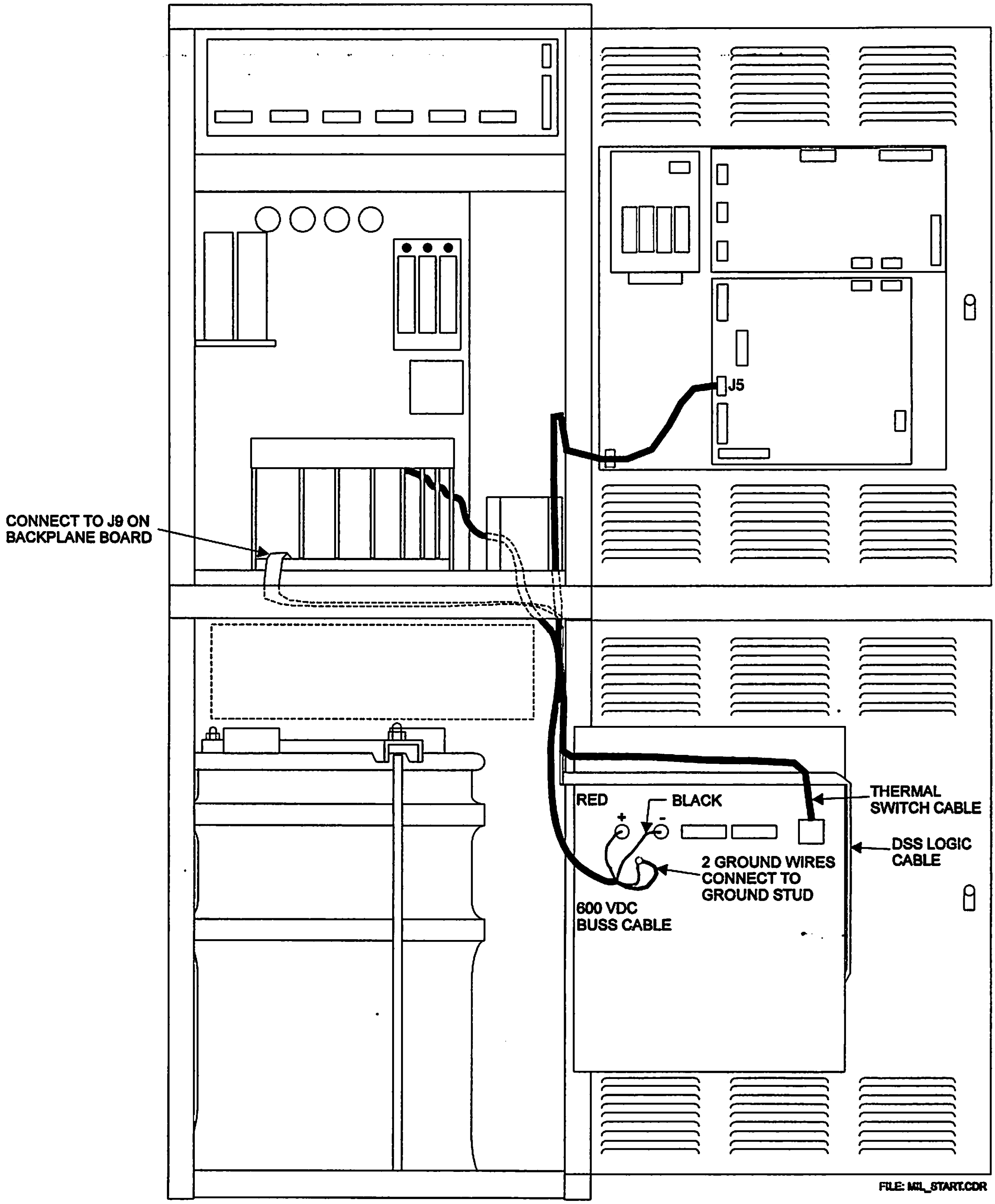


Figure 2-9: Dual speed starter wiring.

2.7.0 EQUIPMENT PLACEMENT

2.7.1 Equipment Cabinet

Place the equipment cabinet in a location that will allow the following:

- easy front access for service and sufficient clearance at the rear for room interface cables.
- air circulation - the front and top of cabinet must be free of obstructions (minimum clearance at top 12" (30cm).
- stable footing - use the leveling feet at the bottom of the cabinet to prevent movement during normal operation.
- close proximity to service disconnect boxes - cables should not be on the floor where they could be stepped on.
- Refer to chapter 1, section 1C: LOCATING THE EQUIPMENT IN THE X-RAY ROOM.

2.7.2 Control Console

Locate the control console in its intended position and ensure that it is stable. Refer to chapter 1, section 1C: LOCATING THE GENERATOR CABINET AND CONTROLLER.

- If the console is located on a shelf, supply index pins or equivalent hardware to the base of the console to prevent slipping.
- Ensure that the console is mounted at a height and angle to allow easy viewing of the displays.
- If the optional CPI pedestal stand is to be used for the console mounting, follow the mounting instructions supplied with the stand.
- Leave sufficient slack in the cabling to the console to allow for future service and maintenance.

- YOU MAY CHOOSE TO TEMPORARILY LOCATE THE CONSOLE NEAR TO THE GENERATOR FOR INITIAL PROGRAMMING AND CALIBRATION. IF THIS IS SO, PLEASE COMPLETE THE FINAL CONSOLE INSTALLATION PER THIS SECTION WHEN THE GENERATOR INSTALLATION IS COMPLETED.

NOTE:	***DO NOT LOCATE THE CONTROL CONSOLE WHERE X-RADIATION MAY BE PRESENT DURING INSTALLATION OR OPERATION.***

2.7.3 Anchoring The Generator To The Floor

If it is desired to anchor the generator to the floor, refer to chapter 1, section 1C. This should not be done until all cable hookups are completed which require rear access to the generator.

2.7.4 Leveling

Adjust the generators leveling feet to allow the cabinet doors to open and close freely. This adjustment must be made for both anchored and free-standing cabinet installations.

Note:	***Local regulations may require anchoring to conform to seismic centers. Refer to chapter 1C for seismic center locations.***

2.8.0 WIRING TO THE GENERATOR

2.8.1 Control Console

1. Connect the free end of the 15 conductor console cable (from J5 at the rear of the console) to J4 of the generator interface board. Ensure that the screw locks are fully tightened to secure the connector. Refer to figure 2-19 for the location of J4 on the generator interface board.

2. Connect a separate ground wire, #14 AWG (2.3 mm^2) or larger from the ground stud on the rear of the console (marked CONSOLE GROUND in figure 2-10) to the ground stud located to the left of the main input fuse block on the HF power supply. This is marked GROUND in figure 2-15.

3. Figure 2-10 shows the designations and functions of the connectors on the rear panel of the control console.

4. Refer to 2.18.0 regarding excess cabling.

⚠ Do not connect unapproved equipment to the rear of the console. J5 is for the interconnect cable to the generator main cabinet, J4 is not used, J2 is a serial port for use by an external computer, and J1 is for connection to an optional printer. **INCORRECT CONNECTIONS OR USE OF UNAPPROVED EQUIPMENT MAY RESULT IN INJURY OR EQUIPMENT DAMAGE.**

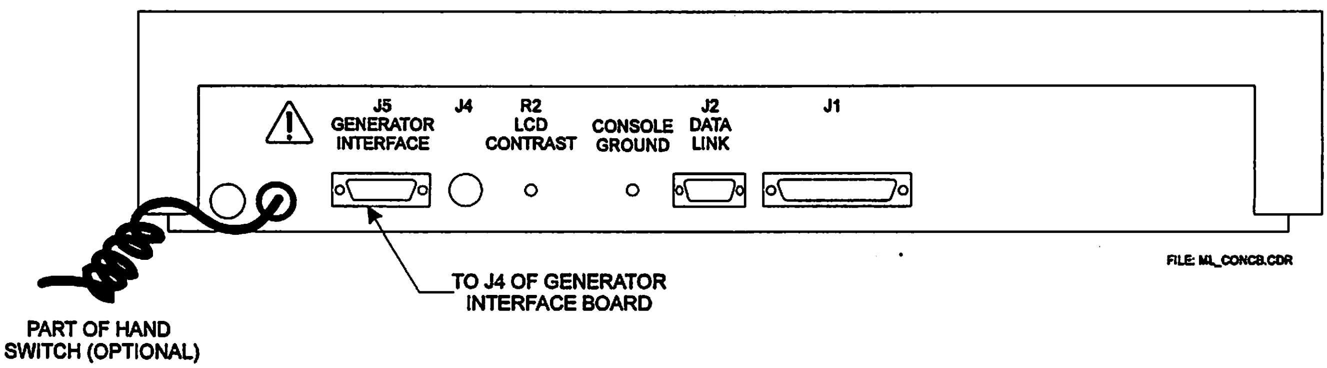


Figure 2-10: Rear of control console

2.8.2 Remote Fluoro Control (Optional)

1. Connect the free end of the 9 conductor remote fluoro cable (from the optional remote fluoro control box) to J11 of the generator CPU board. Ensure that the screw locks are fully tightened to secure the connector. Refer to figure 2-11 for the location of J11 on the generator interface board. Refer to 2.18.0 regarding excess cabling.

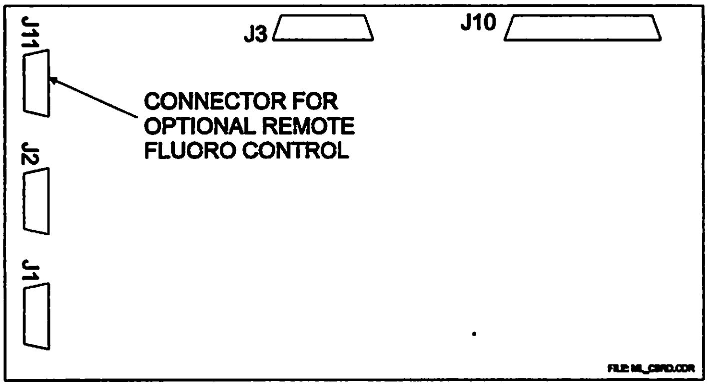


Figure 2-11: Remote fluoro connector on generator CPU board

2.8.3 Handswitch Installation

The optional handswitch is supplied as a kit, that is it must be user installed. If this option is used, refer to separate installation instructions packaged along with the handswitch.

For reference, a drawing is supplied in this section showing the handswitch connections to the console CPU board. See figure 2-12.

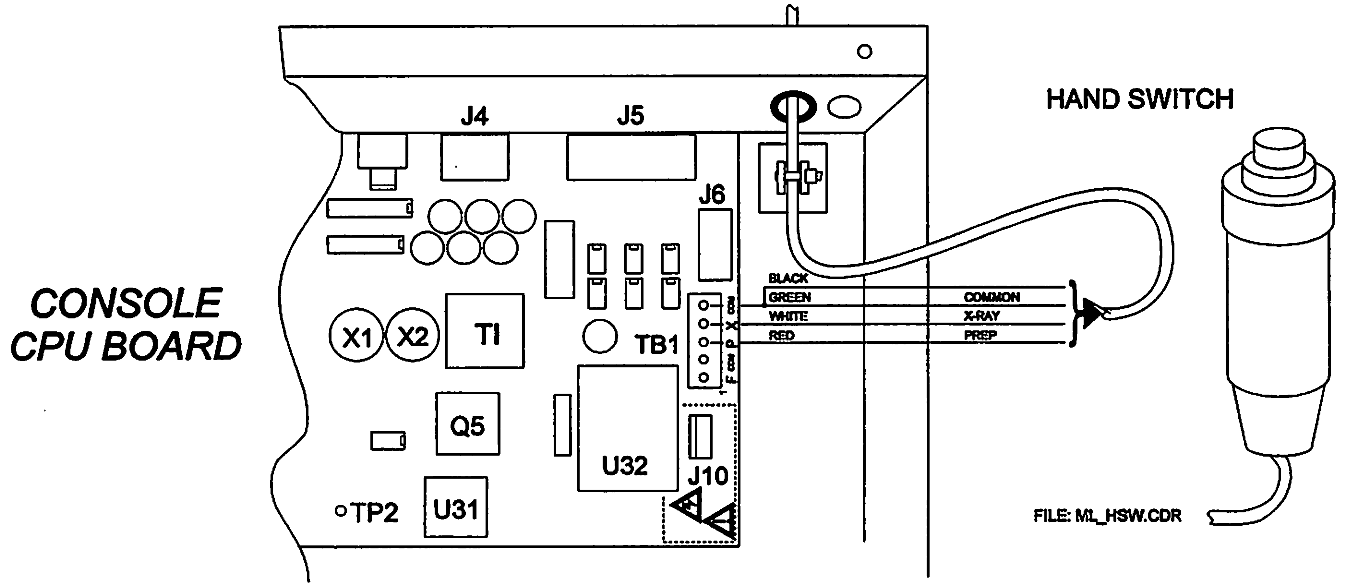


Figure 2-12: Handswitch connections on console CPU board

2.8.4 X -Ray Tube Stator Connection (Low Speed Starter)

Refer to figure 2-13. This section applies only to units fitted with low speed starter.

1. Route the X-ray tube stator cable(s) through the rear access panel on the lower generator cabinet, then route the cables towards the lower generator door where the stator connection terminal block is located. NOTE THAT SHIELDED STATOR CABLES ARE RECOMMENDED.

2. Connect the wires as per figure 2-13. For reference, the terminal assignments are:

Term 1: tube 1 thermal switch	Term 2: tube 1 thermal switch	Term 3: tube 2 thermal switch
Term 4: tube 2 thermal switch	Term 5: tube 1 common	Term 6: tube 1 main
Term 7: tube 1 shift	Term 8: tube 2 common	Term 9: tube 2 main
Term 10: tube 2 shift	Term 11: tube 1 ground (shield)	Term 12: tube 2 ground (shield)

3. Ensure that all terminal connections are tight, then dress and secure the cables.

4. Refer to 2.18.0 regarding excess cabling.

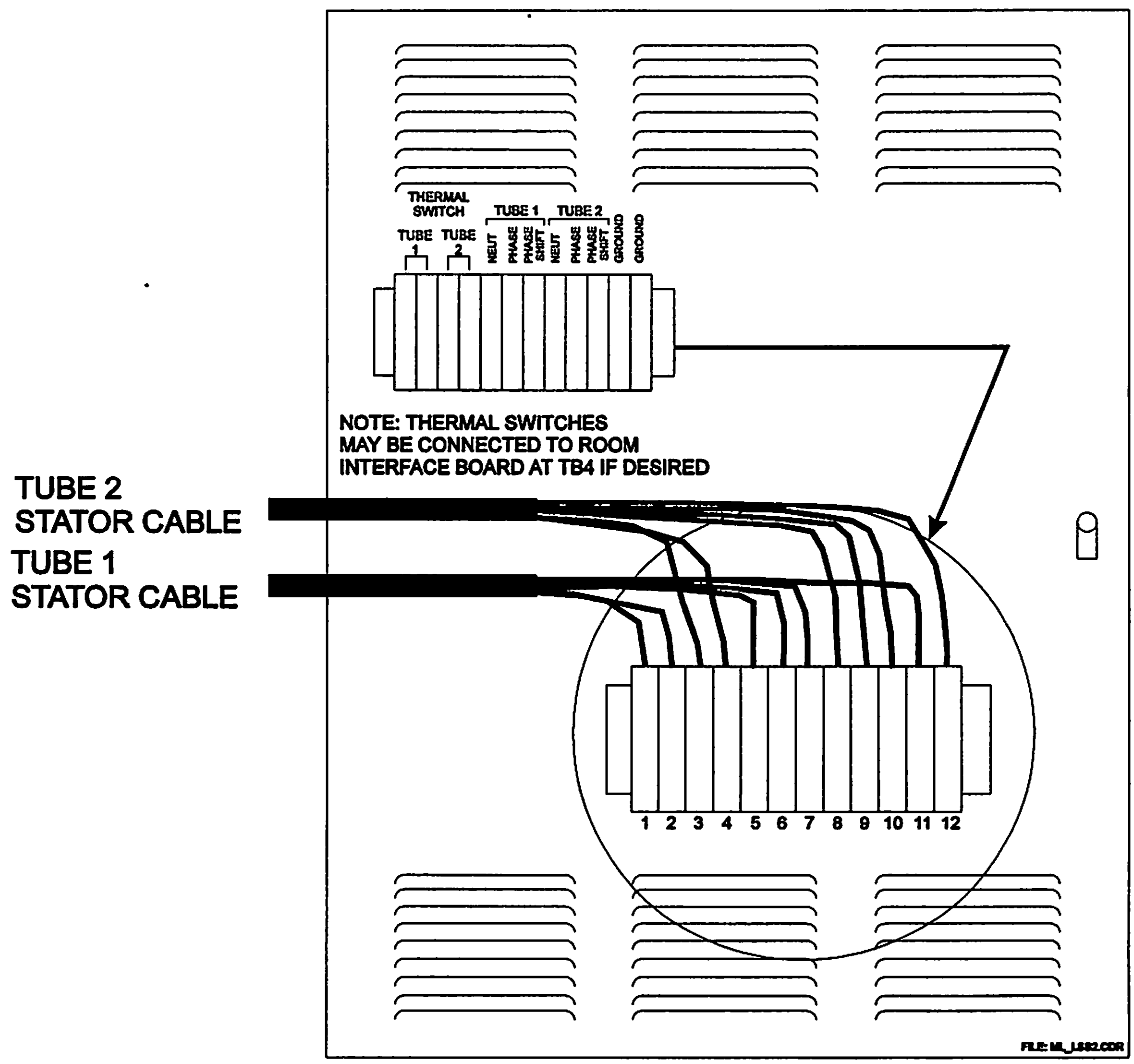


Figure 2-13: Low speed starter connections to generator

2.8.5 X -Ray Tube Stator Connection (Dual Speed Starter)

Refer to figure 2-14. This section applies only to units fitted with dual speed starter.

1. Route the X-ray tube stator cable(s) through the rear access panel on the lower generator cabinet, then route the cables towards the lower generator door where the dual speed starter is located.
   NOTE THAT SHIELDED STATOR CABLES MUST BE USED. THE SHIELD FOR THE STATOR CABLE(S) MUST BE PROPERLY GROUNDED AT THE STATOR TERMINAL CONNECTIONS ON THE DUAL SPEED STARTER.
2. Connect the wires as per figure 2-14.
3. Ensure that all terminal connections are tight, then dress and secure the cables.
4. Refer to 2.18.0 regarding excess cabling.

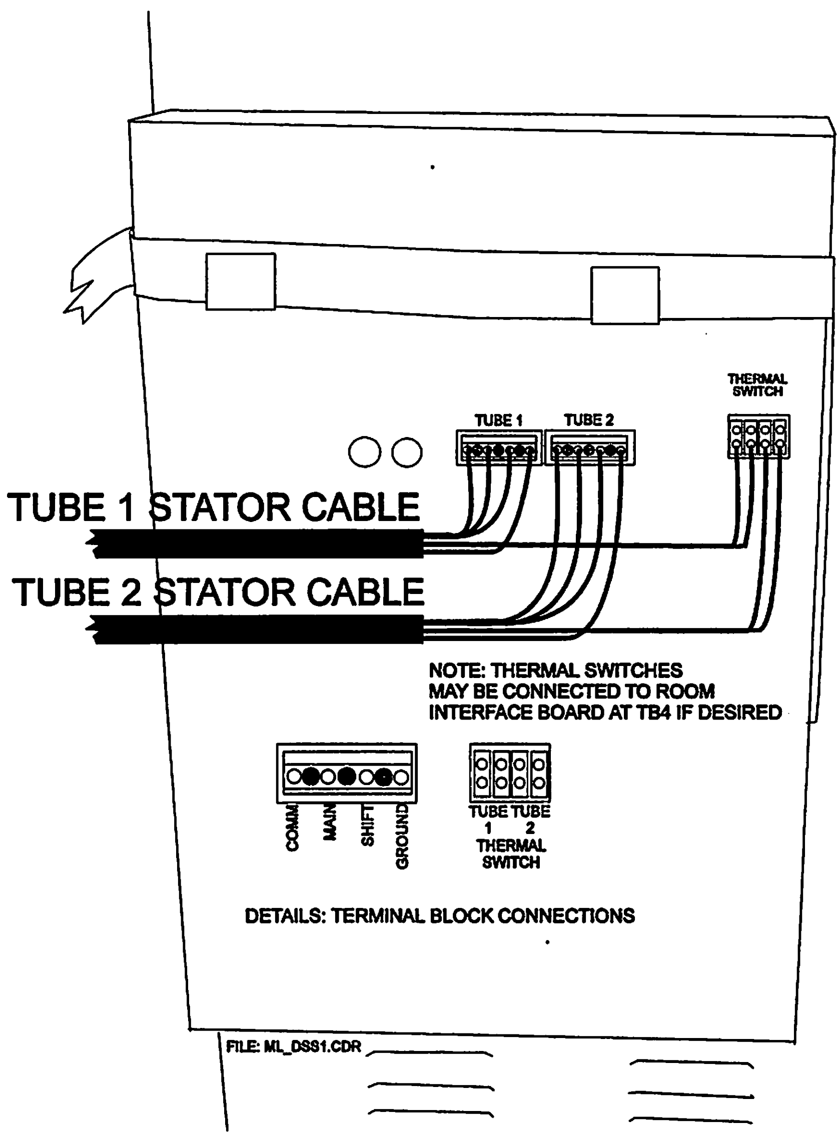


Figure 2-14: Dual speed starter connections to generator

2.8.6 Generator Mains Connection

WARNING:	*TO AVOID ELECTRICAL SHOCK, ENSURE THAT THE AC MAINS DISCONNECT IS LOCKED IN THE OFF POSITION, AND THAT ALL MAINS CABLES ARE DE-ENERGIZED BEFORE CONNECTING TO THE GENERATOR.*

Refer to chapter 1, section 1C for generator power and generator power line requirements.

1. Pass the AC mains cable through the access hole located at the upper left side of the rear of the generator.
2. Use an appropriate cable clamp to secure the mains cable at the cabinet entrance.
3. Temporarily remove the safety cover from the main fuses. Strip sufficient cable jacket to allow the ground wire to reach the main ground connector located at the left side of the main fuse block. Refer to figure 2-15
4. Connect the ground wire to the chassis ground stud, and connect the mains wires to the terminals on top of the main fuseholder (3 wires for 3 phase systems, 2 wires for single phase systems). Be sure to replace the main fuse safety cover after all connections are made and properly tightened.
5. Refer to 2.18.0 regarding excess cabling.

6 **DO NOT SWITCH ON MAINS POWER AT THIS TIME.**

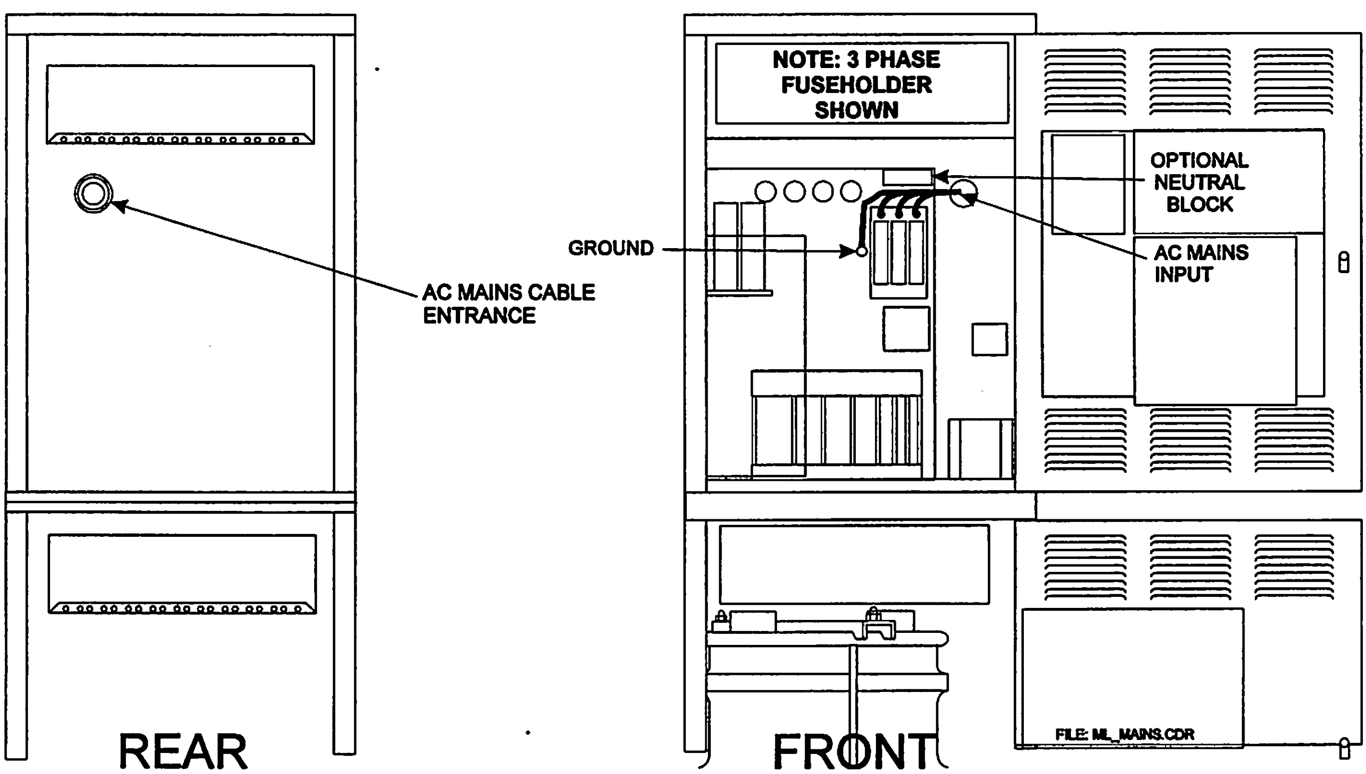


Figure 2-15: Generator mains connections

2.9.0 PROGRAMMING THE LOW SPEED STARTER

This section applies only to units fitted with the low speed starter.

PLEASE BE SURE TO READ AND UNDERSTAND SECTION 2.9.0 FULLY BEFORE PROCEEDING.

The low speed starter run voltage must be set per the requirements of the X-ray tube type(s) used at this site. This is done via a calibration potentiometer on the low speed starter board. Additionally, a jumper on the low speed starter board must be set for 50 Hz or 60 Hz line frequency operation.

> ***WARNING:*** ***240 VAC IS PRESENT ON THE LOW SPEED STARTER BOARD AT ALL TIMES THAT THE GENERATOR IS SWITCHED ON.***
> ***SWITCH OFF THE GENERATOR AND WAIT 5 MINUTES BEFORE ADJUSTING THE LINE FREQUENCY JUMPER.***
> ***SWITCH OFF THE GENERATOR BEFORE ADJUSTING R4, OR USE AN APPROVED INSULATED SCREWDRIVER TO MAKE THIS ADJUSTMENT (ONE WITHOUT A METAL SHANK).***

Follow the steps below to configure and calibrate the low speed starter board (refer to figure 2-16 for the location of the line frequency jumpers and the calibration potentiometer R4):

1. Set the line frequency jumper to position JW2 for 60 Hz mains operation, or to JW1 for 50 Hz mains.

2. Select the desired tube type from table 2-2. Record the tube type number (housing and insert) and the START VOLTS and RUN VOLTS as per the table and verified in accordance with the warning below.
   The voltages listed in the table have been taken from the manufacturers tube data sheets, and are supplied for reference only. Please note that the tube compatibility applies only to the housing and inserts listed, i.e. for the specific manufacturer(s) shown. *Do not proceed further without reading and complying with the warning provided below.*

> ***WARNING:*** ***PLEASE NOTE THAT THE DATA PROVIDED IN TABLE 2-2 INCLUDES INFORMATION TAKEN FROM TUBE DATA SHEETS OF THIRD PARTY MANUFACTURERS. COMMUNICATIONS AND POWER INDUSTRIES (CPI) HAS CAREFULLY COMPILED AND VERIFIED THE DATA PRIOR TO RELEASE OF THIS MANUAL, HOWEVER, CPI IS NOT A RECIPIENT OF CONTROLLED UPDATES OF THE DATA CONTAINED IN THIS TABLE. THIS DATA SHOULD BE USED FOR REFERENCE ONLY. ERRORS MAY EXIST IN THE DATA OR RESULT FROM SPECIFICATION CHANGES BY THE TUBE MANUFACTURER, THEREFORE THE BUYER SHOULD VERIFY THE VALUES IN THIS TABLE PRIOR TO CALIBRATION USING THE CURRENT TUBE DATA SHEETS PROVIDED BY THE TUBE MANUFACTURER. CPI SHALL NOT BE LIABLE FOR ANY DAMAGES WHATSOEVER RESULTING FROM BUYERS USE OR RELIANCE ON DATA CONTAINED IN TABLE 2-2.***

3. If the desired tube type is not listed, please contact CPI product support for assistance.

4. The generator is factory configured to support one type of stator only (for example "R" type stator), therefore only stators of that type may be used with this generator. Refer to the customer product description form in chapter 1D of this manual for compatible X-ray tubes.
   REFER TO SECTION 2.9.1 IF IT IS DESIRED TO USE TUBES WITH STATOR TYPES NOT COMPATIBLE WITH THIS GENERATOR, OR IF YOU ARE NOT CERTAIN THAT THIS GENERATOR IS COMPATIBLE WITH THE STATOR IN YOUR TUBE.

2.9.0 PROGRAMMING THE LOW SPEED STARTER (CONT)

5. Connect a true RMS voltmeter (scaled 300 VAC or higher) across the NEUT and PHASE terminals for tube 1 or tube 2 as appropriate on the stator terminal block. Refer to figure 2-13.

6. Adjust R4 on the low speed starter board to achieve the required RUN voltage as determined in step 2. Wait several seconds after start of boost to ensure that the starter is in RUN mode before attempting to read the voltage.

7. The start voltage is fixed at approximately 240 VAC on the low speed starter. Also, only one RUN voltage setting is available for both tubes. This means that both tube 1 and tube 2 must have similar stator voltage requirements, and that the RUN voltage must be set to accomodate the requirements of BOTH tubes.

8. If a ROTOR FAULT error is noted after adjusting the run voltage, it is possible that the stator current is sensed as being too low. In this case the the RUN voltage should be increased until the fault is cleared, however the tube manufacturers maximum run-voltage specification must not be exceeded.

9 Please confirm all settings using a suitable tachometer to ensure proper anode RPM before making any exposures.

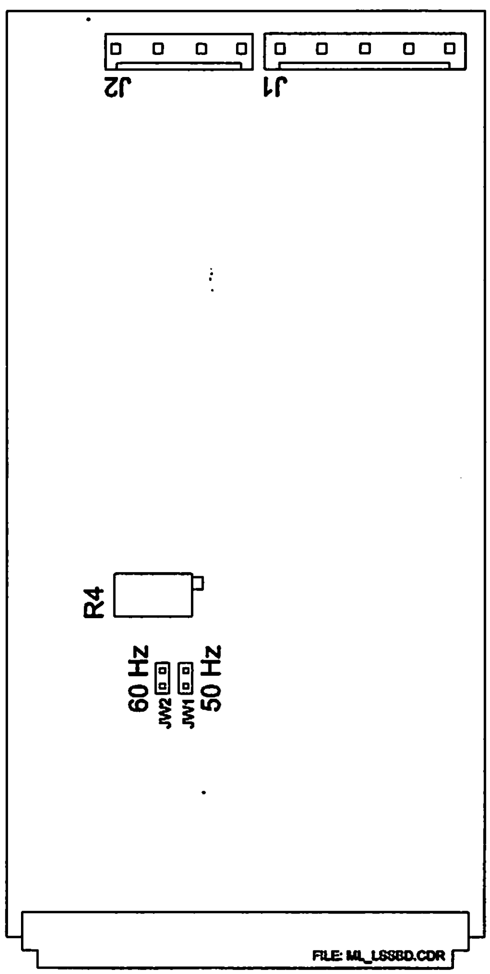


Figure 2-16: Low speed starter board overview

2.9.1 Confirming/Changing LSS Starter Type

The low speed starter board (also known as rotor board), and the low speed phase shift capacitor for the stator start winding must be matched to the desired stator type. For example, the required phase shift capacitor is 30 uF for "R" type stators and 40 uF for GE Maxiray type stators. Therefore, for example, a low speed starter configured for an "R" type stator CANNOT drive a GE Maxiray type stator.

Use the steps in this section to verify that the low speed starter is compatible with the stator in the desired tube.

1. Record the part number of the low speed starter kit in the subject generator. This is printed on a label near the low speed starter terminal block which is mounted on the lower door of the generator.

2. Locate that part number in table 2-2, and then note the value of the SHIFT CAPAC and the ROTOR BOARD part number per the table. Those are the stator-dependent components in the generator. Only tubes requiring that low speed starter (rotor) board and phase shift capacitor value may be connected to that starter.

3. If a tube other than that shown in the compatible X-ray tubes section of the customer product description form is to be used, confirm that the desired tube (housing and insert) is listed in table 2-2 AND that the required low speed starter kit part number for that tube per table 2-2 is the same as is fitted in your generator.

4. If the preceeding steps confirm that the desired tube is fully compatible with the generator, you may proceed with configuration and calibration as per section 2.9.0.

5. If in the preceeding steps it is determined that the desired stator IS NOT compatible with the generator, the phase shift capacitor and / or the low speed starter board will need to be changed to match the requirements of the desired tube. Replacement conversion kits are available to do this as noted in the next step.

6. Note the required low speed starter (ROTOR BOARD) part number and the SHIFT CAPAC value, and the corresponding low speed starter kit number for the desired tube per table 2-2. Using that board number and capacitor value, refer to table 2-1. From this table, select the required conversion kit to convert the low speed starter board and / or shift capacitor as required for the selected tube. The conversion kits are available through the factory / customer support.

   The last several rows in table 2-1, which list a capacitor value only, allow changing the low speed starter configuration where ONLY the capacitor value needs to change, i.e. for applications where the required part number of rotor board is already installed in the generator.

   TO ENSURE THAT CONFIGURATION CONTROL AND TRACEABILITY OF THE PRODUCT IS MAINTAINED IF MAKING THE ABOVE CONVERSION, PLEASE BE SURE TO CHANGE THE PART NUMBER IDENTIFIED IN STEP 1 TO THE NEW PART NUMBER USING AN INDELIBLE MARKER.

TABLE 2-1

SHIFT CAPAC	ROTOR BOARD P/N	CONVERSION KIT P/N
12.5 uF	725911-02	734423-00
15 uF	725911-02	734423-06
25 uF	725911-00	734423-05
30 uF	725911-01	734423-01
40 uF	725911-01	734423-02
15 uF	N/A	734423-07
30 uF	N/A	734423-03
40 uF	N/A	734423-04

2.9.2 Low Speed Starter Tube Select Table

TABLE 2-2: TUBE TYPES (LOW SPEED STARTER)						
TUBE TYPE (HOUSING)	**TUBE TYPE (INSERT)**	**START VOLTS**	**RUN VOLTS**	**SHIFT CAPAC**	**ROTOR BOARD PART NO.**	**LOW SPEED STARTER KIT NO.**
Comet DO7 25/50 Ω stator	DX7	220	40	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 ("350" 1∅ only)
Comet DO9 25/50 Ω stator	DX9 0.6/2.0 DX9 1.2/2.0	220	40	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 ("350" 1∅ only)
Comet DO9 25/50 Ω stator	DX91HS DX92HS DX93HS	230	40	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 ("350" 1∅ only)
Comet DO10 25/50 Ω stator	DX10HS 0.6/1.0 DX10HS 1.0/2.0	220	40	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 ("350" 1∅ only)
Comet DX10 25/50 Ω stator	DX101HS DX104HS DX105HS	230	40	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 ("350" 1∅ only)
Comet XSTAR8 XSTAR74 25/50 Ω stator	XST-8 XST-74	200	40	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 ("350" 1∅ only)
CGR Statorix 240, 260	MN641 MSN742 RSN742	240	90	12.5 uF	725911-02	733522-02 (all 3∅ units) 733955-02 ("350" 1∅ only)
GE Maxiray 75 (3" anode) 23/23Ω equal Z stator	1.0/2.0 15° 0.6/1.0 11°	230	75	40 uF	725911-01	733522-01 (all 3∅ units) 733955-01 ("350" 1∅ only)

2.9.2 Low Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	START VOLTS	RUN VOLTS	SHIFT CAPAC	ROTOR BOARD PART NO.	LOW SPEED STARTER KIT NO.
GE Maxiray 75 (3" anode) High Z stator	0.6/1.5	230	60	15 uF	725911-02	733955-04 (30 kW 1∅ only)
GE Maxiray 100 (4" anode) 23/23Ω equal Z stator	0.3/1.0 11° 0.6/1.0 11° 0.6/1.2 11° 0.6/1.5 11° 0.6/1.25 12.5° 1.0/2.0 15°	230	75	40 uF	725911-01	733522-01 (all 3∅ units) 733955-01 (30 kW 1∅ only)
Gilardoni Rotagil S/AS	AR11-30 AR30-60	220	60	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 (30 kW 1∅ only)
Picker PX1300 3" anode Std "R stator"	PX1302 PX1312	240	60	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 (30 kW 1∅ only)
Picker PX1400 4" anode Std "R" stator	PX1429 PX1431 PX1436 PX1482	240	60	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 (30 kW 1∅ only)
Philips ROT350 ROT351	RO 17/50 SRO 22/50 SRO 33/100	220	50	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 (30 kW 1∅ only)
Siemens Optilix 100L (50 Hz operation only)	Opti-150/12/50C	220	60	25 uF	725911-00	733955-03 (30 kW 1∅ only)
Toshiba Rotanode XH-121	E7132X	200	40	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 (30 kW 1∅ only)

2.9.2 Low Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	START VOLTS	RUN VOLTS	SHIFT CAPAC	ROTOR BOARD PART NO.	LOW SPEED STARTER KIT NO.
Varian B100 DX52 Std "R" stator	A102 A132 A142	240	55	30 uF	725911-01	733522-00 (all 3Ø units) 733955-00 (30 kW 1Ø only)
Varian B100 "STD" stator	A102 A132 A142	240	55	30 uF	725911-01	733522-00 (all 3Ø units) 733955-00 (30 kW 1Ø only)
Varian B130 B150 Std "R" stator	A192 A272 A282 A286 A292 G256 G292	240	55	30 uF	725911-01	733522-00 (all 3Ø units) 733955-00 (30 kW 1Ø only)
Varian Diamond Std "R" stator	RAD13 RAD14 0.3/1.2 RAD14 0.6/1.2 RAD14 0.6/1.5	240	55	30 uF	725911-01	733522-00 (all 3Ø units) 733955-00 (30 kW 1Ø only)
Varian Emerald Std "R" stator	RAD 8 RAD 68 RAD 74	220	40	30 uF	725911-01	733522-00 (all 3Ø units) 733955-00 (30 kW 1Ø only)
Varian Saphire Std "R" stator	RAD21 RAD56 0.6/1.0 RAD56 0.6/1.2 RAD60 RAD92 RAD94	240	55	30 uF	725911-01	733522-00 (all 3Ø units) 733955-00 (30 kW 1Ø only)

2.9.2 Low Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	START VOLTS	RUN VOLTS	SHIFT CAPAC	ROTOR BOARD PART NO.	LOW SPEED STARTER KIT NO.
Varian DX62 300-400 kHu, "STD" stator	A192B A197 A256 A272 A282 A286 A292	240	55	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 (30 kW 1∅ only)
Varian DX62U Universal 300-400 kHu, configured as "STD" or "R" stator	A192B A197 A256 A272 A282 A286 A292	240	55	30 uF	725911-01	733522-00 (all 3∅ units) 733955-00 (30 kW 1∅ only)

2.10.0 PROGRAMMING THE DUAL SPEED STARTER

This section applies only to units fitted with the dual speed starter option.

The dual speed starter must be programmed for the X-ray tube type(s) used at this site. This is done via DIP switches SW1 and SW2 on the dual speed starter.

The following tube functions are set with these switches:

- High speed start and run voltages
- Low speed start and run voltages
- Brake time and brake voltage (high speed)
- Boost times
- Boost time increments. Boost time may be increased in 100 ms steps in the range of 100 to 700 ms

⚠ SW1 and SW2 on the dual speed starter must be set correctly to match the X-ray tube(s) in use. Failure to set these correctly may result in improper anode RPM and therefore may damage the X-ray tube.
PLEASE BE SURE TO READ AND UNDERSTAND SECTION 2.10.1 FULLY BEFORE PROCEEDING.

2.10.1 Setting tube type

1. Select the desired tube type from table 2-4. Record the tube type number (housing and insert) and the binary code as per the table. Please note that the tube compatibility applies only to the housing and inserts listed, i.e. for the specific manufacturer(s) shown.

2. If the desired tube type is not listed, please contact CPI product support for assistance.

3. The generator is factory configured to support one type of stator only (for example "R" type stator), therefore only stators of that type may be used with this generator. Refer to the customer product description form in chapter 1D of this manual for compatible X-ray tubes.
REFER TO SECTION 2.10.2 IF IT IS DESIRED TO USE TUBES WITH STATOR TYPES NOT COMPATIBLE WITH THIS GENERATOR, OR IF YOU ARE NOT CERTAIN THAT THIS GENERATOR IS COMPATIBLE WITH THE STATOR IN YOUR TUBE.

4. Refer to figure 2-17. Set the DIP switch SW1 (for tube 1) with the binary code for the selected tube. The binary code shown in the table programs the tube type (housing and insert), for example housing type Varian Diamond with standard "R" stator and inserts per table 2-4 requires SW1-1 to be set OFF, SW1-2 OFF, SW1-3 ON, SW1-4 OFF and SW1-5 OFF. This programs the voltages, brake times, and boost times in table 2-4.
Additionally, SW1-6 to SW1-8 may be set to give incremental increases in boost time over the preselected values (for example to run an older tube with worn bearings). For example, binary 000 gives zero increase, binary 001 gives 100 ms increase, binary 100 gives 400 ms increase, and binary 111 gives a 700 ms increase in boost time. SW1-6 represents bit 1, SW1-7 bit 2, and SW1-8 represents bit 3.

   EXAMPLE:
   Binary 100 = decimal 4 = 400 ms incremental boost time increase:

1	0	0
Bit 3	Bit 2	Bit 1
SW1-8	SW1-7	SW1-6

2.10.1 Setting tube type (cont)

5. The example DIP switch setting shown in figure 2-17 is for the example in step 4 with an incremental increase in boost time of 200 ms.

6. If this is a two-tube installation, repeat steps 1 to 4 using DIP switch SW2 for the second tube.

7. Please confirm all settings using a suitable tachometer to ensure proper anode RPM before making any exposures.

NOTE: ***FOR TUBES WHERE "LOW SPEED OPERATION ONLY" IS INDICATED, THE DUAL SPEED STARTER MUST BE PROGRAMMED FOR LOW SPEED ONLY, AND WHERE "HIGH SPEED OPERATION ONLY" IS INDICATED, THE DUAL SPEED STARER MUST BE PROGRAMMED FOR HIGH SPEED OPERATION ONLY. REFER TO THE TUBE SELECTION SECTION IN CHAPTER 3C FOR THE PROCEDURE TO DO THIS.***

NOTE THAT THE EXAMPLE DIP SWITCH SHOWN IN FIGURE 2-17 IS REPRESENTATIVE OF ONE STYLE OF SWITCH ONLY. DEPENDING ON MANUFACTURER, YOUR DIP SWITCH STYLE MAY VARY. PLEASE NOTE THE ON/OFF POSITIONS CAREFULLY FOR YOUR UNIT

2.10.1 Setting tube type (cont)

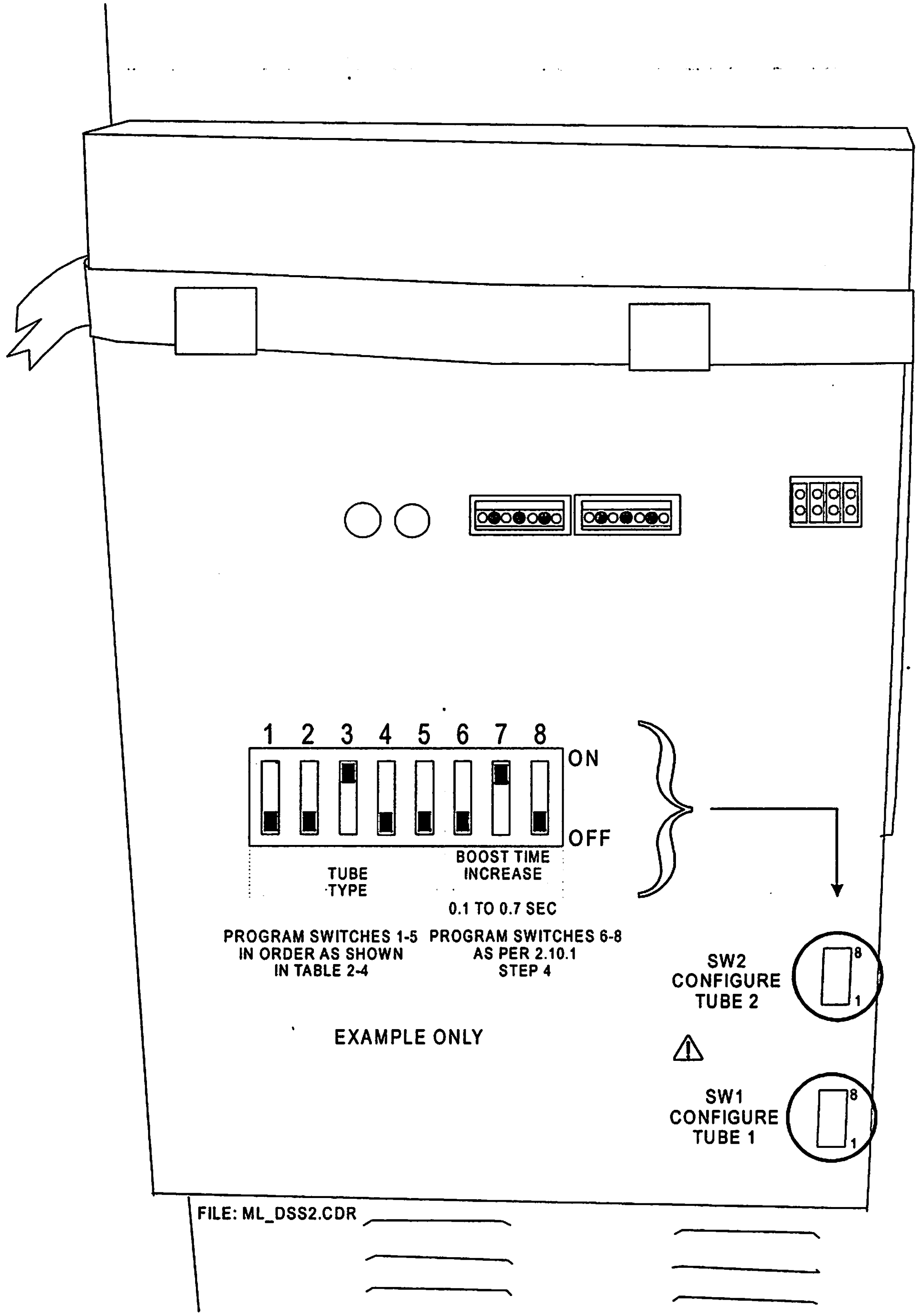


Figure 2-17: DIP switches on dual speed starter.

2.10.2 Confirming/Changing DSS Starter Type

The low speed and high speed phase shift capacitors for the stator start winding must be matched to the desired stator type, for example the required high speed phase shift capacitor is 6 uF for "R" type stators and 7.5 uF for GE Maxiray type stators. Therefore, for example, a dual speed starter configured for an "R" type stator CANNOT drive a GE Maxiray type stator.

Use the steps in this section to verify that the dual speed starter is compatible with the stator in the desired tube.

1. Record the part number of the dual speed starter assy in the subject generator. This is printed on a label near the top of the dual speed starter chassis.

2. Locate that part number in table 2-4, and then note the value of the H.S. SHIFT CAPAC and the L.S. SHIFT CAPAC per the table. Those are the values of the phase shift capacitors in the dual speed starter in the generator. Only tubes requiring those capacitor values may be connected to that starter.

3. If it is desired to use a different tube from that shown in the compatible X-ray tubes section of the customer product description form, confirm that the desired tube (housing and insert) is listed in table 2-4 AND that the required dual speed starter part number for that tube per table 2-4 is the same as is fitted in your generator.

4. If the preceeding steps confirm that the desired tube is fully compatible with the generator, you may proceed with setting the tube type as per section 2.10.1.

5. If in the preceeding steps it is determined that the desired stator IS NOT compatible with the generator, the phase shift capacitors in the dual speed starter will need to be changed to match the requirements of the desired tube. Replacement capacitor kits are available to do this as noted in the next step.

6. Note the required H.S. SHIFT CAPAC and L.S. SHIFT CAPAC values, and the corresponding dual speed starter part number for the desired tube per table 2-4. Using those capacitor values, refer to table 2-3. From this table select the required conversion kit to convert to capacitors as required for the selected tube. The conversion kits are available through the factory/customer support.

   IF MAKING THE ABOVE CONVERSION, PLEASE BE SURE TO CHANGE THE PART NUMBER IDENTIFIED IN STEP 1 TO THE NEW CONFIGURATION USING AN INDELIBLE MARKER. THIS WILL ENSURE THAT CONFIGURATION CONTROL OF THE PRODUCT IS MAINTAINED

TABLE 2-3

HIGH SPD SHIFT CAPAC	LOW SPD SHIFT CAPAC	CONVERSION KIT P/N
6 uF	31uF	734424-00
7.5 uF	47 uF	734424-01
20 uF	60 uF	734424-02
5 uF	30 uF	734424-03

<u>NOTE:</u> ***CAPACITOR VALUES SHOWN IN TABLES 2-3 AND 2-4 ARE EQUIVALENT VALUES OF THE PHASE SHIFT CAPACITORS IN THE DUAL SPEED STARTER. FOR EXAMPLE, THE STANDARD "R" VERSION OF THE DUAL SPEED STARTER USES TWO 12.5 uF CAPACITORS CONNECTED IN SERIES TO GIVE NOMINAL 6 uF FOR HIGH SPEED USE. THIS 6 uF CAPACITANCE IS CONNECTED IN PARALLEL WITH A 25 uF CAPACITOR TO GIVE 31 uF FOR LOW SPEED USE AS SHOWN IN THE TABLES.***

2.10.3 Dual Speed Starter Tube Select Table

All voltages in table 2-4 are at 60/180 Hz unless indicated otherwise.

TABLE 2-4: TUBE TYPES (HIGH SPEED STARTER)												
TUBE TYPE (HOUSING)	**TUBE TYPE (INSERT)**	**BINARY CODE**	**H.S. START VOLTS**	**H.S. RUN VOLTS**	**H.S. BRAKE VOLTS**	**H.S. BRAKE TIME**	**BOOST TIME**	**L.S. START VOLTS**	**L.S. RUN VOLTS**	**H.S. SHIFT CAPAC**	**L.S. SHIFT CAPAC**	**DUAL SPD STARTER PART NO.**
Comet DO7 25/50 Ω stator	DX7	00000	**LOW SPEED OPERATION ONLY** (See note 2 at end of this table)				1.4 sec	240	50	6 uF	31 uF	732685-00
Comet DO9 25/50 Ω stator	DX9 0.6/2.0 DX9 1.2/2.0	00000	**LOW SPEED OPERATION ONLY** (See note 2 at end of this table)				1.4 sec	240	50	6 uF	31 uF	732685-00
Comet DO10 25/50 Ω stator	DI104 0.3/0.8 DI104 0.6/1.0 DI104 0.6/1.3 DI104 0.6/1.8	00011	420	80	150	3.0 sec	1.8 sec	240	80	6 uF	31 uF	732685-00
Comet DO10 25/50 Ω stator	DI106 0.3/0.8 DI106 0.6/1.0 DI106 0.6/1.3	10011	420	80	150	3.0 sec	2.2 sec	240	80	6 uF	31 uF	732685-00
Comet DO700WX 25/50 Ω stator	DI700 0.6/1.0 DI700 1.0/1.8	10011	420	80	150	3.0 sec	2.2 sec	240	80	6 uF	31 uF	732685-00
GE Maxiray 75 (3" anode) 23/23Ω equal Z stator	1.0/2.0 15° 0.6/1.0 11°	01110	400	90	80	2.0 sec	0.9 sec	230	70	7.5 uF	47 uF	732685-04
GE Maxiray 100 (4" anode) 23/23Ω equal Z stator	0.3/1.0 11° 0.6/1.0 11° 0.6/1.2 11° 0.6/1.5 11° 0.6/1.25 12.5° 1.0/2.0 15°	00101	400	90	80	3.0 sec	1.0 sec	230	70	7.5 uF	47 uF	732685-04

2.10.3 Dual Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	BINARY CODE	H.S. START VOLTS	H.S. RUN VOLTS	H.S. BRAKE VOLTS	H.S. BRAKE TIME	BOOST TIME	L.S. START VOLTS	L.S. RUN VOLTS	H.S. SHIFT CAPAC	L.S. SHIFT CAPAC	DUAL SPD STARTER PART NO.
GE Maxiray 75 (3" anode) 23/23Ω equal Z stator	1.0/2.0 15° 0.6/1.0 11°	01110	400	90	80	2.0 sec	0.9 sec	230	70	7.5 uF	47 uF	732685-08 (240 VAC 1φ generators only)
GE Maxiray 100 (4" anode) 23/23Ω equal Z stator	0.3/1.0 11° 0.6/1.0 11° 0.6/1.2 11° 0.6/1.5 11° 0.6/1.25 12.5° 1.0/2.0 15°	00101	400	90	80	3.0 sec	1.0 sec	230	70	7.5 uF	47 uF	732685-08 (240 VAC 1φ generators only)
Gilardoni Rotagil	AR11-30 AR30-60	10101	**LOW SPEED OPERATION ONLY** (See note 2 at end of this table)				1.4 sec	220 *50 Hz*	60 *50 Hz*	6 uF	31 uF	732685-00
Gilardoni Rotagil A/A5	AR20-50 AR30-100 AR40-100	01101	340 *150 Hz*	60 *150 Hz*	80	3.0 sec	1.4 sec	220 *50 Hz*	60 *50 Hz*	6 uF	31 uF	732685-00
Picker PX1300 3" anode Std "R stator"	PX1302 PX1312	11100	240	120	100	3.0 sec	2.3 sec	240	50	6 uF	31 uF	732685-00
Picker PX1400 4" anode Std "R" stator	PX1429 PX1431 PX1436 PX1482	01100	240	120	100	3.0 sec	4.5 sec	240	70	6 uF	31 uF	732685-00
Picker PX1400 4" anode Std "R" stator (see note 1 at end of this table)	PX1429 PX1431 PX1436 PX1482	01100	240	120	100	3.0 sec	4.5 sec	240	70	5 uF	30 uF	732685-06
Picker PX1400 4" anode "Q" stator	PX1429 PX1431 PX1436 PX1482	10110	340	60	100	3.0 sec	1.0 sec	240	70	20 uF	60 uF	732685-05

2.10.3 Dual Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	BINARY CODE	H.S. START VOLTS	H.S. RUN VOLTS	H.S. BRAKE VOLTS	H.S. BRAKE TIME	BOOST TIME	L.S. START VOLTS	L.S. RUN VOLTS	H.S. SHIFT CAPAC	L.S. SHIFT CAPAC	DUAL SPD STARTER PART NO.
Philips ROT350 ROT351	RO 17/50 SRO 22/50 SRO 33/100	00000	**LOW SPEED OPERATION ONLY** (See note 2 at end of this table)				1.4 sec	240	50	6 uF	31 uF	732685-00
Siemens Biangulix 8500 RPM (configured for 150 Hz operation)	Bi 125/20/40	11101	400 *150 Hz*	90 *150 Hz*	80	3.0	1.9 sec	**HIGH SPEED OPERATION ONLY** (See note 2 at end of this table)		5 uF	30 uF	732685-06
Siemens Optilix 100L (configured for 150 Hz operation)	Opti-150/12/50C	11101	400 *150 Hz*	90 *150 Hz*	80	3.0	1.9 sec	**HIGH SPEED OPERATION ONLY** (See note 2 at end of this table)		5 uF	30 uF	732685-07 (240 VAC 1ϕ generators only)
Varian B100 DX52 Std "R" stator	A102 A132 A142	01000	400	100	100	3.0 sec	1.0 sec	240	60	6 uF	31 uF	732685-00
Varian B100 "P" stator	A102 A132 A142	01001	450	140	100	3.0 sec	0.8 sec	240	70	6 uF	31 uF	732685-00
Varian B100 "Q" stator	A102 A132 A142	11010	290	70	60	3.0 sec	0.8 sec	150	50	20 uF	60 uF	732685-05
Varian B130 "P" stator	A192 A272 A282 A286 A292 G256 G292	11001	450	140	100	3.0 sec	1.3 sec	240	70	6 uF	31 uF	732685-00

2.10.3 Dual Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	BINARY CODE	H.S. START VOLTS	H.S. RUN VOLTS	H.S. BRAKE VOLTS	H.S. BRAKE TIME	BOOST TIME	L.S. START VOLTS	L.S. RUN VOLTS	H.S. SHIFT CAPAC	L.S. SHIFT CAPAC	DUAL SPD STARTER PART NO.
Varian B130 B150 Std "R" stator	A192 A272 A282 A286 A292 G256 G292	00000	400	100	100	3.0 sec	1.4 sec	240	50	6 uF	31 uF	732685-00
Varian B130 B150 "Q" stator	A192 A272 A282 A286 A292 G256 G292	00110	290	70	60	3.0 sec	1.3 sec	150	50	20 uF	60 uF	732685-05
Varian Diamond Std "R" stator	RAD13 RAD14 0.3/1.2 RAD14 0.6/1.2 RAD14 0.6/1.5	00100	400	100	100	3.0 sec	1.2 sec	240	50	6 uF	31 uF	732685-00
Varian Emerald Std "R" stator	RAD 8 RAD 68 RAD 74	00000	**LOW SPEED OPERATION ONLY** (See note 2 at end of this table)				1.4 sec	240	50	6 uF	31 uF	732685-00
Varian Diamond Std "R" stator	RAD13 RAD14 0.3/1.2 RAD14 0.6/1.2 RAD14 0.6/1.5	00100	400	100	100	3.0 sec	1.2 sec	240	50	6 uF	31 uF	732685-09 (240 VAC 1ϕ generators only)
Varian Saphire Std "R" stator	RAD21 RAD56 0.6/1.0 RAD56 0.6/1.2 RAD60 RAD92 RAD94	10100	400	100	100	3.0 sec	2.3 sec	240	50	6 uF	31 uF	732685-00

2.10.3 Dual Speed Starter Tube Select Table (cont)

TUBE TYPE (HOUSING)	TUBE TYPE (INSERT)	BINARY CODE	H.S. START VOLTS	H.S. RUN VOLTS	H.S. BRAKE VOLTS	H.S. BRAKE TIME	BOOST TIME	L.S. START VOLTS	L.S. RUN VOLTS	H.S. SHIFT CAPAC	L.S. SHIFT CAPAC	DUAL SPD STARTER PART NO.
Varian DX62 300-400 kHu, "STD" stator	A192B A197 A256 A272 A282 A286 A292	00000	400	100	100	3.0 sec	1.4 sec	240	50	6 uF	31 uF	732685-00
Varian DX62U Universal 300-400 kHu, configured as "STD" or "R" stator	A192B A197 A256 A272 A282 A286 A292	00000	400	100	100	3.0 sec	1.4 sec	240	50	6 uF	31 uF	732685-00

THE DUAL SPEED STARTER USES MODULATION STRATEGIES TO OBTAIN THE DESIRED OUTPUTS. MEASURED VOLTAGES MAY NOT AGREE WITH THOSE LISTED IN THE TABLE. HOWEVER, THE CURRENTS FLOWING IN THE STATOR WINDINGS ARE EQUIVALENT TO THOSE THAT WOULD EXIST IF THE STATOR WAS EXCITED WITH THESE VOLTAGES.

NOTE 1: This tube is also shown in table 2-4 as being compatible with dual speed starter part number 732685-00. Part number 732685-00 is the usual dual speed starter configuration for standard "R" stators.

NOTE 2: Tube types designated as low speed only or high speed only must be programmed for low speed only or high speed only operation. Refer to chapter 3, section 3C.5.1 for details.

2.11.0 X-RAY TUBE HOUSING GROUND

A separate ground wire (10 AWG, 6mm^2) must be connected from each X-ray tube housing to the X-RAY TUBE HOUSING GROUND STUD on the HT tank. Refer to figure 2-18. This ground location will have two other ground wires already connected, ensure that these existing ground wires are not disconnected when making the X-ray tube ground connection.
Failure to make this ground connection may result in intermittent operation and/or exposure errors.

2.12.0 HT TANK VENT

⚠ Some models of HT tank are vented via a screw in the center of the HT tank lid. If your tank has this vent screw (refer to figure 2-18), loosen this screw by 2-3 turns (counterclockwise) at this time.
Be sure to tighten this screw before moving the generator or HT tank, else some of the insulating oil in the tank may spill out through the vent screw.

2.13.0 HIGH TENSION CABLES

The X-ray tube(s) should be mounted on their normal fixtures i.e. tube stand, G.I. table or other devices.

1. Verify that the HT cable terminations are clean, in good condition i.e. no cracks, and coated with vapor proof compound.
2. Connect the high tension cables as per the installation requirements. Use the right angle connectors for the transformer end. Ensure that the cables for tube 1 (and tube 2 if used) are plugged into the proper connectors on the HT tank. Refer to figure 2-18.
3. Be sure that the HT cable connectors are tight and there is ***no play between*** the connector insulator and the screw down ring.
4. Refer to 2.18.0 regarding excess cabling.

2.13.0 HIGH TENSION CABLES (cont)

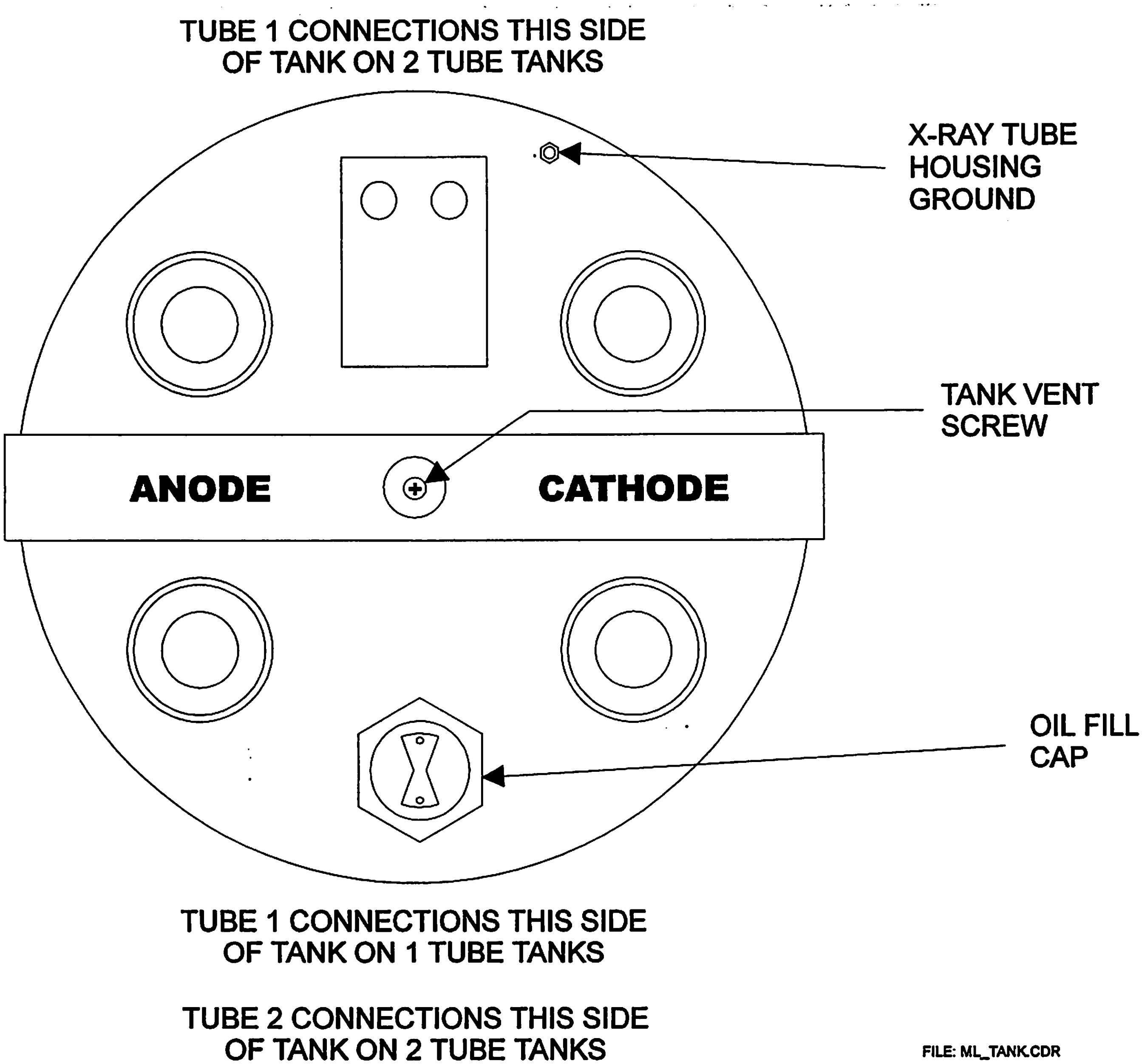


Figure 2-18: HT Tank lid feature identification

2.14.0 GENERATOR LOCKOUT SWITCH

A safety lockout switch (S3) is provided on the generator interface board. When this switch is in the **LOCKOUT** position, the generator cannot be switched on either from the console or from the adjacent service switch S2 on the generator interface board. This prevents inadvertent switching on of the generator while it is being serviced.

S3, the generator lockout switch, must be in the **NORMAL** position to enable switching the generator on. Refer to figure 2-19 for these switch locations.

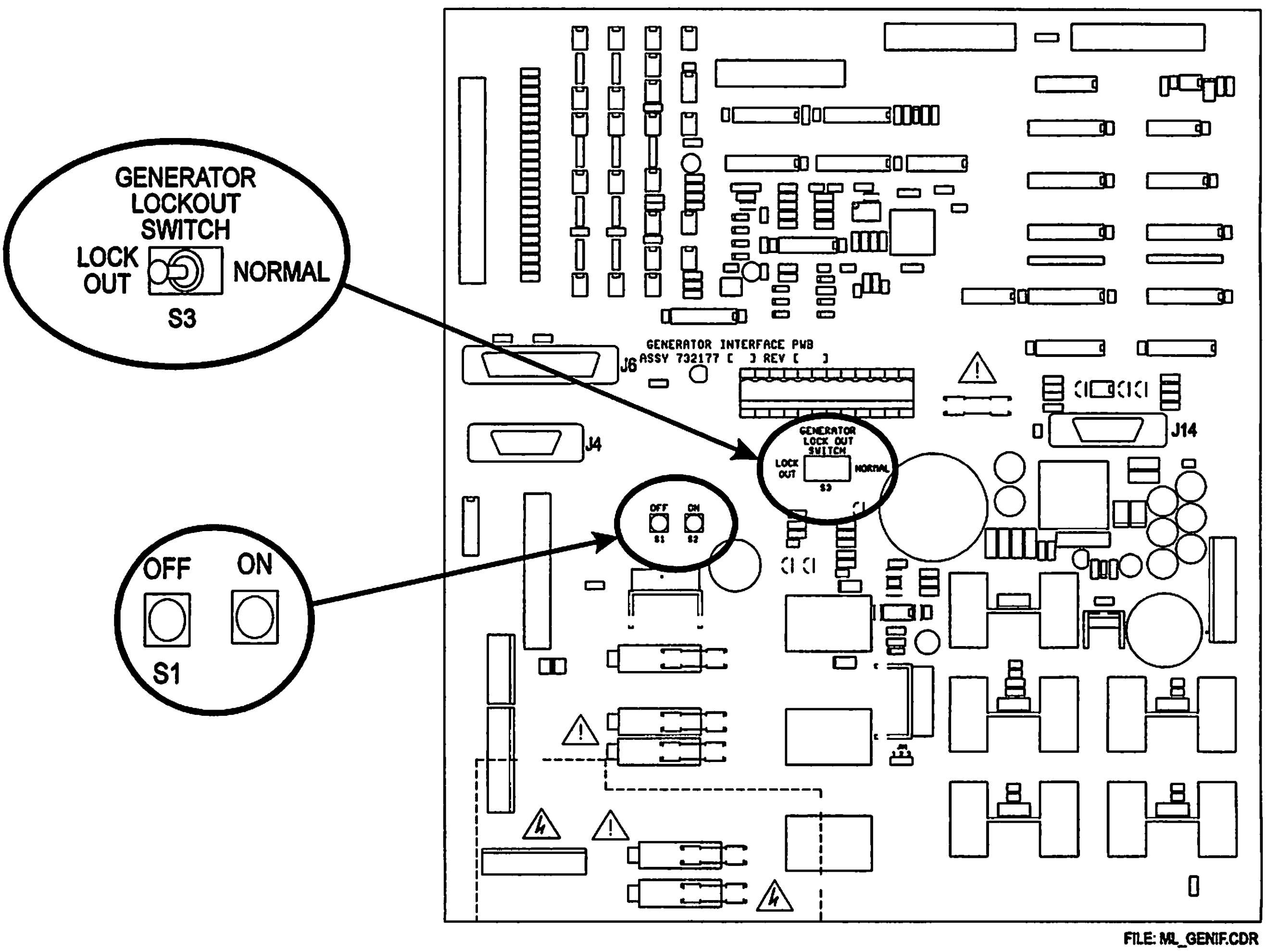


Figure 2-19: Location of lockout switch and local ON/OFF switches

2.15.0 SAFETY INTERLOCKS

It is strongly recommended that the following two interlocks be wired to the generator before preparing to make any exposures:

DOOR INTERLOCK
The room door interlock switch must be wired to TB4-4 and TB4-5 on the room Interface board. This switch will provide a closed contact when the door is closed.

X-RAY TUBE THERMAL SWITCH
The X-ray tube(s) thermal switch(s) should be connected to the generator for tube thermal protection. These may be connected either at the low speed starter terminal block (section 2.8.4), on the dual speed starter (section 2.8.5) or at the room interface board. The connections on the room interface board are TB4-8 and TB4-9 for tube 1, and TB4-6 and TB4-7 for tube 2.

2.16.0 CHECKING THE RAM BACKUP BATTERY VOLTAGE

It is recommended that the backup battery voltage be checked before continuing. The normal life expectancy of these batteries is estimated at 5 years.

CONSOLE CPU BOARD:

1. Turn the operator console upside down carefully to protect the front panel. Remove the 6 screws securing the base to the molded case.
2. Open the Console carefully such that the interconnecting cables are not strained.
3. Locate the battery on the console CPU board, refer to figure 2-20. Measure the battery voltage with a DVM. The top of the battery is the positive side, ground (TP2 on the board) is the negative side.
4. The nominal battery voltage should be approximately 3.0V, replace the battery if it is under 2.80V.
5. Before closing the console, refer to section 2.17.0, console CPU board DIP switch settings.
6. Re-assemble the console. DO NOT OVERTIGHTEN THE SCREWS SECURING THE BASE TO THE MOLDED CONSOLE TOP.

GENERATOR CPU BOARD:

1. Locate the battery on the generator CPU board, refer to figure 2-20. Measure the battery voltage with a DVM. The top of the battery is the positive side, ground (TP21 on the board) is the negative side.
2. The nominal battery voltage should be approximately 3.0V, replace the battery if it is under 2.80V.

2.16.0 CHECKING THE RAM BACKUP BATTERY VOLTAGE (cont)

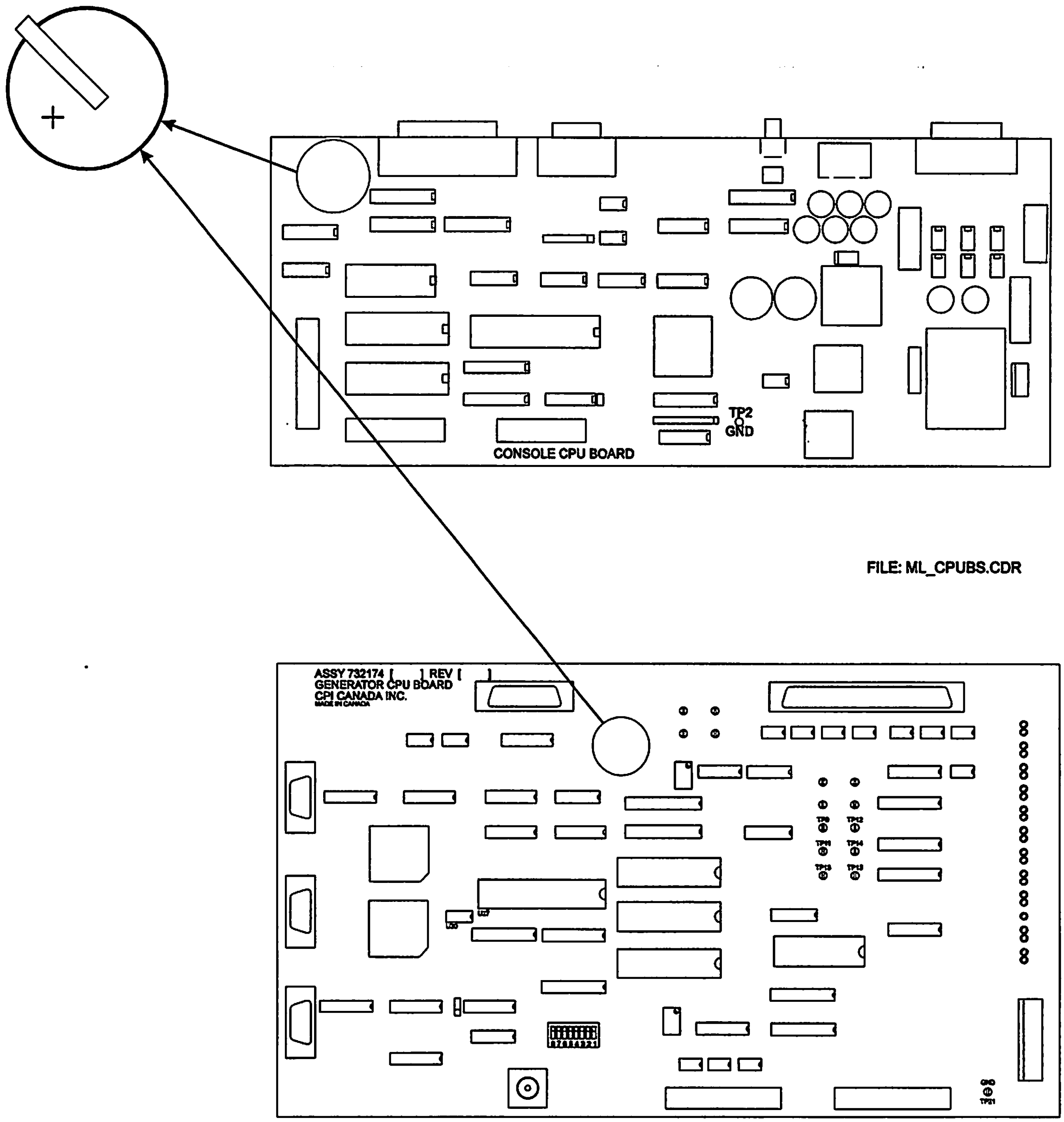


Figure 2-20: Location of batteries on generator and console CPU boards

2.17.0 DIP SWITCH SETTINGS

Before continuing, verify the DIP switch settings on the console CPU board and generator CPU board. These switches have been factory set but may have been readjusted, particularly if this generator is a re-install.

CONSOLE CPU BOARD:

- Verify the settings on SW1, the switches should all be set to OFF. Setting SW1-8 ON at power up restores factory default settings for the console. SW1-1 to SW1-7 should remain in the OFF position at all times.

GENERATOR CPU BOARD:

- Verify the settings on SW1. Refer to chapter 7, under GENERATOR CPU BOARD for the proper settings for this switch.

2.18.0 EXCESS CABLING

All cables that interface the generator to the room equipment should be cut to the correct length if possible. Excess lengths of cables may contribute to EMI/RFI problems, and as such should be avoided. If it is not possible to trim the cables to the correct length for the installation (HT cables and console cable for example), try to minimize the area inside any loops of the excess cables as these loops are in effect an antenna. Keep this excess cabling away from sensitive electronic equipment. ***EXCESS CABLING MUST NEVER BE BUNDLED UP AND STORED INSIDE THE GENERATOR***
Please review the installation at this time to ensure compliance to this requirement.

2.19.0 INITIAL RUN-UP

2.19.1 Initial Voltage Measurements

1. Verify that the mains voltage and current capacity is correct for the generator installation. Refer to the product ID label on the generator cabinet and chapter 1, section C of this manual.
2. Temporarily remove the safety cover over the main input fuses in the generator.
3. If the mains supply is compatible with the generator, switch on the main breaker and/or disconnect switch and check for the following voltages:

NOTE:	***DO NOT SWITCH ON THE GENERATOR AT THIS TIME (ONLY THE AC MAINS TO THE GENERATOR IS TO BE SWITCHED ON AT THIS TIME).***

2.19.1 Initial Voltage Measurements (cont)

WARNING:	***1. USE EXTREME CARE IN MEASURING THESE VOLTAGES. ACCIDENTAL CONTACT WITH MAINS VOLTAGES MAY CAUSE SERIOUS INJURY OR DEATH.*** ***2. MAINS VOLTAGE WILL BE PRESENT INSIDE THE GENERATOR CABINET, EVEN WITH THE CONSOLE SWITCHED OFF.*** ***3. THE BUS CAPACITORS, LOCATED ON THE BASE OF THE POWER SUPPLY, PRESENT A SAFETY HAZARD FOR A MINIMUM OF 5 MINUTES AFTER THE POWER HAS BEEN REMOVED FROM THE UNIT. CHECK THAT THESE CAPACITORS ARE DISCHARGED BEFORE TOUCHING ANY PARTS.***

4. Measure and record the voltage across the main line fuses in the power supply. Single phase units will only use one set of voltage measurements.

   L1 phase to L2 phase = ______ VAC.
   L1 phase to L3 phase = ______ VAC.
   L2 phase to L3 phase = ______ VAC.

5. Confirm that these voltages are within specification for the generator as per chapter 1C. ***IF ANY PHASE TO PHASE VOLTAGE IS GREATER THAN 418 VAC (400 VAC UNITS), A TAP CHANGE MUST BE MADE ON THE AUXILIARY TRANSFORMER IN THE HF POWER SUPPLY. REFER TO 2.19.2 FOR THE PROCEDURE TO DO THIS.***

   NOTE: STEP 6 APPLIES ONLY TO 480 VAC UNITS

6. Measure and record the line voltage across F4 and F6 on the driver/auxiliary board in the HF power supply. These fuses are located to the left of the main power supply ground on the large circuit board.

F4 to F6 _______ VAC
Verify that this voltage is 400 VAC +/- 10%: ______ Check

7. Switch OFF the mains power to the generator. Verify that there is no voltage present across any of the mains input phases. Replace the safety cover on the main input fuse block, then switch ON the mains and generator.

8. Verify that the red LED (DS1) located near the center of the generator interface board is lit.

_____ Check

2.19.2 Auxiliary Transformer Tap Selection

If any phase to phase voltage measured in step 4 above exceeds 418 VAC on 400 VAC generators, follow the procedure below to change the line voltage tap on the auxiliary transformer in the HF power supply.

1. Switch OFF the generator and disconnect or lock-out the mains power. Ensure that the DC bus capacitors are fully discharged before proceeding.

2. Locate the driver/auxiliary board in the HF power supply. Refer to the appropriate figure in chapter 1E for the location of this board.

2.19.2 Auxiliary Transformer Tap Selection (Cont)

3. In the upper left corner of the driver/auxiliary board, identify the line voltage jumper. This jumper is typically red in colour and connects from E11 (common) to E9 (380 VAC tap) as originally shipped from the factory.

4. Disconnect the line voltage jumper from the E9 position and connect it to E10 (440 VAC tap). This will ensure proper operation at the high end of 400 VAC mains operation.

2.19.3 Initial Power Up

1. Switch on the generator at the console and observe the startup sequence on the console APR display.

   - MEMORY TEST.... will be displayed
   - HIGH FREQUENCY GENERATOR **XX** KW WILL BE DISPLAYED (**XX** will be the kW rating for that model)
   - The next screen will show console software revision and power software revision

2. In the generator cabinet, verify the following:

   - D43 on driver/auxiliary board in the HF power supply is ON.
   - On the generator CPU board verify that the following LEDs are ON (these indicate presence of the DC rails as indicated):

DS38	+5 V
DS41	+15 V
DS43	-15 V
DS45	+12 V
DS46	-12 V

2.20.0 PROGRAMMING AND CALIBRATION USING THE CONSOLE

2.20.1 Entering Into Programming/Calibration Mode

This section presents a brief overview of the generator setup menu only. For more detail, refer to chapter 3C.

To enter into the programming and calibration mode for the generator follow the steps below. Refer to Figure 2-21 for references to APR buttons.

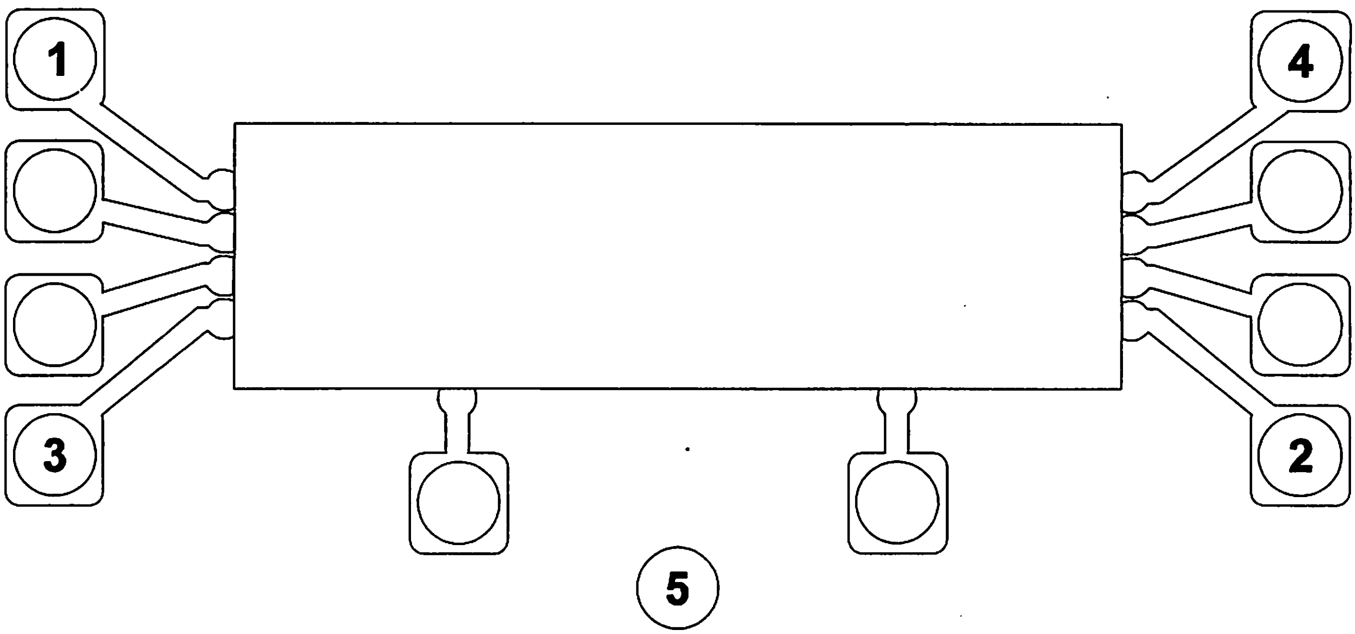


Figure 2-21: Programming/calibration mode reference

1. Start with the generator switched OFF.
2. While pressing and holding the RESET button (5), press the generator POWER ON button on the console
3. The generator will go through the start-up sequence, then display the message ENTER PASSWORD.
4. Enter the factory default password by pressing the following button sequence: [1] - [2] - [3] - [4].

2.20.1 Entering Into Programming/Calibration Mode (Cont)

5. The APR menu will now display the following:

```
                    * GENERATOR SETUP *
UTILITY                              APR EDITOR: DISABLED
                                      GEN  CONFIGURATION
                                               DATA LINK

EXIT SETUP
```

2.20.2 Menu Selections

UTILITY
Allows access to the following functions:

SET TIME & DATE:
Allows setting of: YEAR, MONTH, DAY, HOUR, and MINUTE

ERROR LOG:
Allows review of the generators error log for recorded errors.

STATISTICS:
Allows review of the tube exposure counter(s), the fluoro exposure counter if applicable, and the generator accumulated exposure counter. Also allows resetting of the tube exposure counter(s), and the fluoro exposure counter if used.

CONSOLE:
Allows setting the following parameters for the installation: key speed (scroll rate for the displays), speaker volume, LCD screen mode, and APR mode.

APR EDITOR

This enables or disables technique factor changes. When **APR EDITOR** is set to **ENABLED**, the technique factors may be changed. The new values may then be saved to overwrite the existing values. Reference chapter 3C for further information.

2.20.2 Menu Selections (Cont)

GEN CONFIGURATION

Allows the service engineer to access the following functions. Further details are in chapter 3C.

- TUBE SELECTION — Selects from the available group of X-ray tubes.
- GENERATOR LIMITS — Sets the operating limits of the generator.
- RECEPTOR SETUP — Allows programming of each image receptor.
- I/O CONFIGURATION — Allows setting the inputs and outputs of all image receptors.
- AEC SETUP — Defines properties for each channel of the AEC device.
- AEC CALIBRATION — Allows calibration of the AEC device.
- FLUORO SETUP — Allows setting of the fluoro properties.
- TUBE CALIBRATION — Enables the X-ray tube auto calibration feature.

DATA LINK

Used with the CPI GenWare™ utility software. This allows for data communication with a computer in order to download additional tube types, transfer APR data, run the A^2EC^2 ™ utility, and for other minor functions. Further documentation is included with the software package in the form of an MS WORD document (MANUAL.DOC).

A computer (i.e. laptop) and a 9 pin null modem cable with socket connectors (female) on both ends are required to run this software and interface to the generator.

2.21.0 TUBE AUTO CALIBRATION

Prior to beginning tube auto calibration, the tube(s) used in this installation must be properly selected, and the generator limits should be programmed. Refer to chapter 3C.

It is recommended that the tube(s) be conditioned (seasoned) before beginning tube auto calibration, refer to chapter 6.

WARNING: ***THE FOLLOWING PROCEDURES PRODUCE X-RAYS. TAKE ALL SAFETY PRECAUTIONS TO PROTECT PERSONNEL FROM X-RADIATION.***

CAUTION: ***ALWAYS VERIFY THE MANUFACTURER OF THE TUBE INSERT. IF THE X-RAY TUBE HAS BEEN REBUILT, THE TUBE INSERT AND TUBE HOUSING MAY BE FROM DIFFERENT MANUFACTURERS.***

Step	Action	Result
1.	From the **GENERATOR SETUP** menu (section 2.20.1) select **GEN CONFIGURATION.**	The **TUBE CALIBRATION** menu will display.
2.	Select **TUBE CALIBRATION.**	The **TUBE AUTO-CAL** menu appears.
3.	Select the desired tube (tube 1 or tube 2) by pressing the **TUBE** button.	The selected tube will appear. Selection of the second tube is only available on two tube generators.
4.	Press **FOCAL SPOT** to toggle between **SMALL** and **LARGE.** Start with **SMALL.**	The selected focal spot displays.
5.	Press and hold the X-RAY button (or use the optional handswitch) to begin the calibration procedure.	The menu will indicate the mA and filament current while the generator takes a series of exposures.
6.	Press **RETURN** to repeat calibration on the other focal spot or on the other tube.	
7.	When auto-calibration is completed, press **EXIT** to exit the tube auto calibration menu.	The **GEN CONFIGURATION** menu will display.
8.	Press **EXIT** to return to the **GENERATOR SETUP** menu.	The **GENERATOR SETUP** menu will display.
9.	Press **EXIT SETUP** to exit out of the setup and calibration mode and return to the normal operation mode.	

NOTE: ***SHOULD AN ERROR OCCUR DURING AUTO CALIBRATION, AN ERROR MESSAGE WILL BE DISPLAYED. THE GENERATOR WILL THEN LIMIT THE TUBES OPERATION TO THE RANGE IN WHICH IT WAS CALIBRATED, THUS ALLOWING FOR PARTIAL OPERATION OF THE GENERATOR.***

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CHAPTER 3

SYSTEM INTERFACING, PROGRAMMING, AEC/ABS CALIBRATION, AND DAP SETUP AND CALIBRATION (INDICO 100)

3.0.0 INTRODUCTION

3.1.0 Purpose

This chapter describes the interfacing to the generator of the X-ray room imaging equipment, and programming of the Millenia and Indico 100 family of generators. This chapter also allows the installer to record the necessary information to complete the installation, as well as to record the programming values. The installation of the AEC (Automatic Exposure Control) and ABS (Automatic Brightness Stabilization) devices and their calibration are also covered in this chapter.

Chapter 3F is used in Indico 100 manuals only, and covers setup and calibration of the optional DAP (Dose-Area Product) meter.

This Chapter contains the following sections.

Section	Title
3A	Setup information.
3B	System interfacing
3C	Programming the generator
3D	Automatic Exposure Control (AEC) calibration
3E	Automatic Brightness Stabilization (ABS) calibration
3F	DAP (Dose-Area Product) setup and calibration. Indico 100 only.

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CHAPTER 3

SECTION 3A

SETUP INFORMATION

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3A.2.3 Automatic Exposure Control 3A-3
3A.2.4 Collimator 3A-3
3A.2.5 Image System 3A-3
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3A.1.0 INTRODUCTION

Please record the setup information for your installation in this section before programming the generator. Enter the information appropriate for your generator model. The data tables will accommodate installations up to a standard R&F installation with the following: tilting G.I. table with bucky, spot film device, standard image tube with a medical T.V. system, wall bucky and an overhead tube stand, spot film camera and a digital acquisition system.

3A.2.0 INSTALLATION RECORD

3A.2.1 X-Ray Tubes

Please enter the appropriate information.

a)	Over table X-ray tube (or TUBE # 1)		
b)	Manufacturer and type:		
c)	Focal spot combination:	large =	small =
d)	kW of each focal spot:	large =	small =
e)	Maximum kVp:		
f)	Type of stator:		
g)	Dual or single speed:		
h)	Stator delay:	sec =	
i)	Start and run voltage, low speed:	start volts =	run volts =
j)	Start and run voltage, high speed:	start volts =	run volts =
k)	Brake voltage:	volts =	
l)	Maximum filament current:	amps =	
m)	Minimum filament current, stand-by:	amps =	
n)	Thermal switch included:		
o)	Under table X-ray tube (or TUBE # 2)		
p)	Manufacturer and type:		
q)	Focal spot combination:	large =	small =
r)	kW of each focal spot:	large =	small =
s)	Maximum kVp:		
t)	Type of stator:		
u)	Dual or single speed:		
v)	Stator delay:	sec =	
w)	Start and run voltage, low speed:	start volts =	run volts =
x)	Start and run voltage, high speed:	start volts =	run volts =
y)	Brake voltage:	volts =	
z)	Maximum filament current:	amps =	
aa)	Minimum filament current, stand-by:	amps =	
bb)	Thermal switch included:		
cc)	X-ray tube fan included:		

3A.2.2 Mains Supply And Fusing

Please record the following information on the mains voltage and current capacity. Check that the information is appropriate for the generator according to the nameplate on the generator cabinet.

Line voltage: ________ VAC

Line frequency: __ 50 Hz. __ 60 Hz. Line capacity: _____ kVa

Disconnect fuses (main): ______ amps

3A.2.3 Automatic Exposure Control

Chamber Type (optional):

Solid State: ________________ Ion Chamber ______________ PMT _____________

Make: ______________________ Model: ________________

Receptors with AEC (optional):

Table bucky	__ yes	Spot film device	__ yes	Digital System	__ yes
Wall bucky	__ yes	Auxiliary bucky	__ yes		

3A.2.4 Collimator

Type:	__________________
Compatible with X-ray tube:	__ yes __ no
Exposure interlock (dry contacts):	__ yes __ no
Tomo/stereo by-pass:	__ yes __ no

3A.2.5 Image System

Conventional: ____ (make and model)
Digital: ____(make and model)

Image intensifier:	__dual mode	__tri-mode
24 hour supply:	__ yes	__ no__
Image system park/position switch.	__ yes	__ no
Fluoro foot switch to initiate fluoro and spot exposure:	__ yes	__ no_
Spot film advance delay: greater than 850 mSec. __ yes		__ no
Remote Fluoro controller.	__ yes	__ no
AEC compensation for multi-spot SFD use.	__ yes	__ no

3A.2.6 ABS Pickup Assembly

Optical diode: _______ PMT: _______ Proportional DC: _______ Composite Video _______

Make: ______________________ Model: ________________

3A.2.7 Table Type

Table type: ____________________________________ Model/Make: ______________________

Grid: __________ Ratio: _________ L/P Inch: _________ Focus Distance: _________

3A.2.8 Wall Receptor

Type: ____________________________

Grid: __________ Ratio: _________ L/P Inch: _________ Focus Distance: _________

3A.2.9 Receptor Assignment

Receptor 1: ______________________

Receptor 2: ______________________

Receptor 3: ______________________

Receptor 4: ______________________

Receptor 5: ______________________

Receptor 6: ______________________

3A.2.10 Miscellaneous Notes

3A.3.0 X-RAY TUBE AND GENERATOR PARAMETER WORKSHEET

Note: ***The information in this table is to be derived from the GEN CONFIGURATION menu.***

Generator Model: ______________ Serial No: _____________

TUBE SELECTION	TUBE 1		TUBE 2	
	DEFAULT	SELECTED	DEFAULT	SELECTED
TUBE SELECTED				
TUBE SPEED				
MAX SF KW LS				
MAX LF KW LS				
MAX SF KW HS				
MAX LF KW HS				
MAX KV				
MAX SF MA				
ANODE HU WARNING				
ANODE HU LIMIT				
SF STANDBY				
LF STANDBY				
SF MAX				
LF MAX				
FIL BOOST				
FIL PREHEAT				
GENERATOR LIMITS	DEFAULT	SELECTED		
MAX KW				
MAX MA				
MIN MA				
MAX MAS				

3A.4.0 IMAGE RECEPTOR PROGRAMMING WORKSHEET

IMAGE RECEPTOR PROGRAMMING WORKSHEET DATE:________ SERIAL #:________

FUNCTION	RECEPTOR 1	RECEPTOR 2	RECEPTOR 3	RECEPTOR 4	RECEPTOR 5	RECEPTOR 6
RECEPTOR NAME						
TUBE						
TOMO						
FLUORO						
SERIAL						
INTERFACE OPTS						
FUNCTIONAL OPTS						
RECEPTOR SYM						
FLUORO HANG						
RAD HANG						
LAST IMAGE HOLD						
MEMORY						
REM TOMO BUT						
SF/LF SWITCH						
AEC BACKUP						
AEC BACKUP MAS						
AEC BACKUP MS						
AEC CHANNEL						

3A.5.0 I/O CONFIGURATION WORKSHEET

NOTE: BOXES WITH DOTTED LINES CANNOT HAVE THEIR STATE CHANGED!

FUNCTIONS	STANDBY	PREP	GEN RDY	RAD EXP	FLUORO EXP
INPUTS					
REMOTE EXP	-----		-----		-----
REMOTE PREP	-----		-----	-----	-----
REMOTE FL. EXP	-----	-----	-----	-----	
CONSOLE EXP	-----		-----		-----
CONSOLE PREP	-----		-----	-----	-----
TOMO EXP	-----	-----	-----		-----
REM. TOMO SEL		-----	-----	-----	-----
I/I SAFETY	-----		-----		
COLL. ITLK	-----		-----		
BUCKY CONTACTS	-----	-----	-----		-----
SPARE			-----		
THERMAL SW 1			-----		
THERMAL SW 2			-----		
DOOR ITLK			-----		
MULTI SPOT EXP		-----	-----	-----	-----
OUTPUTS					
BKY 1 SELECT					
BKY 2 SELECT					
BKY 3 SELECT					
TOMO/BKY 4 SEL					
TOMO/BKY STRT					
ALE					
COLL. BYPASS					
ROOM LIGHT					
SPARE					

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CHAPTER 3

SECTION 3B

SYSTEM INTERFACING

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3B.1.0 INTRODUCTION

The Millenia generator may be interfaced to various tables, imaging systems, tube stands, tomographic devices, AEC pickups, buckys, ABS pickups, X-ray tubes and collimators.

The generator interface may be programmed to supply a voltage, an isolated contact, receive a voltage, or an external isolated contact.

All interfacing cables enter the generator at either the top or middle at the rear of the generator cabinet.

NOTE:	*The installer must provide the necessary interfacing cables.*

WARNING

NOTE:	*The generator interface board has 110 and 220 VAC present at all times that the main disconnect is switched ON. Use caution when servicing this board.*

3B.2.0 LOCATIONS OF INPUTS AND OUTPUTS

3B.2.1 Generator Pictorial Showing Connections

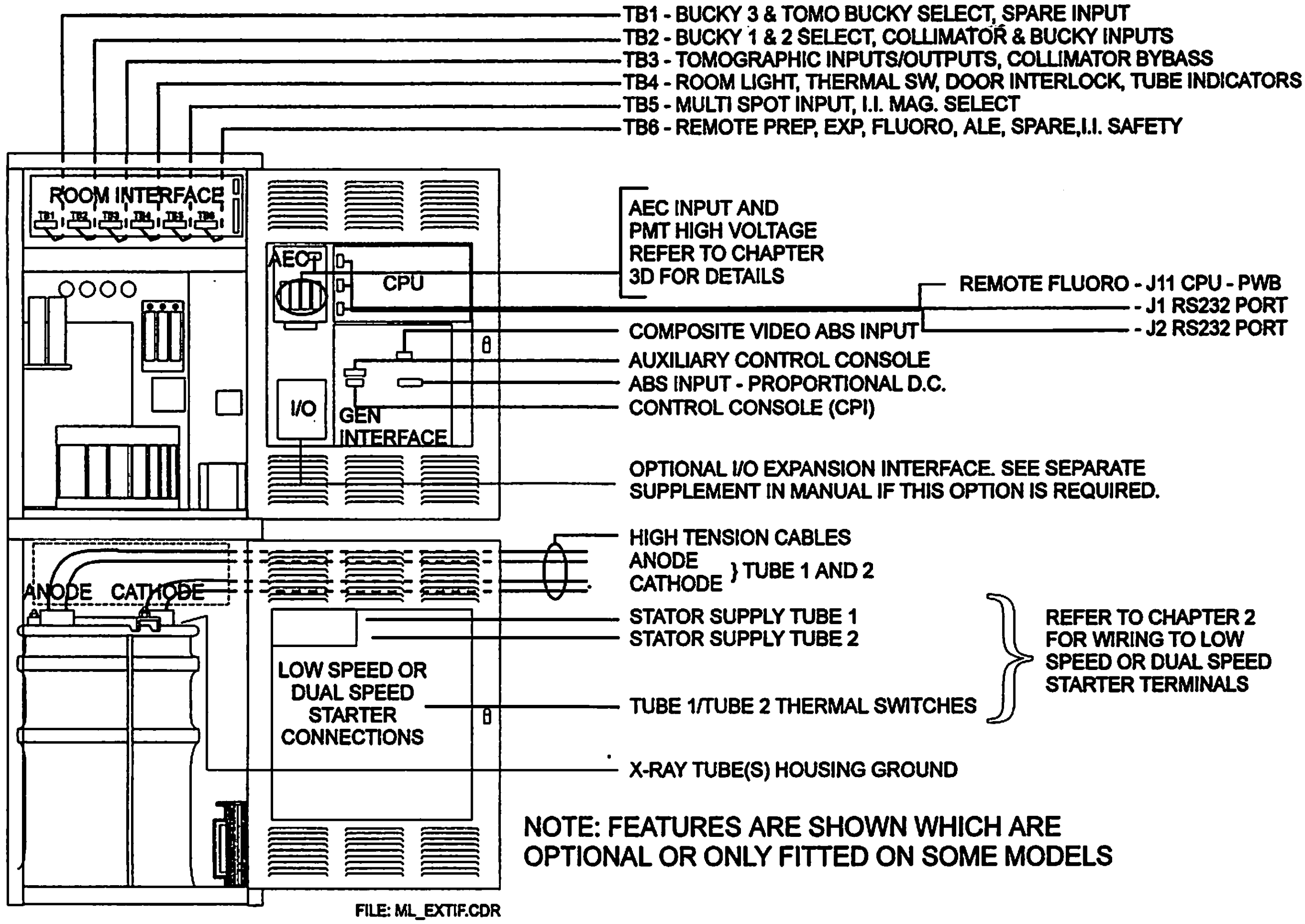

Figure 3B-1: Generator to room interface

CAUTION:	***ENSURE THAT ALL X-RAY TUBE HOUSINGS ARE CONNECTED TO THE GROUND STUD ON THE HIGH TENSION TRANSFORMER. USE A SEPARATE GROUND WIRE, 10 AWG (6 mm^2), OR GREATER FOR EACH TUBE***

3B.2.2 Low Speed/Dual Speed Starter

Refer to chapter 2 (installation) for instructions on wiring to the low speed or dual speed starter terminal blocks. Note that the X-ray tube thermal switches may be connected at the starter terminal blocks, or at the room interface board. Both sets of terminals are connected in parallel, and either may be used.

3B.2.3 High Tension Transformer

Accepts the high tension cables from either one or two x-ray tubes.

3B.2.4 Generator Interface Board

The generator interface board accepts the following (ABS only on R&F generators):

- ABS - composite video (J8).
- ABS - proportional DC (J7).

(Jumpers must be configured for different ABS types, refer to chapter 3E).

- Control console (J4).

3B.2.5 Generator CPU Board

The generator CPU board accepts the following (all are optional):

- Remote fluoro controller (J11).
- RS 232 Port (J1).
- RS 232 Port (J2).

3B.2.6 AEC Board

Depending on the Millennia generator's configuration, different AEC boards may be fitted. Refer to chapter 3D.

3B.2.7 Console CPU Board

The optional handswitch connects to the console CPU board, refer to chapter 2 for details. If it is desired to connect a remote fluoro footswitch (normally customer suplied), connect to terminals "F" and "COM" on TB1 on the console CPU board.

3B.2.8 I/0 Expansion Board (optional)

This optional I/0 board will be used when the Millennia generator is interfaced with digital systems, film changers and various dedicated products. A separate supplement will be included in the manual for this board, if fitted.

3B.2.9 Room Interface Board

All the necessary inputs and outputs for the external room equipment are located on this board.

- TB1 - Bucky 3 and tomo bucky select, spare input,
- TB2 - Bucky 1 and 2 select, collimator and bucky inputs.
- TB3 - Tomographic inputs and outputs, collimator bypass.
- TB4 - Room light, thermal switches, door interlock, tube indicators.
- TB5 - Multiple spot input, I.I. mag. select.
- TB6 - Remote prep, exposure and fluoro inputs, I.I. safety input, ALE output, spare output.

3B.3.0 FEATURES OF THE ROOM INTERFACE BOARD

Refer to the following schematics and figures.

- Figure 3B-2, room interface board layout.
- System interface schematic, drawing 732612.
- Generator interface board schematic, drawing 732175 (sheet 1).
- Room interface board schematic, drawing 731967

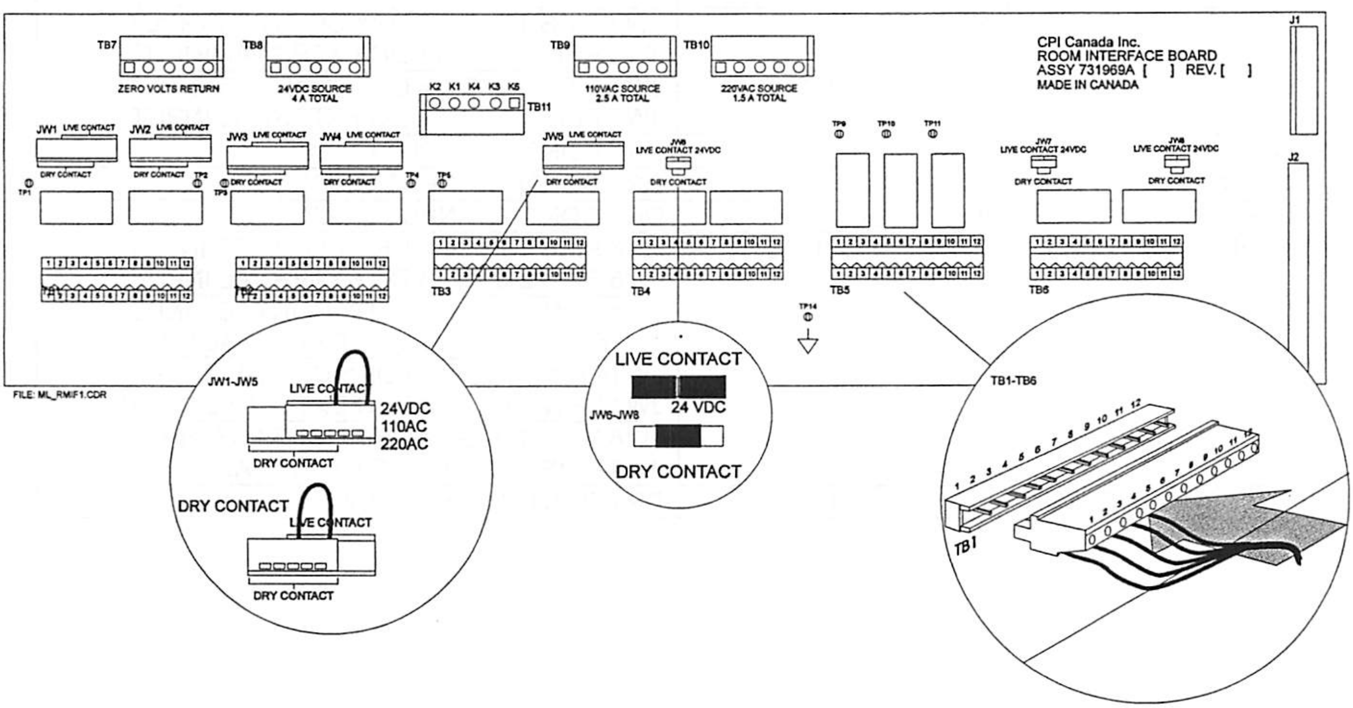

Figure 3B-2: Room interface board

3B.3.1 Inputs

- All inputs are opto coupled, select inputs may be configured to use an external +/- 24 VDC source or may be configured to accept a closed dry contact.
- Note the following inputs and jumper configurations per the table below:

NOTE:	***The Millenia generator is shipped from the factory with all inputs configured for dry contact inputs.***

JUMPER CONFIGURATION (INPUTS):

ROOM INTERFACE BOARD	GENERATOR INTERFACE BOARD JUMPER CONFIGURATION
TB1 PINS 4 & 5 (SPARE)	JW7 PINS 1-2, 3-4 = DRY CONTACT INPUT JW7 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB2 PINS 6 & 7 (COLLIMATOR)	JW9 PINS 1-2, 3-4 = DRY CONTACT INPUT JW9 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB2 PINS 4 & 5 (BUCKY CONTACTS)	JW10.PINS 1-2, 3-4 = DRY CONTACT INPUT JW10 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB3 PINS 6 & 7 (TOMO EXPOSURE)	JW3 PINS 1-2, 3-4 = DRY CONTACT INPUT JW3 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB3 PINS 4 & 5 (REMOTE TOMO SELECT)	JW2 PINS 1-2, 3-4 = DRY CONTACT INPUT JW2 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB4 PINS 8 & 9 (THERMAL SWITCH 1)	DRY CONTACT INPUT ONLY
TB4 PINS 6 & 7 (THERMAL SWITCH 2)	DRY CONTACT INPUT ONLY
TB4 PINS 4 & 5 (ROOM DOOR INTLK)	DRY CONTACT INPUT ONLY
TB5 PINS 11 & 12 (MULT. SPOT EXPOSURE)	JW6 PINS 1-2, 3-4 = DRY CONTACT INPUT JW6 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB6 PINS 9 & 10 (REMOTE EXPOSURE)	JW15 PINS 1-2, 3-4 = DRY CONTACT INPUT JW15 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB6 PINS 7 & 8 (REMOTE PREP)	JW14 PINS 1-2, 3-4 = DRY CONTACT INPUT JW14 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB6 PINS 3 & 4 (I.I. SAFETY)	JW8 PINS 1-2, 3-4 = DRY CONTACT INPUT JW8 PINS 2-3 = 24 VDC EXTERNAL INPUT
TB6 PINS 5 & 6 (REMOTE FLUORO EXP)	DRY CONTACT INPUT ONLY

3B.3.2 Outputs

- Outputs are via relay contacts, some of which may be configured to supply a dry contact closure or to supply 24 VDC, 110 VAC, or 220 VAC upon closure.
- Note the following outputs and jumper configurations per the table below:
- To supply power to a ***grounded*** load, use TB1 pin 12 (for example) and jumper on "dry contacts". This applies also to TB1 pin 1, TB2 pin 12, TB2 pin 1 and TB3 pin 12.

NOTE:	***The Millenia generator is shipped from the factory with JW1 to JW5 configured for dry contacts, and JW6 to JW8 configured for 24 VDC output on relay closure.***

JUMPER CONFIGURATION (OUTPUTS):

ROOM INTERFACE BOARD	ROOM INTERFACE BOARD JUMPER CONFIGURATION
TB1 PINS 11 & 12 (BUCKY 3 SELECT)	JW2 DRY CONTACTS OUTPUT JW2 LIVE CONTACTS OUTPUT
TB1 PINS 1 & 2 (TOMO BUCKY SELECT)	JW1 DRY CONTACTS OUTPUT JW1 LIVE CONTACTS OUTPUT
TB2 PINS 11 & 12 (BUCKY 1 SELECT)	JW4 DRY CONTACTS OUTPUT JW4 LIVE CONTACTS OUTPUT
TB2 PINS 1 & 2 (BUCKY 2 SELECT)	JW3 DRY CONTACTS OUTPUT JW3 LIVE CONTACTS OUTPUT
TB3 PINS 11 & 12 (TOMO/BUCKY START)	JW5 DRY CONTACTS OUTPUT JW5 LIVE CONTACTS OUTPUT
TB3 PINS 1 & 2 (COLLIMATOR BYPASS)	DRY CONTACT OUTPUT ONLY
TB4 PINS 11 & 12 (ROOM LIGHT)	DRY CONTACT OUTPUT ONLY
TB4 PINS 1 & 2 TUBE 2 INDICATOR TB4 PINS 1 & 3 TUBE 1 INDICATOR	JW6 PINS 1-2, 3-4 = 24VDC OUTPUT JW6 PINS 2-3 = DRY CONTACT OUTPUT
TB5 PINS 8 & 9 (I.I. MAG 1)	DRY CONTACT OUTPUT ONLY
TB5 PINS 5 & 6 (I.I. MAG 2)	DRY CONTACT OUTPUT ONLY
TB5 PINS 2 & 3 (I.I. MAG 3)	DRY CONTACT OUTPUT ONLY
TB6 PINS 1 & 2 (ALE OUTPUT)	JW7 PINS 1-2, 3-4 = 24VDC OUTPUT JW7 PINS 2-3 = DRY CONTACT OUTPUT
TB6 PINS 11 & 12 (SPARE OUTPUT)	JW8 PINS 1-2, 3-4 = 24VDC OUTPUT JW8 PINS 2-3 = DRY CONTACT OUTPUT

3B.3.3 Selecting Output Voltages

Five outputs (K1, K2, K3, K4 and K6 for bucky selects and bucky start) may be jumper configured for a choice of the following voltages:

- 24 VDC 4 AMPS total.
- 110 VAC 2.5 AMPS total.
- 220 VAC 1.5 AMPS total.

NOTE:	***2.5 AMPS IS AVAILABLE AT 110 VAC <u>OR</u> 1.5 AMPS IS AVAILABLE AT 220 VAC, BUT BOTH ARE NOT AVAILABLE SIMULTANEOUSLY. TOTAL POWER CONSUMPTION MUST NOT EXCEED 350 VA.***

3B.3.3 Selecting Output Voltages (Cont)

These output voltage sources are not compatible with:

- Collimator lamps (24 VDC 150 watts). These exceed the 4 Amp rating of the 24 VDC supply.
- Fluorescent lamps. These have high starting currents and generate transients when the tube strikes.
- Some inductive loads may cause difficulties (for example some motors, under table tube fans, and solenoids).

IT IS STRONGLY RECOMMENDED THAT CLAMPING/RECOVERY DIODES BE USED ON INDUCTIVE DEVICES SUCH AS RELAYS ETC WHICH ARE CONNECTED TO THE ROOM INTERFACE BOARD.

Voltage selections are made by adding jumper wires from TB11 to TB8, TB9, or TB10, and placing the jumpers on JW1, JW2, JW3, JW4, or JW5 in the live contact position.
Review figure 3B-3 for typical examples.

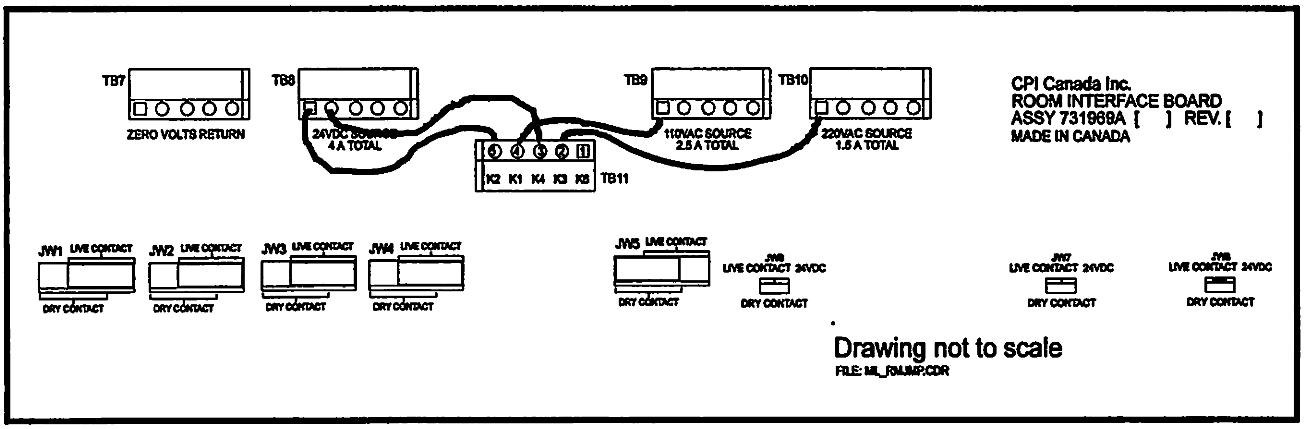

Figure 3B-3: Typical jumper arrangement on the room interface board

SOME INSTALLATIONS REQUIRE THAT THE OUTPUTS OF RELAYS K1, K2, K3, K4, OR K6 DRIVE THE INPUTS OF OPTO COUPLERS. IN INSTALLATIONS WHERE THESE RELAYS SOURCE 110 OR 220 VAC, THE LEAKAGE CURRENT THROUGH THE RC SNUBBER ACROSS THE RELAY CONTACTS MAY BE SUFFICIENT TO ENERGIZE THE OPTO COUPLERS WHEN THE RELAYS ARE OPEN. IF THIS IS EXPERIENCED, THE SNUBBER SHOULD BE REMOVED. REMOVING THE SERIES RESISTOR, PART OF THE RC SNUBBER, FROM THE CIRCUIT WILL ELIMINATE THIS PROBLEM.

IT IS THE RESPONSIBILITY OF THE INSTALLER TO PROVIDE THE PROPER INTERFACING CIRCUITS TO THE OPTO COUPLER(S) IN THESE TYPES OF INSTALLATIONS.

For reference, the RC snubbers components associated with each of the subject relays is listed below:

RELAY	SNUBBER RESISTOR	SNUBBER CAPACITOR
K1	R2	C2
K2	R1	C1
K3	R3	C3
K4	R4	C4
K6	R6	C6

3B.3.4 Typical Examples

Selected Output Relay	Plug and Jumper	Wire Jumper
K2 (24 VDC)	JW2: Live Contact	(K2) TB11 - 5 to TB8
K1 (110 VAC)	JW1: Live Contact	(K1) TB11 - 4 to TB9
K4 (24 VDC)	JW4: Live Contact	(K4) TB11 - 3 to TB8
K3 (220 VAC)	JW3: Live Contact	(K3) TB11 - 2 to TB10
K6 (dry contacts)	JW5: Dry Contact	(K6) TB11 - no connection
K12 (24 VDC)	JW7: Live Contact 24VDC	N/A
K13 (dry contacts)	JW8: Dry Contact	N/A
K7 (24 VDC)	JW6: Live Contact 24VDC	N/A

The previous examples will configure the outputs as shown below:

- K2 when selected will provide 24 VDC to a load at TB1 pins 11 and 12.
- K1 when selected will supply 110 VAC to a load at TB1 pins 1 and 2.
- K4 when selected will supply 24 VDC to a load at TB2 pins 11 and 12.
- K3 when selected will supply 220 VAC to a load at TB2 pins 1 and 2.
- K6 when selected will supply closed contacts at TB3 pins 11 and 12.
- K12 when selected will supply 24 VDC at TB6 pins 1 and 2.
- K13 when selected will supply closed contacts at TB6 pins 11 and 12.
- K7 will supply 24 VDC at TB4 pin 3 for tube 1, or 24 VDC at TB4 pin 2 for tube 2. Ground reference will be at TB4 pin 1.

3B.3.5 Wiring The Room Interface Terminal Plugs

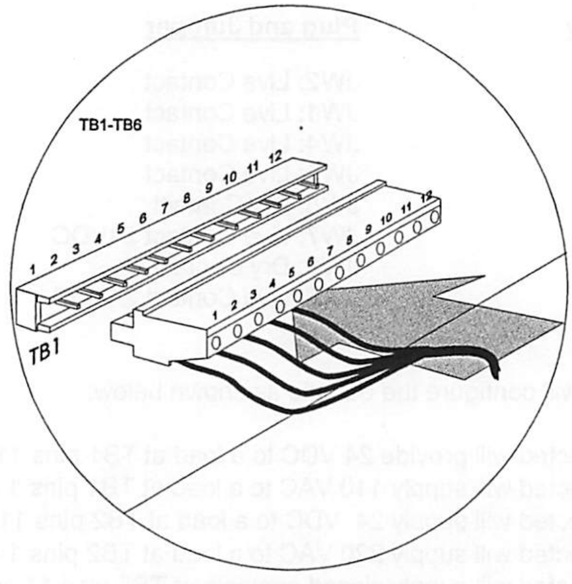

Figure 3B-4: Terminal plug

- Remove the required mating connectors from TB1 to TB6 on the room interface board.
- Back out the wire retaining screws as required.
- Dress the interface cable with a minimum of 5 inch (130 mm) flying leads.
- Strip each wire .25 inches (6 mm).
- Insert the wire into the plug and tighten the terminal screw. Several wires may be inserted into a single terminal connection.
- Be sure the plug numbering matches the input/output signals.
- Insert the plug into the room interface plug as shown in Figure 3B-4.
- Leave sufficient cable to allow interface access.
- To eliminate confusion, label each plug.

3B.4.0 GENERATOR INTERFACE BOARD PROGRAMMING FOR 110/220 VAC

The 110/220 VAC supplies available at TB9 and TB10 of the room interface board may be programmed such that:

- 110/220 VAC is present at TB9 and TB10 at all times that the generator main disconnect is switched ON.
- 110/220 VAC is present at TB9 and TB10 only when the generator itself is switched ON.

The desired selection is made using JW1 on the generator interface board. Setting the jumper to JW1 pins 1-2 selects the condition where 110/220 VAC is present at TB9 and TB10 only when the generator is switched ON.

Setting the jumper to JW1 pins 2-3 selects 110/220 VAC to be present at TB9 and TB10 at all times that the generator main disconnect is switched ON.

Refer to figure 3B-5, this shows the jumper position JW1 pins 1-2 which only provides for 110/220 VAC when the generator is switched ON.

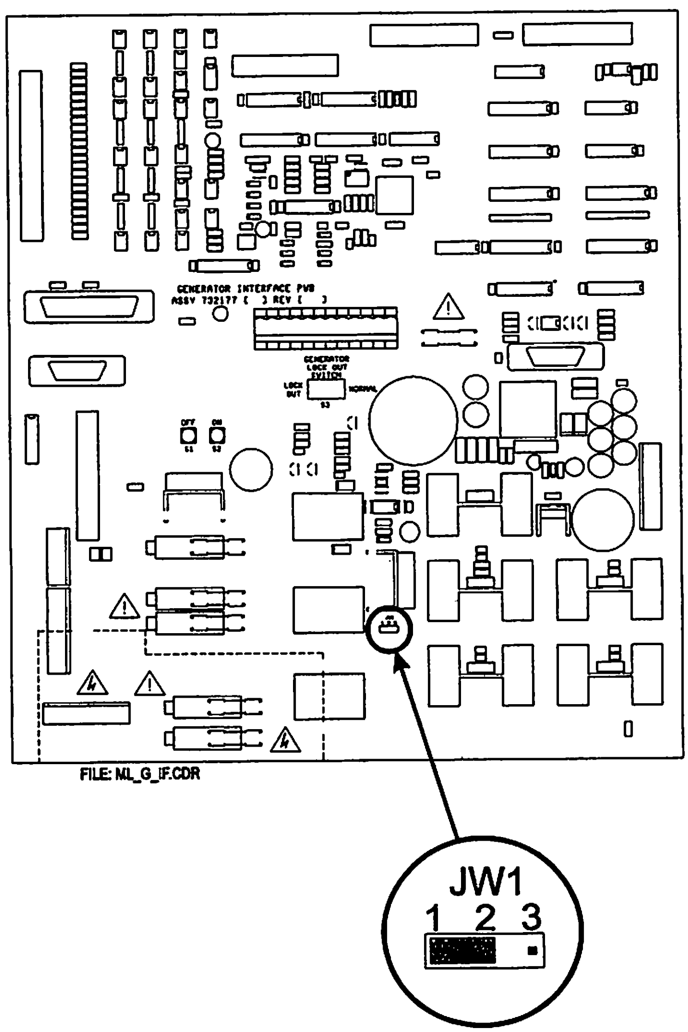

Figure 3B-5: 110/220 VAC programming

3B.5.0 TYPICAL R&F ROOM CONNECTIONS

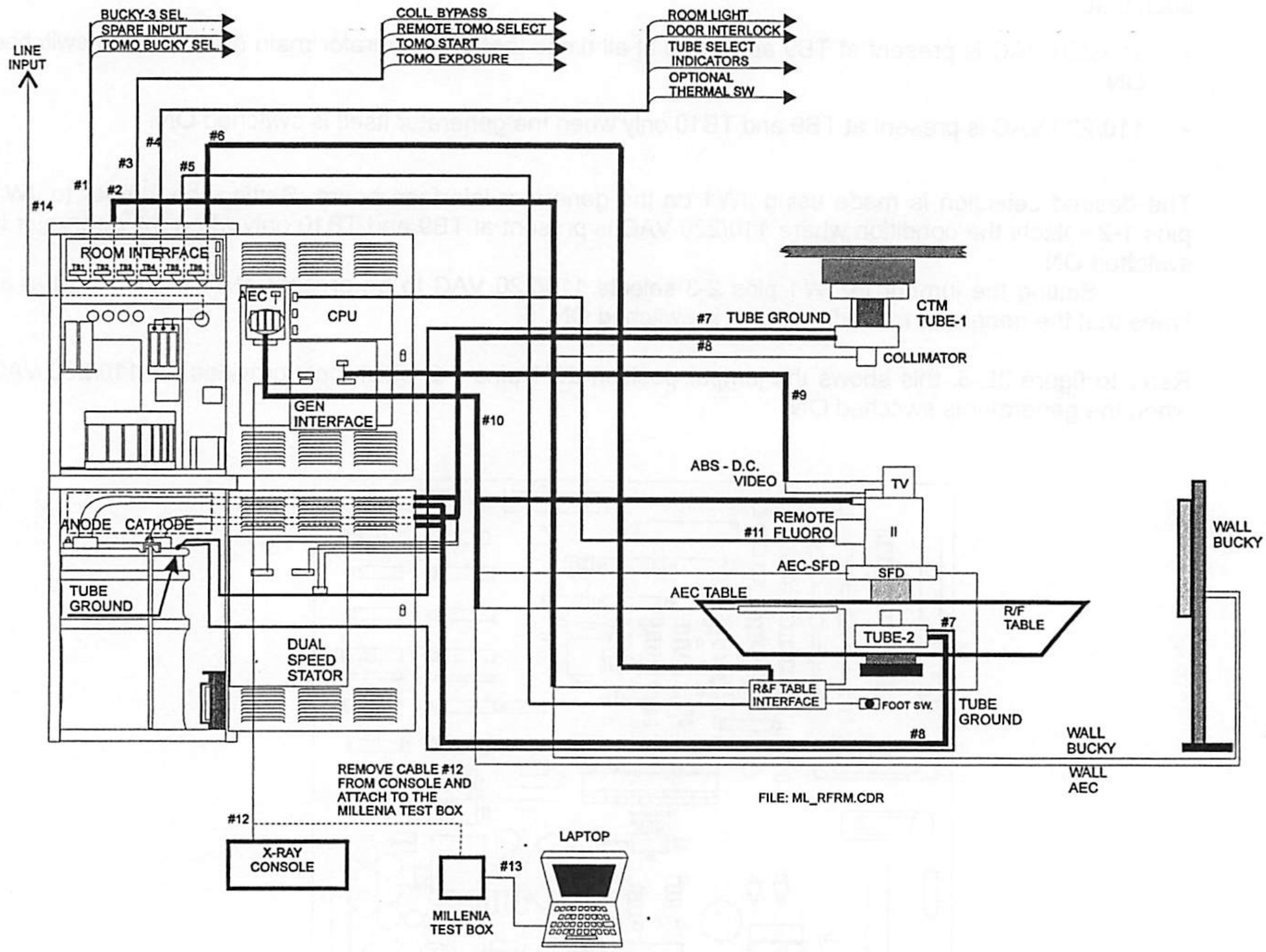

Figure 3B-6: Typical R&F room

3B.6.0 TYPICAL ROOM CABLING AND INTERFACING

The following is for reference only and represents a typical R&F procedure room.

- Cable assembly #1
  1. Bucky 3 select (image receptor).
  2. Spare input, may be programmed for an auxiliary input.
  3. Tomo bucky select, usually used to select a tomographic device.

- Cable assembly #2
  1. Bucky 1 select (image receptor), usually used to select the R&F table bucky.
  2. Collimator interlock, will prevent an exposure if the collimator inputs are not satisfied.
  3. Bucky contacts, all bucky contacts are paralleled at this connector. Diode isolation may be required.
  4. Bucky 2 select (image receptor), usually used to select vertical wall bucky.

- Cable assembly #3
  1. Collimator bypass. Usually used with the collimator associated with the tomographic device, to allow non-PBL operation in the tomographic mode.
  2. Remote tomo select, used for selecting tomography operation from a remote R&F table.
  3. Tomo start, will issue a start to sweep signal to a tomographic device.
  4. Tomographic exposure, the generator waits for a switch closure during the tomographic sweep.

- Cable assembly #4
  1. Room light. Provides a closed contact to energize the X-ray room warning light. Maximum 250 watts.
  2. Door interlock. Requires a closed dry contact to interlock the generator exposure with the X-ray room's entrance door.
  3. Tube select indicator (source select indicator). Indicates which X-ray tube has been selected.
  4. Optional thermal switch inputs.

- Cable assembly #5
  1. Mag. select. Interfaces with the image intensifier to select the magnification modes.
  2. Multiple-spot exposure. When multi-spot operation is selected at the spot film device, (example: 4 on 1) and this input receives a closed dry contact, the AEC calibration will be offset to compensate for the small fields.

- Cable assembly #6
  1. Interfaces to the table (conventional or remote R&F), the X-ray prep, expose and fluoro footswitch.
  2. The I.I. safety position interlock switch, used if the I.I. may be removed from the spot film device.
  3. ALE - required if an SFC or a serial changer is used.
  4. Spare output.

3B.6.0 TYPICAL ROOM CABLING AND INTERFACING (CONT)

- Cable assembly #7
  1. Must be a #10 AWG (6 mm^2) wire or greater, connected from the housing of both X-ray tubes to ground at the high tension transformer.

- Cable assemblies #8
  1. Pair of H.T. cables from the over table (tube-1) X-ray tube to the HT Transformer.
  2. Pair of H.T. cables from the under table (tube-2) X-ray tube to the HT transformer.

- Cable assembly #9.
  1. Interfaces the ABS signal from the TV camera as either DC proportional or composite video.
  2. Interfaces the PMT's high voltage and signal to the generator, if used.
     Refer to chapter 3E for details.

- Cable assembly #10
  1. These cables are usually supplied by the AEC vendor. Be sure these cables are placed away from any electrical noise areas. When interfacing AEC cables be careful not to cause ground loops. Grounding should **only** be at the AEC board.
     Refer to chapter 3D for details.

- Cable assembly #11
  1. This cable is supplied by CPI for the remote fluoro controller interface.

- Cable assembly #12
  1. This cable is supplied by CPI for the control console interface.

- Cable assembly #13
  1. Supplied with the optional laptop computer interconnect box.

- Cable assembly #14
  1. AC mains cable.

CHAPTER 3

SECTION 3C

PROGRAMMING THE GENERATOR

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3C.1.0 INTRODUCTION

Programming of the generator is performed using the operator control console. All programming menus are displayed in the LCD display window on the console. The ten "soft key" buttons (1 to 10 in the figure below) are used to navigate through the programming screens and to select and enter values in this section.

In this section, ***SELECT*** means to press the button adjacent to the desired function shown in the LCD display window.

3C.1.1 Entering Into Programming Mode

To enter into the programming mode for the generator follow the steps below. Refer to figure 3C-1 for the button locations referenced in this section. This figure depicts both the 23 X 56 (cm) console, and the 31 X 42 (cm) console.

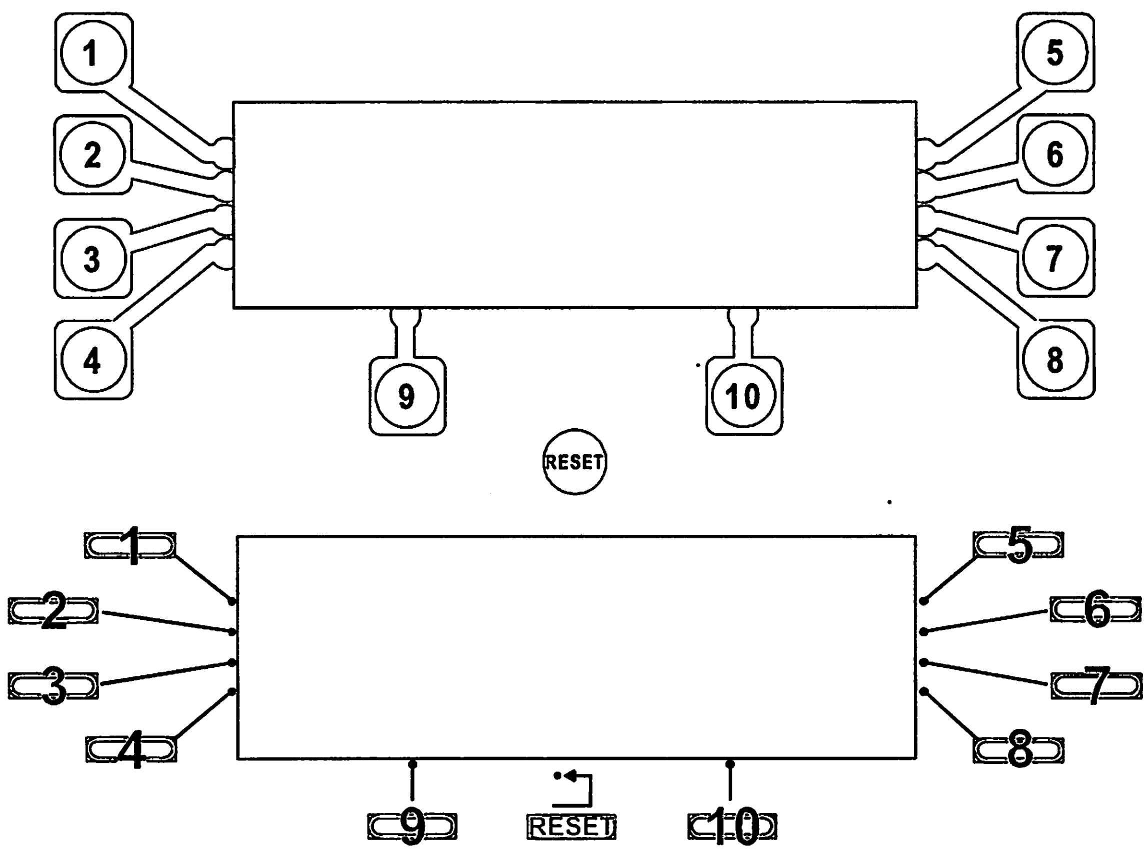


Figure 3C-1: Programming/calibration mode reference

Step	Action	Result
1.	Start with the generator switched OFF.	
2.	While pressing and holding the **RESET** button, press the generator POWER ON button on the console.	The generator will go through its start-up sequence, then display the message **ENTER PASSWORD.**
3.	Enter the password by pressing the button sequence: [1] - [8] - [4] - [5].	The **GENERATOR SETUP** menu will now be displayed as shown in the next section.

3C.2.0 GENERATOR SETUP MENU

The **GENERATOR SETUP** menu presents the user with 5 main options.

```
                    * GENERATOR SETUP *
UTILITY                              APR EDITOR: DISABLED
                                        GEN CONFIGURATION
                                                DATA LINK

EXIT SETUP
```

The table below shows the functions available within each of the options in the **GENERATOR SETUP** menu. Select one of these options to access the corresponding function.

UTILITY	• Set time & date • Error log • Statistics • Console
APR EDITOR	• Enables / disables changes to APR techniques
GEN CONFIGURATION	• Tube selection • Generator limits • Receptor setup • I/O configuration • AEC setup • AEC calibration • Fluoro setup • Tube calibration
DATA LINK	• Download / upload software via a laptop computer
EXIT SETUP	• Returns to normal operating mode (non setup / programming mode)

3C.3.0 UTILITY MENU

The **UTILITY** menu presents the user with 5 options as shown below.

```
                    * UTILITY *
SET TIME & DATE
ERROR LOG
STATISTICS
CONSOLE
     EXIT
```

3C.3.1 Setting Time And Date

The **SET TIME & DATE** menu allows changing or setting of the time and date.

```
                 * SET TIME & DATE *
YEAR:    2000                              HOUR:  18
MONTH:      9                              MIN:   29
DAY:       15                                      +
                                                   -
       EXIT
```

Use these steps to set the time and date.

Step	Action
1.	From the **UTILITY** menu, select **SET TIME & DATE**.
2.	Select **YEAR** and press the **+** or **-** buttons to set the year.
3.	Select **MONTH** and press the **+** or **-** buttons to set the month.
4.	Select **DAY** and press the **+** or **-** buttons to set the date.
5.	Select **HOUR** and press the **+** or **-** buttons to set the hour (in 24 hour format).
6.	Select **MIN** and press the **+** or **-** buttons to set the minutes.
7.	Select **EXIT** to return to the **UTILITY** menu.

3C.3.2 Error Log

The **ERROR LOG** menu allows the display of error messages stored in the generator's error log. Parameters such as kV, mA, time, receptor, focus, technique selection, field, film screen and fluoro parameters will be displayed simultaneously on the console LED displays.

```
                   * ERROR LOG *
ERROR #  1 OF 18
DATE:    8-19-2000                         TIME: 13:09
ERROR CODE: 200                                      +
ERROR MESSAGE:  ANODE HEAT WARN                      -
       EXIT
```

Use these steps to access the error log.

Step	Action	Result
1.	From the **UTILITY** menu select **ERROR LOG.**	
2.	Select **ERROR #** and press the **+** or **-** buttons to scroll through the error log.	The error code, error message, date and time of the error will be displayed in the LCD window, and the associated parameters will be displayed on the console displays.
3.	Select **EXIT** to return to the **UTILITY** menu.	

3C.3.3 Statistics

The **STATISTICS** menu shows the tube exposure count, accumulated fluoro hours if applicable, and the accumulated generator exposure count. This also allows resetting of select counters.

	* STATISTICS *	
TUBE 1 EXP:	500	RESET TUBE 1 EXP
TUBE 2 EXP:	600	RESET TUBE 2 EXP
FLUORO HOURS:	100	RESET FLUORO HOURS
TOTAL EXP:	1100	
EXIT		

Use these steps to access the statistics menu. RAD only or 1 tube generators will show a subset of the above menu items.

Step	Action
1.	From the **UTILITY** menu select **STATISTICS.**
2.	To reset the tube exposure counter, select **RESET TUBE 1 EXP** or **RESET TUBE 2 EXP**. Select **RESET FLUORO HOURS** to reset the fluoro exposure counter.
3.	Select **EXIT** to return to the **UTILITY** menu.

3C.3.4 Console

The **CONSOLE** menu allows setting of the items below to suit operator preferences:

	* CONSOLE *	
SLOW KEY REPEAT:	200MS	LCD SCREEN
MED. KEY REPEAT:	150MS	APR MODE: NO
FAST KEY REPEAT:	75MS	+
SPEAKER VOLUME:	15	-
EXIT		

Definitions of console parameters as used in this section.

- **SLOW KEY REPEAT** — Determines the speed at which displays change while the selected key is pressed for the first 5 counts.
- **MED. KEY REPEAT** — Determines the speed at which displays change while the selected key is pressed for the next 5 counts.
- **FAST KEY REPEAT** — Determines the speed at which displays change while the selected key is pressed after 10 counts.
- **SPEAKER VOLUME:** — Sets the speaker volume for the control console in the range **1** to **15.**
- **LCD SCREEN** — Toggles between normal and reverse video for the LCD display.
- **APR MODE:** — **NO** allows the operator to select an APR view, and still have the ability to manually select receptors, focus, technique, film screen, AEC fields, etc.

  YES allows the operator to select all of the above *EXCEPT* the technique selection (AEC, mAs, mA/ms).

3C.3.4 Console (cont)

Use these steps to access the **CONSOLE** menu.

Step	Action
1.	From the **UTILITY** menu select **CONSOLE.**
2.	Select the desired parameter to change. SLOW, MED, FAST KEY REPEAT and SPEAKER VOLUME are adjusted by pressing the **+** or **-** buttons. LCD SCREEN and APR MODE are toggled by pressing the adjacent selection button.
3.	Select **EXIT** to return to the **UTILITY** menu.
4.	Select **EXIT** again to return to the **GENERATOR SETUP** menu.

3C.4.0 APR EDITOR

The **APR EDITOR** enables / disables the ability of the operator to make *and then save* changes to APR techniques.

```
                    * GENERATOR SETUP *
UTILITY                              APR EDITOR: DISABLED
                                     GEN CONFIGURATION
                                     DATA LINK

EXIT SETUP
```

Two modes of operation are available for the **APR EDITOR**:

- **ENABLED** — Allows the operator to change the default APR technique(s), and then save the changes to memory. The APR will subsequently default to the changed technique.
- **DISABLED** — Allows temporary editing of APR technique(s), but does not allow the changes to be saved to memory. The APR will always default to the original technique when the generator is switched OFF and then ON again.

GENERATORS WITH CPU BOARD 732174: When the generator is switched OFF and then ON again, the APR editor will default to the DISABLED state. Further APR changes will require that the APR editor be re- set to ENABLED to allow APR techniques to be changed and then saved.

GENERATORS WITH CPU BOARD 734573: The generator stores the last APR editor setting prior to being switched OFF. If the APR editor was previously ENABLED, APR changes may subsequently be made and then saved in normal operating mode without the need to manually set the APR editor to ENABLED. To disable APR technique changes, the APR editor must be set to DISABLED.

Use these steps to set the **APR EDITOR.**

Step	Action
1.	From the **GENERATOR SETUP** menu select **APR EDITOR.**
2.	Press the **APR EDITOR** button again to toggle to the desired selection.

3C.4.0 APR EDITOR (cont)

NOTE:	***APR TEXT MAY BE ALTERED BY USING A COMPUTER RUNNING THE CPI GenWare™ UTILITY SOFTWARE. FURTHER DOCUMENTATION REGARDING THIS FUNCTION IS INCLUDED WITH THE SOFTWARE PACKAGE IN THE FORM OF AN MS WORD DOCUMENT.***

3C.5.0 GENERATOR CONFIGURATION

The **GEN CONFIGURATION** menu presents the user with 9 options as shown below. Select one of these options to access the corresponding menu.

* GEN CONFIGURATION *	
TUBE SELECTION	AEC SETUP
GENERATOR LIMITS	AEC CALIBRATION
RECEPTOR SETUP	FLUORO SETUP
I/O CONFIGURATION	TUBE CALIBRATION
EXIT	>>
	*

* The **>>** function is only available on generators with the DAP (Dose-Area Product) option. Refer to section 3F for details.

3C.5.1 Tube Selection

The **TUBE SELECTION** menus allow the desired tube type to be selected and assigned to TUBE 1 and to TUBE 2 (two tube generators only), and allow setting of the default limits for that tube.

This menu will not be displayed on one-tube generators.

*TUBE SELECTION *
TUBE 1
TUBE 2
EXIT

The next menus show the default tube selections. The number of tube selection screens, and the actual tube selections, may not be exactly as shown.

* TUBE 1 SELECTION *	
A192B 0.6/1.2	G256 0.6/1.0
A256 0.6/1.0	G292 0.6/1.2
A292 0.6/1.2	G1082 0.3/1.0
A272 0.3/0.6	RAD8 1.0/2.0
EXIT	>>

3C.5.1 Tube Selection (cont)

* TUBE 1 SELECTION *	
RAD14 0.6/1.2	RAD74 0.6/1.5
RAD21 0.6/1.2	RAD92 0.6/1.2
RAD56 0.6/1.2	DX10HS 0.6/1.0
RAD60 0.6/1.2	DX92HS 0.6/1.2
<<	>>

* TUBE 1 SELECTION *	
DX93HS 0.6/1.5	RO1750 0.6/1.3
DX101HS 0.6/1.3	
MX75 1.0/2.0	
MX100 0.6/1.25	
<<	>>

The following menu is only available if additional tubes have been downloaded via a computer running CPI GenWare™ software.

* TUBE 1 SELECTION *	
***USER DOWNLOADED TUBES DISPLAYED HERE**	
<<	RETURN

Use these steps to access the **TUBE SELECTION** menus.

Step	Action	Result
1.	From the **GEN CONFIGURATION** menu select **TUBE SELECTION.**	
2.	Select **TUBE 1** or **TUBE 2.** This step not available on one tube generators, go directly to step 3.	The available tubes to choose from will display.
3.	Select the X-ray tube type to be assigned to that tube location by pressing the button adjacent to the desired selection. Use the **>>** and **<<** buttons to navigate through the tube selection menus if the desired tube is not displayed on the current screen.	This will assign the selected X-ray tube to the desired tube location.
4.	Once the desired tube has been selected, parameters for that tube are displayed showing the default values. DO NOT adjust the default values at this time.	See next page for further details. Do not press **RETURN** or **>>** until this is requested in a later step.
5.	Additional tube types may be downloaded using the CPI GenWare™ utility software. Refer to section 3C.7.0 **DATA LINK.**	

3C.5.1 Tube Selection (cont)

When the desired tube is selected, the default limits are displayed. Please consult the X-ray tube data sheet(s) before making any changes.

The dual speed starter operates at 60 or 180 Hz (50 or 150 Hz for some tube types) independent of line frequency. The low speed starter operates at 50 Hz for 50 Hz mains, or 60 Hz for 60 Hz mains. Therefore for generators equipped with the low speed starter, the 60 Hz tube ratings are automatically derated for 50 Hz operation if required.

PLEASE DO NOT CHANGE ANY DEFAULTS UNLESS THE IMPACT OF THOSE CHANGES IS CLEARLY UNDERSTOOD. INITIAL CALIBRATION SHOULD BE PERFORMED USING THE DEFAULT VALUES.

> ***NOTE:*** ***BEFORE CHANGING X-RAY TUBE DEFAULT PARAMETERS, PLEASE FILL IN THE X-RAY TUBE AND GENERATOR PARAMETER WORKSHEET. A BLANK FORM THAT SHOULD BE PHOTOCOPIED IS LOCATED IN SECTION 3A 3.0. THIS ALLOWS RECORDING OF THE DEFAULT VALUES AND THE NEW (CHANGED) VALUES.***

The next three menus show the default tube limits. These menus appear after a tube has been selected in the previous steps.

```
            *TUBE 1:  RAD60   0.6/1.2   12°   REV 1.4*
TUBE SPEED: DUAL                               MAX SF KW HS:  35.2
MAX SF KW LS:  21.3                            MAX LF KW HS:  99.0
MAX LF KW LS:  58.9                                              +
MAX KV: 150                                                      -
       RETURN                                  >>
```

```
            *TUBE 1:  RAD60   0.6/1.2   12°   REV 1.4*
MAX SF MA:   320
ANODE HU WARNING:  80%
ANODE HU LIMIT:  90%                                            +
                                                                -
       <<                                      >>
```

```
            *TUBE 1:  RAD60   0.6/1.2   12°   REV 1.4*
SF STANDBY: 2.5A                               FIL BOOST:  200MS
LF STANDBY: 2.5A                               FIL PREHEAT:  800MS
SF MAX: 5.2A                                                     +
LF MAX: 5.5A                                                     -
       <<                                   RETURN
```

3C.5.1 Tube Selection (cont)

Definitions of tube limits as used in this section. These settings are tube specific, i.e. tube 1 and tube 2 each have their own tube limit settings.

- **TUBE SPEED** — May be altered on dual speed generators. **DUAL** means that the *generator* determines whether to use low speed or high speed operation.
- **MAX SF KW LS** — Sets the maximum small focus low speed kW limit.
- **MAX LF KW LS** — Sets the maximum large focus low speed kW limit.
- **MAX KV:** — Sets the maximum kV allowed for that tube.
- **MAX SF KW HS** — Sets the maximum small focus high speed kW limit.
- **MAX LF KW HS:** — Sets the maximum large focus high speed kW limit.
- **MAX SF MA** — Sets the maximum mA in small focus. This should be set as low as possible to preserve the focal spot track wear and focal spot blooming.
- **ANODE HU WARNING** — Sets the limit at which the anode heat warning message is displayed.
- **ANODE HU LIMIT** — Sets the limit at which exposures will be inhibited. If the present anode heating is under the threshold, the exposure will be inhibited if the next exposure is calculated to exceed the anode HU limit.
- **SF STANDBY** — Sets the small focus standby filament current. The required value should be obtained from the X-ray tube data sheets.
- **LF STANDBY** — As above but for large focus.
- **SF MAX** — Sets the small focus maximum filament current.
- **LF MAX** — As above but for large focus.
- **FIL BOOST** — Sets the filament rapid boost duration in order to quickly raise the filament temperature. In installations where a spot film or equivalent device is used, default boost and preheat values may be decreased if needed to allow for one second R/F change over time.
- **FIL PREHEAT** — The time that the filament is held at the required emission level before an exposure is permitted

Typically, the boost time should be between 200 and 250 msec, and the preheat time should be in the range of 700 - 800 ms.
If in doubt, monitor the filament feedback and be sure the filament is not being over or under driven ***during an exposure.***

Standby current must be below the emission point. If the standby current is too high, the lower fluoro mA values may not calibrate properly resulting in a high mA fault error during fluoro operation.

If the maximum filament current is increased, be careful not to exceed the tube manufacturer's specifications.

3C.5.1 Tube Selection (cont)

Use these steps to modify the tube defaults.

Step	Action
1.	Use the **>>**, **<<**, and **RETURN** buttons to navigate through the TUBE DEFAULTS screens.
2.	Select the appropriate default value to change. Refer to the definitions on the previous page.
3.	Use the **+** and **-** buttons to change the selected values. Pressing the **TUBE SPEED** button toggles the selection between LOW, HIGH and DUAL speed (generators with dual speed starter only).
4.	When finished altering the tube default values, press the **<<, RETURN** or **EXIT** button(s) as required to return to the **TUBE SELECTION** menu (two tube generators) or **GEN CONFIGURATION** menu (one tube generators).
5.	Select the second X-ray tube if desired by repeating the previous steps (two tube generators only).
PLEASE ENSURE THAT THE SELECTED X-RAY TUBE STATOR(S) ARE COMPATIBLE WITH THE LOW SPEED OR DUAL SPEED STARTER IN YOUR GENERATOR.	
6.	Select **EXIT** to return to the **GEN CONFIGURATION** menu (two tube generators only).

3C.5.2 Generator Limits

The **GENERATOR LIMITS** menu allows the setting of generator limits as defined below.

```
              * GENERATOR LIMITS*
MAX KW:           80
MAX MA:         1000
MIN MA:           10                        +
MAX MAS          630                        -
       EXIT
```

Definitions of generator limits as used in this section.

- **MAX KW** Sets the maximum generator kW limit.
- **MAX MA** Sets the maximum generator mA limit.
- **MIN MA** Sets the minimum generator mA limit.
- **MAX MAS** Sets the maximum generator mAs limit.

BEFORE MAKING ANY CHANGES IN THIS SECTION, PLEASE CONSULT THE X-RAY TUBE DATA SHEETS TO ENSURE THAT THE PROPOSED CHANGES DO NOT EXCEED THE MANUFACTURERS RECOMMENDED LIMITS.

NOTE: ***BEFORE CHANGING GENERATOR LIMITS, PLEASE FILL IN THE X-RAY TUBE AND GENERATOR PARAMETER WORKSHEET. A BLANK FORM THAT SHOULD BE PHOTOCOPIED IS LOCATED IN SECTION 3A 3.0. THIS ALLOWS RECORDING OF THE DEFAULT VALUES AND THE NEW (CHANGED) VALUES.***

3C.5.2 Generator Limits (Cont)

Use these steps to set the generator limits.

Step	Action
1.	From the **GEN CONFIGURATION** menu select **GENERATOR LIMITS.**
2.	Select a limit to be changed. Refer to the previous definitions.
3.	Use the **+** and **-** buttons to change the selected values.
4.	When finished altering the generator default values, press **EXIT** to return to the **GEN CONFIGURATION** menu.

3C.5.3 Receptor Setup

The **RECEPTOR SETUP** menus allow each of the image receptors to be programmed as defined in the table following the example menu screens. Refer to the *configuration A* or *configuration B* menu screens, depending on the generator model.

MENU 1 (Configuration A)

```
                    * RECEPTOR  SETUP [sym] *
TUBE:     1                                  AEC CHANNEL: 1
TOMO: NO                                  INTERFACE OPTS: 0
FLUORO: NO                                                +
SERIAL:   NO                                              -
        EXIT                              >>
```

OR

MENU 1 (Configuration B)

```
                    * RECEPTOR  SETUP [sym] *
TUBE:     1                               INTERFACE OPTS: 0
TOMO: NO                                 FUNCTIONAL OPTS: 0
FLUORO: NO                                                +
SERIAL:   NO                                              -
        EXIT                              >>
```

MENU 2 (Configuration A and configuration B)

```
                    * RECEPTOR SETUP [sym]*
RECEPTOR SYM: [sym]                             MEMORY: DEF
FLUORO HANG:   30 SEC                 REM TOMO BUT: 2000 MS
RAD HANG:  0 SEC                                          +
LAST IMAGE HOLD:   40 MS                                  -
        <<                                >>
```

3C.5.3 Receptor Setup (cont)

MENU 3 (Configuration A)

* RECEPTOR SETUP [sym]*	
SF/LF SWITCH: MAN	DEFAULTS
AEC BACKUP: FIXED	
AEC BACKUP MAS: 500	+
AEC BACKUP MS: 3200	-
<<	

OR

MENU 3 (Configuration B)

* RECEPTOR SETUP [sym]*	
SF/LF SWITCH: MAN	DEFAULTS
AEC BACKUP: FIXED	AEC CHANNEL: 1
AEC BACKUP MAS: 500	+
AEC BACKUP MS: 3200	-
<<	

NOTE: *THE **DEFAULTS** SELECTION IN MENU 3 IS ONLY AVAILABLE IF **MEMORY** IN MENU 2 WAS SET TO **DEF**.*
*RECEPTOR MENUS 4 AND 5 BELOW ARE ONLY ACCESSIBLE IF **DEFAULTS** IS ENABLED.*

MENU 4 (Configuration A and configuration B)

* RECEPTOR SETUP [sym] DEFAULTS*	
TECHNIQUE: AEC	LEFT FIELD: YES
FOCUS: SMALL	CENTER FIELD: YES
FILM SCREEN: 1	RIGHT FIELD: YES
<<	>>

MENU 5 (Configuration A and configuration B)

* RECEPTOR SETUP [sym] DEFAULTS*	
KV: 75	DENSITY: 0
MA: 320	
MS: 50	+
	-
<<	

3C.5.3 Receptor Setup (cont)

Definitions of receptor setup programming as used in this section follow. The selections made when programming a receptor apply to that receptor only. *Some of the functions listed are optional.*

- **TUBE** — Selects the tube assigned to that receptor. Selecting **NONE** disables that receptor.
- **TOMO** — Enables or disables tomographic operation (**NO** is disabled).
- **FLUORO** — Enables or disables fluoroscopic operation (**NO** is disabled).
- **SERIAL** — Allows repeated (serial) X-ray exposures without the need to re-prep after each exposure. Normally used with serial film changers (**NO** is disabled).
- **INTERFACE OPTS** — Selects pre-defined digital interface options:

  0 = None.

  1 = InfiMed GoldOne.

  2 = ATS ESI.

  3 = Gilardoni digital pulsed RAD.

  4 = Gilardoni digital HCF.

  5 = Reserved.

  6 = Syracuse Fluorecord.

  7 = Camtronics Video plus / Imacom DigiStar.

  8 = CMT SmartSpot.

  9 = Apelem Paladio.
- **FUNCTIONAL OPTS** — Selects pre-defined special functional options:

  0 = None.

  1 = Table stepper function.
- **RECEPTOR SYM** — Allows one of the predefined receptor symbols **[sym]** to be associated with the selected receptor.
- **FLUORO HANG** — Sets the time that the rotor will continue spinning after a fluoro exposure has terminated.
- **RAD HANG** — Sets the time that the rotor will continue spinning after a rad exposure has terminated.
- **LAST IMAGE HOLD** — Sets the time that the exposure will continue after the fluoro footswitch has been released. This enables a frame store device to complete the last image.
- **MEMORY** — Defines the techniques that will be defaulted to when a receptor is selected:

  YES: The selected receptor will remember it's last techniques such that those techniques are displayed when that receptor is re-selected.

  NO: The selected receptor will not remember the last techniques used on that receptor. The techniques used will be the same as last used on the previous receptor.

  DEF: The techniques used for that receptor will be as programmed. See receptor setup menu 4 and 5.

3C.5.3 Receptor Setup (cont)

- **REM TOMO BUT** — Sets the default tomo backup time when tomo is selected via the REMOTE TOMO SELECT input.
- **SF/LF SWITCH** — **AUTO:** Small or large focus will automatically be selected by the generator depending on the tube current.

  MAN: The operator must manually select small/large focus.
- **AEC BACKUP** — Defines the AEC backup mode to be used:

  FIXED: The generator will determine the maximum AEC backup time, not to exceed preset AEC backup mAs/ms values or system limits. The characters **AEC** will be displayed in the time window of the LED display during AEC operation.

  MAS: Allows the operator to adjust the AEC backup mAs, not to exceed preset AEC backup mAs/ms values or system limits. The mAs value will be displayed in the time window of the LED display during AEC operation.

  MS: Allows the operator to adjust the AEC backup ms, not to exceed preset AEC backup mAs/ms values or system limits. The ms value will be displayed in the time window of the LED display during AEC operation.
- **AEC BACKUP MAS** — Sets the maximum backup mAs, to a limit of 500 mAs (600 mAs for some generator models).
- **AEC BACKUP MS** — Sets the maximum back-up ms.
- **DEFAULTS** — This selection is available only if **MEMORY** was set to **DEF** in RECEPTOR SETUP menu 2.
- **AEC CHANNEL** — Defines which AEC channel will be used by the receptor. This must be set to a valid AEC input channel number, or to **0** as noted below. For example, if using an AEC board with only 3 input channels (channels 1 to 3) then selecting AEC channel 4 will cause an error. Selecting **0** disables AEC operation on that receptor.

THE FOLLOWING SELECTIONS ARE ONLY AVAILABLE IF DEFAULTS WAS ENABLED AS PREVIOUSLY DESCRIBED.

- **TECHNIQUE** — Defines which technique will be defaulted to when a receptor is selected. Options are **AEC, MA, MAS.**
- **FOCUS** — Defines which focus will be defaulted to when a receptor is selected. Options are **LARGE** or **SMALL.**
- **FILM SCREEN** — Defines which film screen will be defaulted to when a receptor is selected and AEC enabled. Options are film screen **1**, **2**, or **3**.
- **LEFT FIELD** — Selects the left field on the AEC device when AEC is selected.
- **CENTER FIELD** — As above, but for center field.
- **RIGHT FIELD** — As above, but for right field.

3C.5.3 Receptor Setup (cont)

- **KV** Selects the default kV value.
- **MA** Selects the default mA value.
- **MS** Selects the default time value.
- **DENSITY** Selects the default density value.

NOTE: ***IT IS RECOMMENDED THAT THE IMAGE RECEPTOR PROGRAMMING WORKSHEET BE FILLED IN FOR EACH RECEPTOR THAT IS PROGRAMMED. A BLANK FORM THAT SHOULD BE PHOTOCOPIED IS LOCATED IN SECTION 3A 4.0. THIS WILL PROVIDE A RECORD OF THE RECEPTOR SETUP FOR FUTURE REFERENCE.***

If the image receptor defaults are changed, please record the original defaults in a copy of the following table:

IMAGE RECEPTOR DEFAULT SETTINGS						
FUNCTION	RECEPTOR 1	RECEPTOR 2	RECEPTOR 3	RECEPTOR 4	RECEPTOR 5	RECEPTOR 6
TECHNIQUE						
FOCUS						
FILM SCREEN						
LEFT FIELD						
CENTER FIELD						
RIGHT FIELD						
KV						
MA						
MS						
DENSITY						

NOTE: ***DO NOT SWITCH OFF THE GENERATOR WHILE IN *RECEPTOR SETUP DEFAULTS* MENUS 4 AND 5. DOING SO WILL CAUSE THE UPDATED RECEPTOR SETUP PARAMETERS NOT TO BE SAVED. IT IS RECOMMENDED THAT THE FIRST RECEPTOR PROGRAMMING BE COMPLETED, THE RECEPTOR SETUP MENUS BE EXITED TO THE GEN CONFIGURATION MENU, THEN THE RECEPTOR SETUP MENU BE RESELECTED TO PROGRAM THE NEXT RECEPTOR. THE ABOVE SHOULD BE REPEATED UNTIL ALL RECEPTORS ARE PROGRAMMED. THIS WILL ENSURE THAT THE UPDATED PARAMETERS ARE SAVED.***

3C.5.3 Receptor Setup (cont)

Use these steps to set up the receptor parameters.

Step	Action
1.	From the **GEN CONFIGURATION** menu select **RECEPTOR SETUP**.
2.	Select the desired image receptor to be programmed.
3.	Use the << and >> buttons to navigate through the screens. As noted earlier, the **RECEPTOR SETUP DEFAULTS** menus (if enabled) are accessed by selecting **DEFAULTS** in screen 3.
4.	Select the appropriate parameter to change. Refer to the definitions on the previous pages in this section.
5.	Certain selections are toggled (press the selection button again to change the value), other parameters must be selected via the adjacent selection button. The values are then changed using the **+** and **-** buttons.
6.	When finished setting the parameters and/or defaults for the current receptor, press the **<<** or **EXIT** button(s) as required to return to the **GEN CONFIGURATION** menu.
7.	Reselect **RECEPTOR SETUP**, then select the next receptor to be programmed.
8.	When finished programming all receptors, return to the **GEN CONFIGURATION** menu as per step 6.

3C.5.4 I/O Configuration

The **I/O CONFIGURATION** menus allow programming the states of exposure for the inputs and the outputs on the room interface board.

```
                        * INPUTS [sym] *
REMOTE EXP :            ...__...__...            STANDBY STATE
REMOTE PREP:            ...__.........
REMOTE FL. EXP:         ............---
CONSOLE  EXP:           ...---...---...
            EXIT          ⇑                      >>
```

```
                        * INPUTS [sym] *
CONSOLE PREP:           ...---.........          STANDBY STATE
TOMO EXP:               ........ ---...
REM. TOMO SEL.:         ---...........
I/I SAFETY:             ...---...------
            <<            ⇑                      >>
```

```
                        * INPUTS [sym] *
COLL. ITLK:             ...---...------          STANDBY STATE
BUCKY CONTACTS:         .........---...
SPARE:                  ------...------
THERMAL SW 1:           ------...------
            <<            ⇑                      >>
```

```
                        * INPUTS [sym] *
THERMAL SW 2:           -----...-----            STANDBY STATE
DOOR ITLK:              ----- ...-----
MULTI SPOT EXP:         ---...........

            <<            ⇑                      >>
```

```
                        * OUTPUTS [sym] *
BKY 1 SELECT:           ---------------          STANDBY STATE
BKY 2 SELECT:           ---------------
BKY 3 SELECT:           ---------------
TOMO/BKY 4 SEL:         ---------------
            <<            ⇑                      >>
```

3C.5.4 I/O Configuration (cont)

```
                        * OUTPUTS [sym] *
TOMO/BKY STRT:          ---------------          STANDBY STATE
ALE:                    ---------------
COLL. BYPASS:           ---------------

            <<                 ⇑                  >>
```

```
                        * OUTPUTS [sym] *
ROOM LIGHT:             ---------------          STANDBY STATE
SPARE:                  ---------------


            <<                 ⇑                RETURN
```

The **STATE** button on the upper right hand side of the menu selects the current state. The word **STATE** will be preceded by the description of the state: for example, **STANDBY**.

The arrow in the lower middle area points to one of the five states described below. Moving to the next state is accomplished by pressing the **STATE** button. The states are as follows:

- **STANDBY** — Sets the state of the I/O when the generator is in standby or idle mode. Standby mode also defines the state when the generator is in fluoroscopic hangover.
- **PREP** — Sets the state of the I/O when the generator first enters PREP mode.
- **GEN RDY** — Sets the state of the I/O when the generator has completed PREP mode and is ready to expose.
- **RAD EXP** — Sets the state of the I/O when the generator starts a radiographic exposure.
- **FLUORO EXP** — Sets the state of the I/O when the generator starts a fluoroscopic exposure.

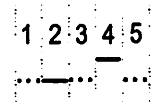
Pressing one of the buttons next to the selected function on the left of the display selects that function. The logic level of the selected state is then changed by pressing the selection button again (low = off / inactive, high = on / active).

For inputs, a logic "low" means that the input is ignored during that state. A Logic "high" requires that the input be satisfied before the generator will advance to the next state. If multiple inputs are programmed "high", for example if REMOTE PREP and CONSOLE PREP are both high in the prep state, then both inputs will need to be active before the generator will enter the prep state.

Setting an output to logic "low" causes the relay associated with that output to be de-energized during the selected state. Logic "high" will cause the associated relay to be energized during the selected state.

Certain functions have states indicated by a dotted line. The dotted line indicates invalid states, which cannot be altered. Only states shown by a solid line can be changed. Refer to figure 3C-2 for examples of a TYPICAL input configuration.

3C.5.4 I/O Configuration (cont)

REMOTE EXP: 

1 = STANDBY STATE (cannot be changed)
2 = PREP STATE (shown low/inactive)
3 = GEN RDY STATE (cannot be changed)
4 = RAD EXP STATE (shown high/active)
5 = FLUORO EXP STATE (cannot be changed)

FILE: ML_IOSTE.COR

Figure 3C-2: Example of input states

NOTE:	***IT IS RECOMMENDED THAT THE I/O CONFIGURATION WORKSHEET BE FILLED IN FOR EACH INPUT OR OUTPUT THAT IS PROGRAMMED. A BLANK FORM THAT SHOULD BE PHOTOCOPIED IS LOCATED IN SECTION 3A.5.0. THIS WILL PROVIDE A RECORD OF THE I/O CONFIGURATION FOR FUTURE REFERENCE.***

Use these steps for programming the I/O functions

Step	Action
1.	From the **GEN CONFIGURATION** menu, select **I/O CONFIGURATION.**
2.	Select the desired receptor to be programmed.
3.	Select the desired input(s) or output(s) to program. Use the **>>**, **<<**, and **RETURN** buttons to navigate through the screens.
4.	Press the **STATE** button to cycle through and select the desired state to program.
5.	Select the function to be programmed (example **REMOTE EXP**). Press the selection button again to change the logic level for that state. States with dashed lines (...) *CANNOT BE CHANGED.*
6.	Repeat steps 4 and 5 for each state in the selected I/O function.
7.	Repeat steps 3 to 6 for each input or output to be programmed.
8.	When finished the I/O programming for the current receptor, press the **<<** or **EXIT** button(s) as required to return to the **GEN CONFIGURATION** menu.
9.	Reselect **I/O CONFIGURATION,** then select the next receptor to be programmed.
10.	When finished programming all receptors, return to the **GEN CONFIGURATION** menu as per step 8.

3C.5.5 AEC Setup

The **AEC SETUP** menu(s) allows the setting of AEC parameters for each AEC channel.

MENU 1 (All models)

```
                         * AEC SETUP*
CHANNEL:     1                          CHAMBER TYPE:  ION
LEFT FIELD:        YES                 FILM SCREEN  1 :  YES
CENTER FIELD:       YES                FILM SCREEN   2 :  YES
RIGHT FIELD:        YES                 FILM SCREEN  3 :  YES
         EXIT                              >>
```

MENU 2 (Some models only). Do not adjust these values at this time.

```
                         * AEC SETUP*
                                       C FIELD COMP:        0
                                        L FIELD COMP:       0
                                                            +
R FIELD COMP:         0                                     -
           <<
```

Definitions of **AEC SETUP** parameters as used in this section. *Some of the functions listed are optional.*

- **CHANNEL** — Selects the AEC channel to be programmed.
- **LEFT FIELD** — Enables or disables the left field for the selected AEC channel (**NO** is disabled).
- **CENTER FIELD** — As above but for center field.
- **RIGHT FIELD** — As above but for right field.
- **CHAMBER TYPE** — Selects **ION CHAMBER, S/S** (Solid State), or **APL** (Apelem) chamber for the selected AEC channel.
- **FILM SCREEN 1** — Enables or disables the selection of FILM SCREEN 1 for that AEC channel (**NO** is disabled).
- **FILM SCREEN 2** — As above, but for film screen 2.
- **FILM SCREEN 3** — As above, but for film screen 2.
- **R FIELD COMP** — Allows AEC field matching by setting the output compensation for the right AEC field.
- **C FIELD COMP** — As above, but for the center AEC field.
- **L FIELD COMP** — As above, but for the left AEC field.

3C.5.5 AEC Setup (Cont)

Use these steps to perform the **AEC SETUP**.

Step	Action
1.	From the **GEN CONFIGURATION** menu select **AEC SETUP**.
2.	Select the AEC channel to be setup. Pressing the **CHANNEL** button will scroll through the available AEC channels.
3.	Select the desired parameter to change for that AEC channel. DO NOT adjust the R, C, or L field compensation settings at this time (if available); these are part of the AEC calibration procedure.
4.	Press the selection button for that parameter to toggle the available selections.
5.	Repeat steps 2 to 4 to program each AEC channel.
6.	When finished the **AEC SETUP,** press **EXIT** to return to the **GEN CONFIGURATION** menu.

3C.5.6 AEC Calibration

For AEC calibration, refer to chapter 3D, AEC CALIBRATION.

3C.5.7 Fluoro Setup

For fluoro setup and calibration, refer to chapter 3E, ABS CALIBRATION.

3C.5.8 Tube Calibration

Refer to chapter 2, the section TUBE AUTO CALIBRATION.

3C.6.0 DAP SETUP

For setup and calibration of the optional DAP (Dose-Area Product) meter, refer to chapter 3F, DAP SETUP AND CALIBRATION.

3C.7.0 DATA LINK

This is used with the CPI GenWare™ utility software. This allows for data communication with a computer in order to download additional tube types, transfer APR data, run the A^2EC^2 ™ utility, and for other minor functions. Further documentation is included with the software package in the form of an MS Word document.

A computer (i.e. laptop) and a 9 pin null modem cable with socket connectors (female) on both ends are required to run this software and interface to the generator.

CHAPTER 3

SECTION 3D

AEC CALIBRATION

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3D.1.0 INTRODUCTION

This section covers interfacing and calibration of the various AEC board assemblies that are used in Millenia and Indico 100 generators (for ion chambers, solid state chambers or PMT pickups).

PLEASE NOTE THAT THE GENERATOR IS FACTORY CONFIGURED FOR SPECIFIC AEC DEVICE(S). REFER TO THE COMPATIBILITY STATEMENT / PRODUCT DESCRIPTION IN CHAPTER 1D FOR THE FACTORY CONFIGURED AEC COMPATIBILITY OF THIS GENERATOR.

The introduction in this section contains background information relevant to AEC operation. It is strongly suggested that this be read and understood prior to beginning AEC calibration.

AEC calibration requires that a calibration curve be established which relates optical density to various kV breakpoints.

The 75 kV knee breakpoint is calibrated at the slowest film screen combination. The remaining kV breakpoints are calibrated next, then the breakpoint calibration is repeated at the next highest film speed, with the highest film speed being calibrated last.

After breakpoint calibration, ± density setup is done at the slowest film speed, and then RLF compensation and multiple spot compensation are done if desired.

3D.1.1 A^{2}EC^2 ™ (Automated Automatic Exposure Control Calibration)

The optional A^{2}EC^2 ™ kit automates most of the AEC calibration functions, simplifying and reducing AEC calibration time by up to 80%. The kit consists of a photo detector which is placed inside the film cassette, a preamplifier, interface cabling and adapters, A^{2}EC^2 ™ software, and an A^{2}EC^2 ™ instruction manual all packaged in a convenient carrying case.

The A^{2}EC^2 ™ system must be used in conjunction with the CPI GenWare® utility software. Refer to the section DATA LINK at the end of chapter 3C for information on equipment required to run the GenWare® software.

Please contact the factory for further information.

3D.1.2 AEC Limitations: Minimum Response Time

The X-ray generator (including the AEC pickup chamber) has a minimum response time from start of the exposure command to a kV value sufficient to start X-rays. There is a further delay to the start of current flow from the AEC device. Likewise, there is a minimum response time from when the AEC stop command is issued to when the kV has actually decreased to the point that X-rays are no longer produced. Figure 3D-1 depicts this graphically.

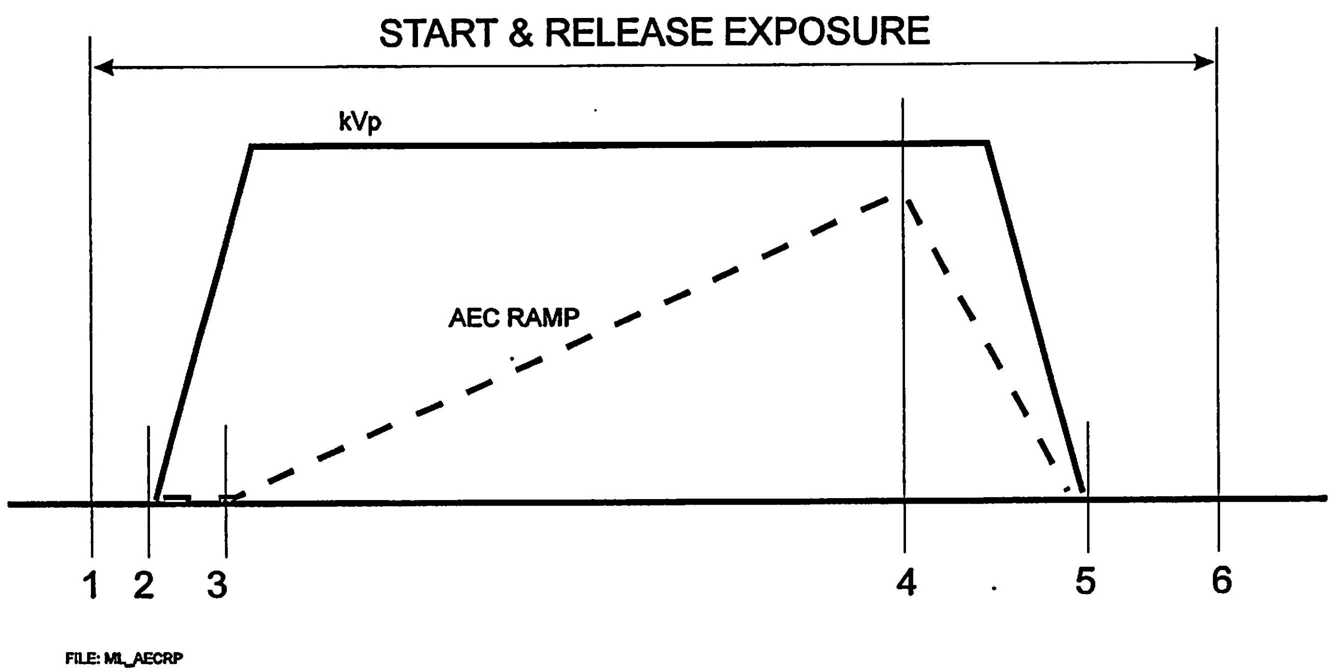


Figure 3D-1: Relative timing of AEC ramp vs exposure command and kVp

- 1 to 2 is the time from the exposure start command to kVp start.
  Time = 1 to 3 ms.
- 2 to 3 is the reaction time of the solid state / ion chamber to start a current flow.
  Time = 1 to 3 ms.
- 3 to 4 is the required exposure time.
- 4 is the AEC stop command from the generator AEC circuits.
- 4 to 5 is the generator shut down time including cable discharge time etc.
  Time = 1.5 to 3.0 ms.
- 1 to 6 is the total time the exposure switch is activated.
- **FOR AEC BOARDS WITH SHORT AEC TIME COMPENSATION (FIGURE 3D-9 AND 3D-11) AEC TECHNIQUES SHOULD HAVE MINIMUM EXPOSURE TIMES GREATER THAN 5 MS. FOR ALL OTHER AEC BOARDS MINIMUM EXPOSURE TIMES SHOULD BE GREATER THAN 15 MS.**

3D.1.3 AEC Limitations: Maximum Exposure Times

AEC exposures should normally be kept well under one second. When X-ray techniques are used that result in longer exposures, the film density will not be correct due to failure of reciprocity of the film.

RLF (reciprocity law failure) compensation is provided to compensate for longer AEC exposure times. An offset may be added to each AEC calibration set (each film screen combination) to increase the AEC ON time as exposure time increases. RLF compensation is applied to the following range of times:

- 50 ms to 500 ms.
- 500 ms to 1000 ms.
- 1000 ms and above.

Care must be exercised when using table buckys with low kV values because most tabletops and grids absorb considerable radiation in the range of 60 - 65 kVp. This will adversely affect AEC operation.

Figure 3D-2 shows the effect of kVp, optical density, and radiation. Note particularly the nonlinear change in density at 85-90 kVp.

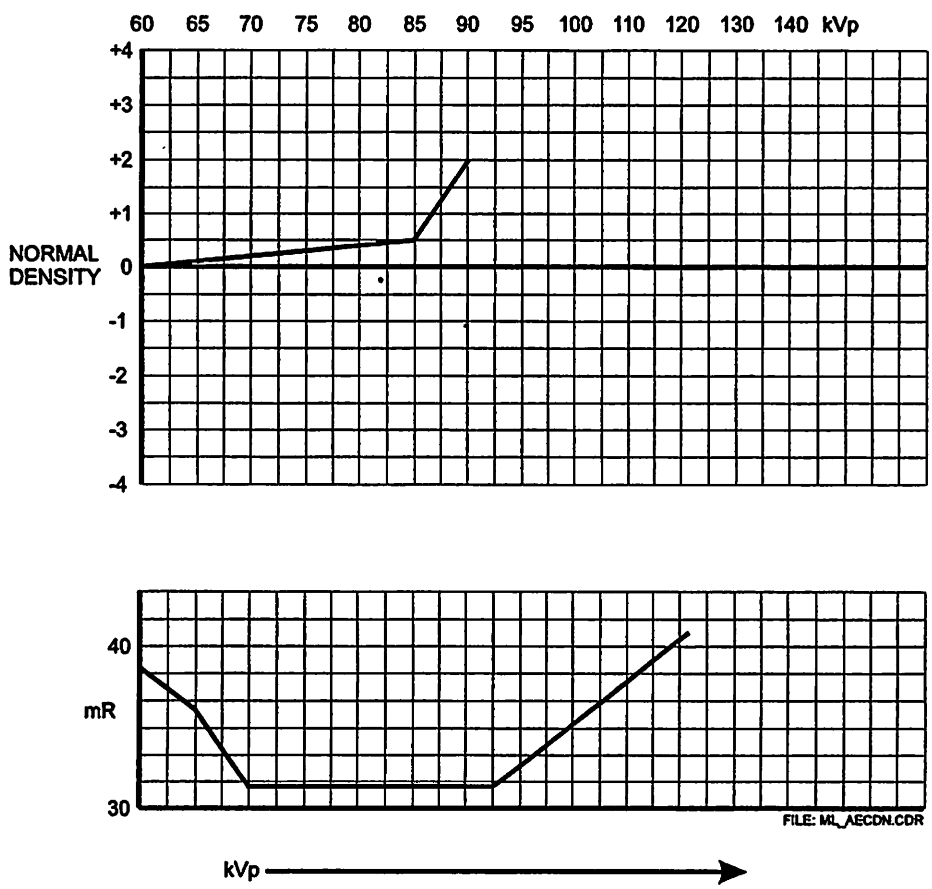


Figure 3D-2: kVp vs. optical density vs. dose

3D.1.4 Film/Screen Response vs. kVp

Film screen response to kVp is not linear; therefore compensation must be provided in order to maintain constant film density as kVp is changed for different anatomical studies. By selecting and calibrating various kV breakpoints, the overall system response will be compensated such as to yield a constant film density.

Up to eight breakpoints per film screen combination are available. The eight breakpoints are spread over three kV ranges as shown below:

- Low kV: 50, 55, 65 kV
- Knee kV: 75 kV
- High kV: 85, 95, 110, 130 kV.

Refer to figure 3D-3.

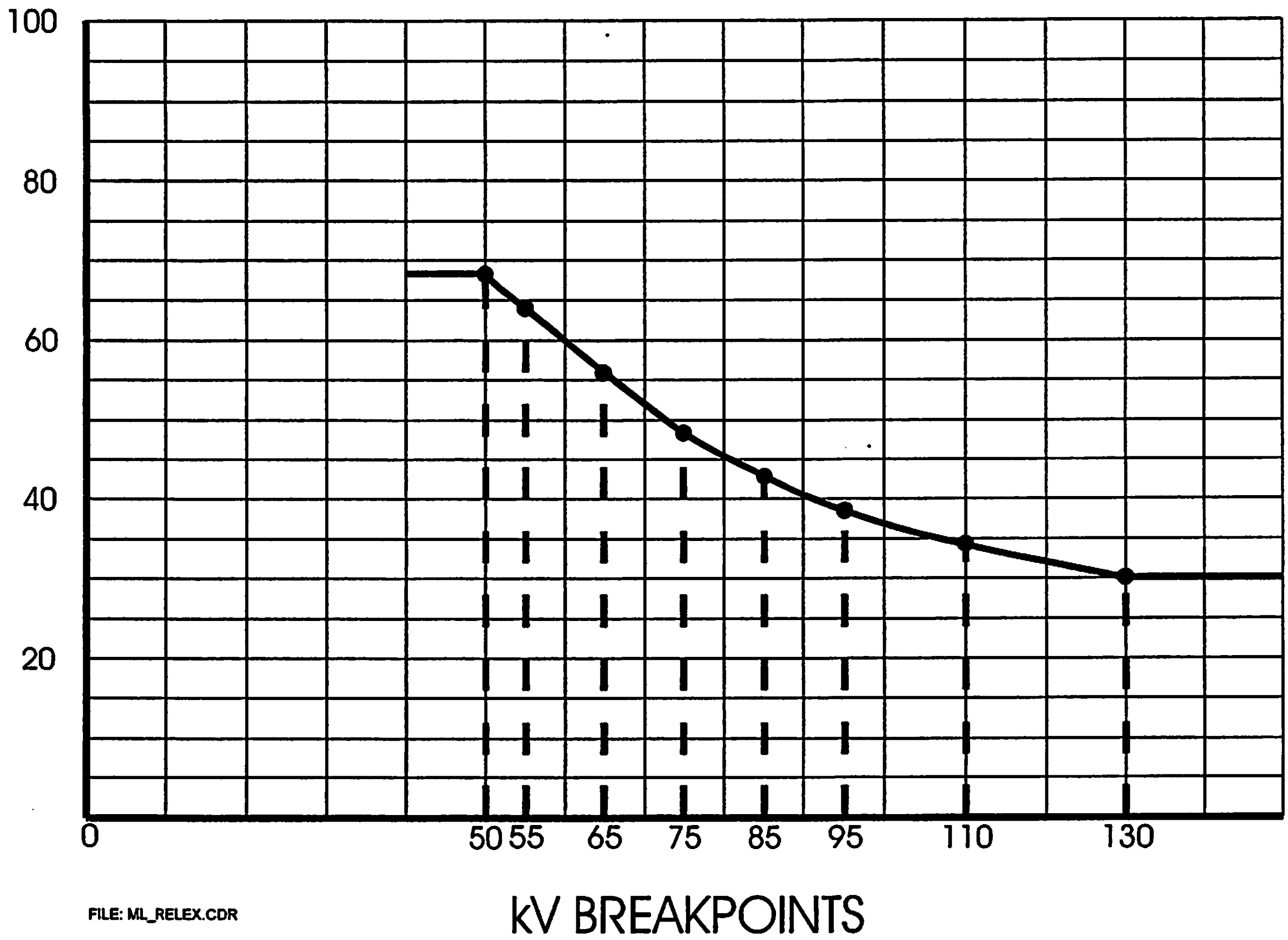
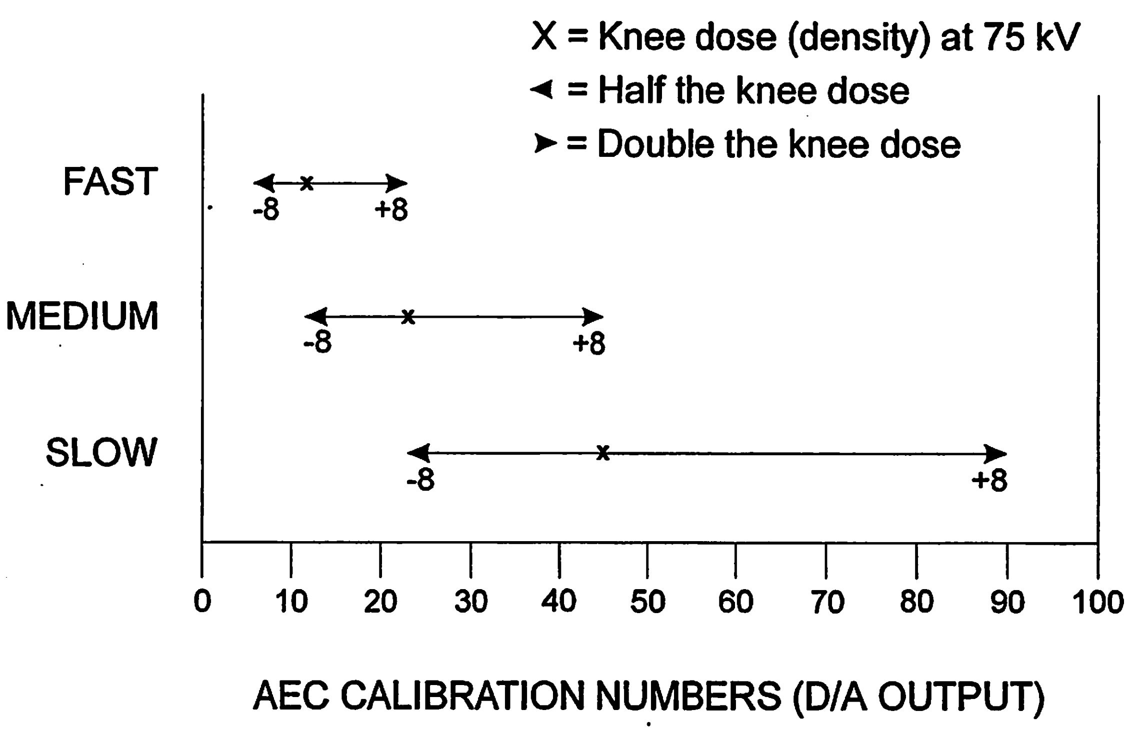


Figure 3D-3: kV breakpoints vs relative density

3D.1.5 AEC Calibration Range

Since the Millenia and Indico 100 family of generators allow for up to three separate film screen combinations to be calibrated, the following points must be considered:

- The AEC board allows for a 0 to a maximum of 10 volt ramp at the comparator input. All AEC signals must fit within this range (for all film / screens, densities, and techniques).
- Most X-ray applications require the use of two or more different film screen combinations, all of which will require different exposure doses.
- Using the slowest film screen combination, the required film input dose will be determined.
- Once this value is determined (during AEC calibration), the density calibration is performed to allow 100% (double the dose) and 50% (half the dose) values. These are typical values, and will determine the maximum required range of the AEC reference voltage (the output from the D/A converter).
- Figure 3D-4 illustrates the different windows required for various film screen combinations.



FILE: ML_AECDA.CDR

Figure 3D-4: Film/screen speed vs. D/A output

3D.1.6 Multiple Spot Compensation

Separate density compensation is provided when a SFD (Spot Film Device) is used for multiple film splits. This allows compensation when the SFD diaphragm is in the X-ray field.

An external output from the SFD must be provided when multiple spots are requested to enable this function.

3D.1.7 A Typical R&F Room

Figure 3D-5 shows source-image distances and image receptors as used in a typical R&F installation.

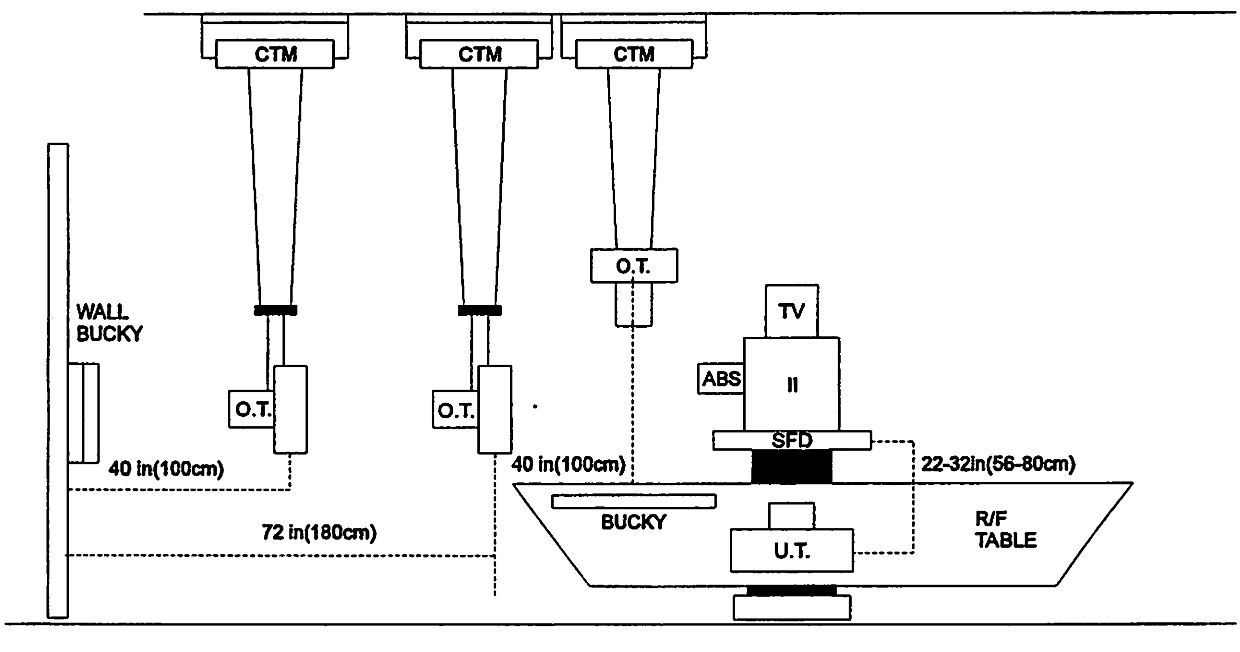


Figure 3D-5: Typical R&F installation

3D.2.0 PRECALIBRATION SETUP

3D.2.1 AEC Setup Worksheet

Before continuing, it is suggested that a copy of the table below be filled in with all required information. Refer to the example AEC setup worksheet on the next page.

FUNCTION		RECEPTOR 1	RECEPTOR 2	RECEPTOR 3	RECEPTOR 4
Film/Screen	1.				
	2.				
	3.				
Nominal optical density:					
Grid ratio/SID:					
Min - max kVp range:					
± Density steps					
Density dose change (per step)	+%:				
	-%:				
Chamber type:					
Regulatory AEC dose requirements?					
Is film processing maintained?					
Assigned receptor name:					
Are all cassettes similar?					
Additional notes:					
Additional notes:					

Table 3D-1: AEC setup worksheet

ALL RECEPTORS MUST HAVE THE SAME NUMBER OF DENSITY STEPS AND THE SAME DENSITY DOSE CHANGE PER STEP (DENSITY SETTINGS ARE COMMON TO ALL FILM SCREENS AND RECEPTORS).

3D.2.1 AEC Setup Worksheet (Cont)

***Note:** The example below is supplied for reference only. It does not represent an actual installation.*

FUNCTION		RECEPTOR 1	RECEPTOR 2	RECEPTOR 3	RECEPTOR 4
Film/Screen	1.	Lanex/reg	Lanex/reg	Lanex/reg	PMT/I.I.
	2.	Lanex/med	Lanex/chest		
	3.				
Nominal optical density:		1.2	1.1	1.4	
Grid ratio/SID:		12:1	8:1	10:1	10:1
Min - max kVp range:		60 - 120	65 - 140	80 - 110	70 - 120
± Density steps		± 8	± 8	± 8	± 8
Density dose change (per step)	+%:	12.5	12.5	12.5	12.5
	-%:	6.25	6.25	6.25	6.25
Chamber type:		Ion	Solid state	Ion	PMT
Regulatory AEC dose requirements?		Yes	Yes	Yes	Yes
Is film processing maintained?		Yes	Yes	Yes	Yes
Assigned receptor name:		Table	Wall	SFD	Digital
Are all cassettes similar?		Yes	Yes	Yes	N/A
Additional notes:					
Additional notes:					

Table 3D-2: Sample AEC setup worksheet

3D.2.2 AEC Precalibration Checks

It is recommended that a copy of the form below be filled in with the required information before attempting AEC calibration.

1.	Verify that the AEC chambers are mounted correctly in the Bucky or spot film device. Note that some chamber types must be physically isolated from equipment ground, refer to figure 3D-6 as an example.	CHECK:
2.	Verify that each AEC chamber / pickup is properly connected to its intended input channel on the AEC board. ***Refer to AEC board pictorials, figure 3D-8 to 3D-11 for input channel designations***	CHECK:
3.	Make and type of AEC chamber/pickup:	AEC Ch 1__________ AEC Ch 2__________ AEC Ch 3__________ AEC Ch 4__________
4.	Verify signal grounding for the AEC chamber. The only electrical ground should be at the AEC board in the generator. This applies to the ground braid (shield) for the AEC signal cable and to the ground return conductor(s) in the AEC signal cable.	CHECK:
5.	Verify that the AEC board is fully inserted into the mating edge connector (if applicable), that all connections to the AEC board are secure, and that the AEC board is securely fastened.	CHECK:
6.	Before calibrating, verify that the AEC system is functioning. This includes the AEC chambers / devices and the AEC circuits in the generator. Each of the fields on the AEC device must be able to terminate the exposure.	CHECK:
7.	Radiographic techniques to be performed with the equipment (high kV chest, G.I. studies etc)?	
8.	Normal exposure factors used by the customer (typical mAs / kV range)?	

Table 3D-3: Precalibration checklist

3D.2.3 AEC Chamber Installation

Figure 3D-6 shows an installed AEC chamber. Note particularly the use of a suitable insulating material to isolate the body of the chamber from the receptor ground. This is required for non-insulated AEC chambers.

3D.2.3 AEC Chamber Installation (Cont)

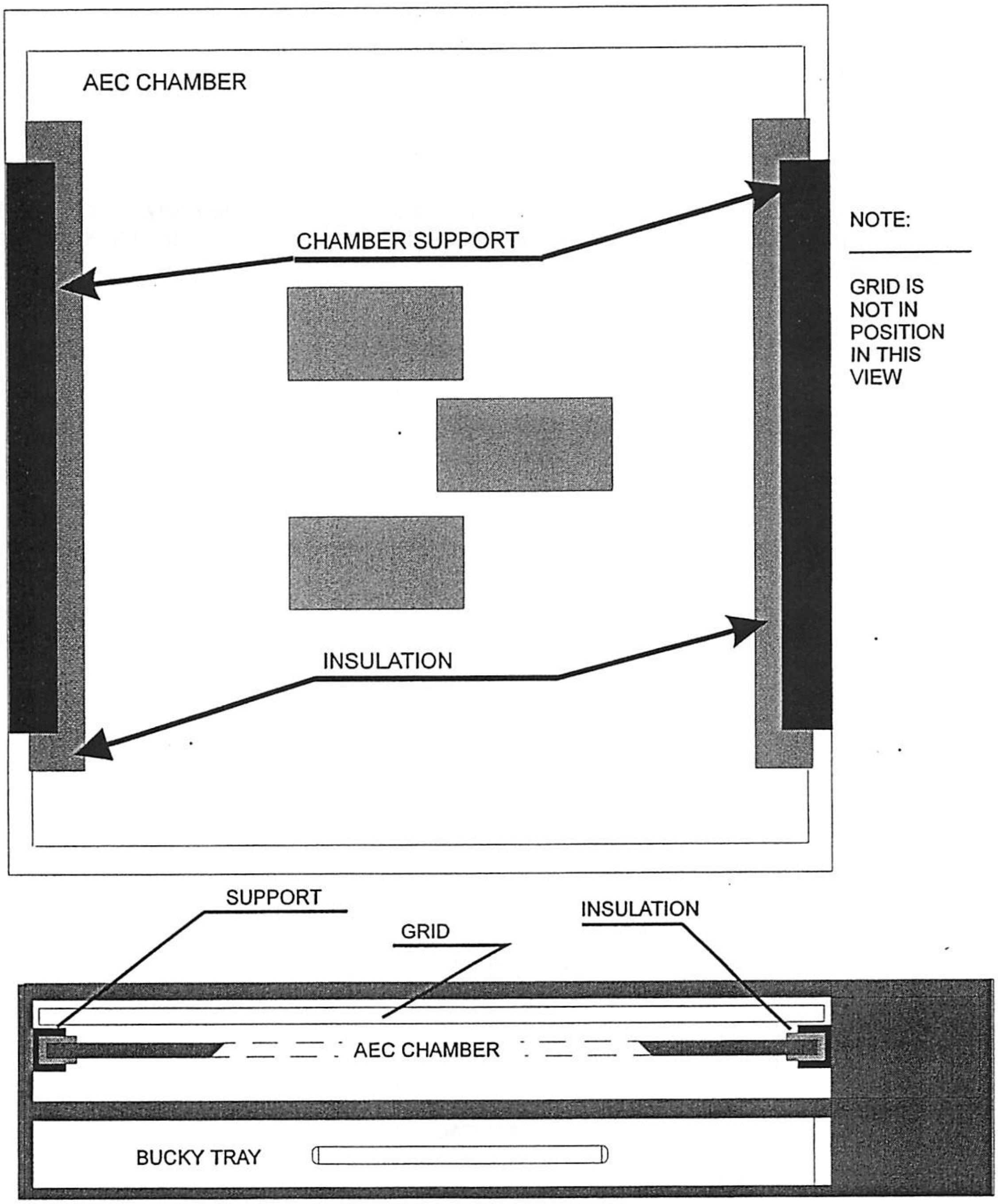


Figure 3D-6: AEC chamber installation

3D.2.4 AEC Pickup Connections (Overview)

Review the applicable sections of chapter 3 section B and C for interfacing AEC devices and programming the image receptors to select the correct AEC device (or no AEC if desired). It should be ensured that each receptor used for AEC has a Bucky or equivalent. A typical R&F room configuration will consist of the following:

- Table Bucky
- Wall Bucky
- Spot film Bucky
- Aux - digital acquisition

Refer to Figure 3D-7 for typical AEC connections. This is a simplified view only, refer to figures 3D-8 to 3D-11 for AEC board layouts used in Millenia and Indico 100 generators. Refer to chapter 1E for the AEC board location in your generator.

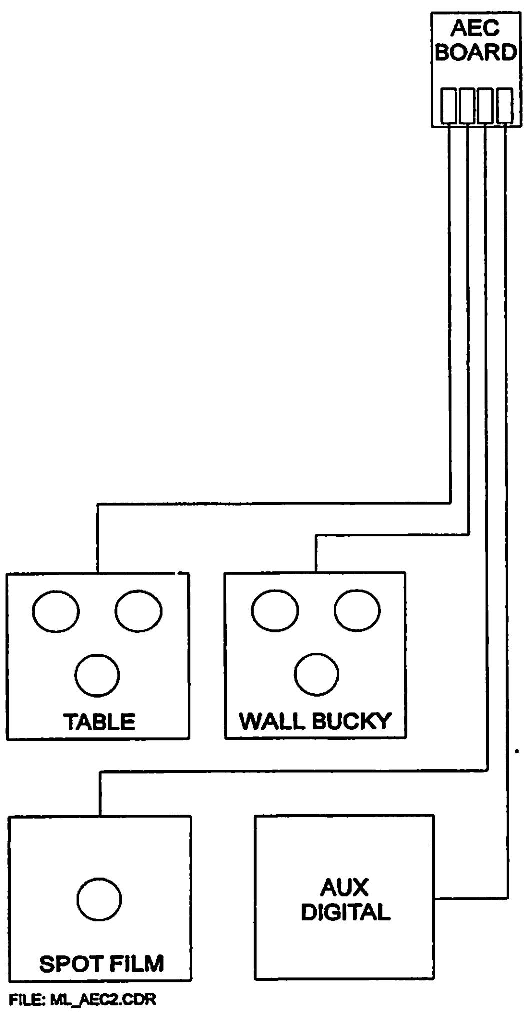


Figure 3D-7: AEC pickup connections

3D.2.5 AEC Board (Solid State Chambers)

The AEC board shown below is compatible with various makes / models of solid state chambers (i.e. Comet, Ziehm, Gilardoni). This AEC board is used in various models of generators requiring those AEC chamber types.

This board will be fitted with 6 pin circular connectors (J1 to J4) or with 5 pin in-line connectors (J11 to J14), depending on the application.

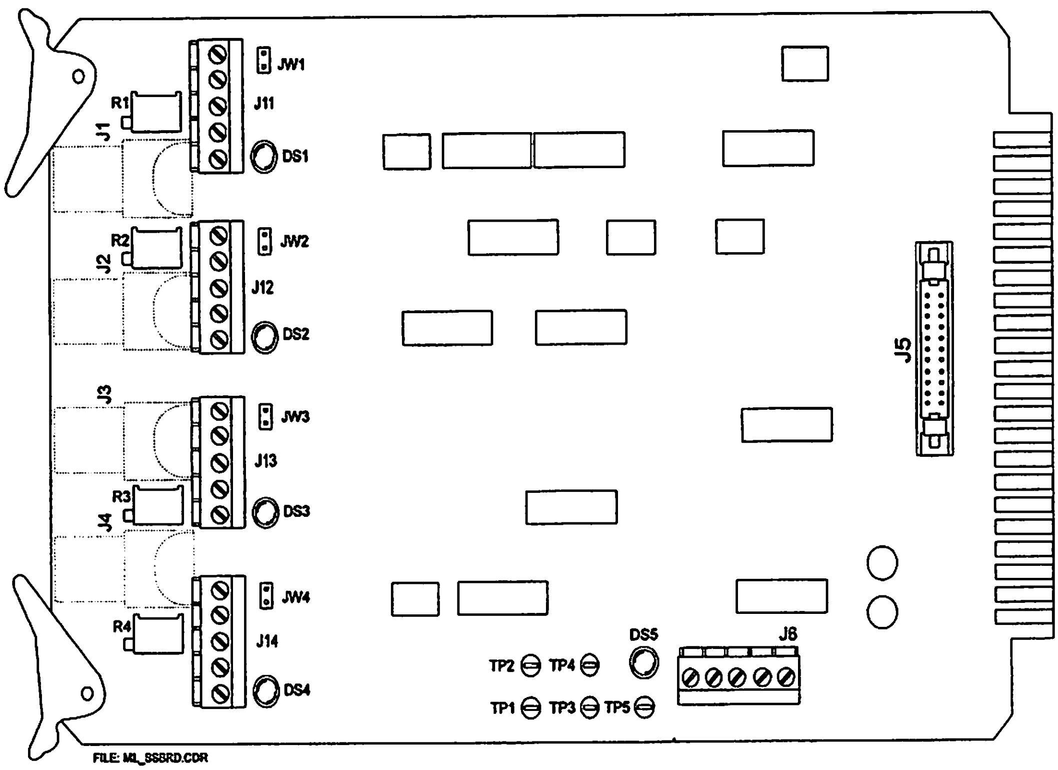


Figure 3D-8: Dedicated solid state AEC board

AEC board input assignment:

- Ch 1 = J1 / J11 - Table Radiographic Bucky.
- Ch 2 = J2 / J12 - Vertical Wall Bucky.
- Ch 3 = J3 / J13 - Spot Film Device
- Ch 4 = J4 / J14 - Aux. (Extra Bucky, Digital Acquisition, etc.)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R2 is used for channel 2 gain adjustment.
- R3 is used for channel 3 gain adjustment.
- R4 is used for channel 4 gain adjustment.

3D.2.5 AEC Board (Solid State Chambers) Cont

The following tables show the pin outs for both the 6 pin circular connectors and for the 5 pin in-line connectors on the AEC board in figure 3D-8.

FUNCTION	PIN	
Anode	1	NOTE: PINS 1, 2, AND 3 ON THE
Anode	2	CIRCULAR CONNECTOR ARE
Anode	3	ALL CONNECTED IN PARALLEL.
Cathode, left	4	
Cathode, right	5	
Cathode, middle	6	
Ground	Connector shell	

Table 3D-4: Pin outs for 6 pin circular connector

FUNCTION	PIN
Anode	2
Cathode, left	3
Cathode, right	5
Cathode, middle	4
Ground	1

Table 3D-5: Pin outs for 5 pin in-line connector

If the AEC input signal has excessive electrical noise superimposed on the signal, it is suggested that jumpers JW1 to JW4 as appropriate be temporarily installed. If this improves the signal to noise ratio, the jumper(s) should be left in. Excessive signal to noise ratio generally shows up as inconsistent AEC exposure times at low mAs values.

It is the responsibility of the installer to determine the need for these jumper(s).

3D.2.6 AEC Board (Ion Chambers)

The AEC board shown below is compatible with various makes / models of ion chambers (i.e. AID, GE, Vacutec, Philips Amplimat). This AEC board is used in various models of generators requiring those AEC chamber types and requiring short AEC time compensation.

This board will be fitted with 15 pin D connectors (J11 to J14), or with 12 pin in-line connectors (J1 to J4), depending on the application.

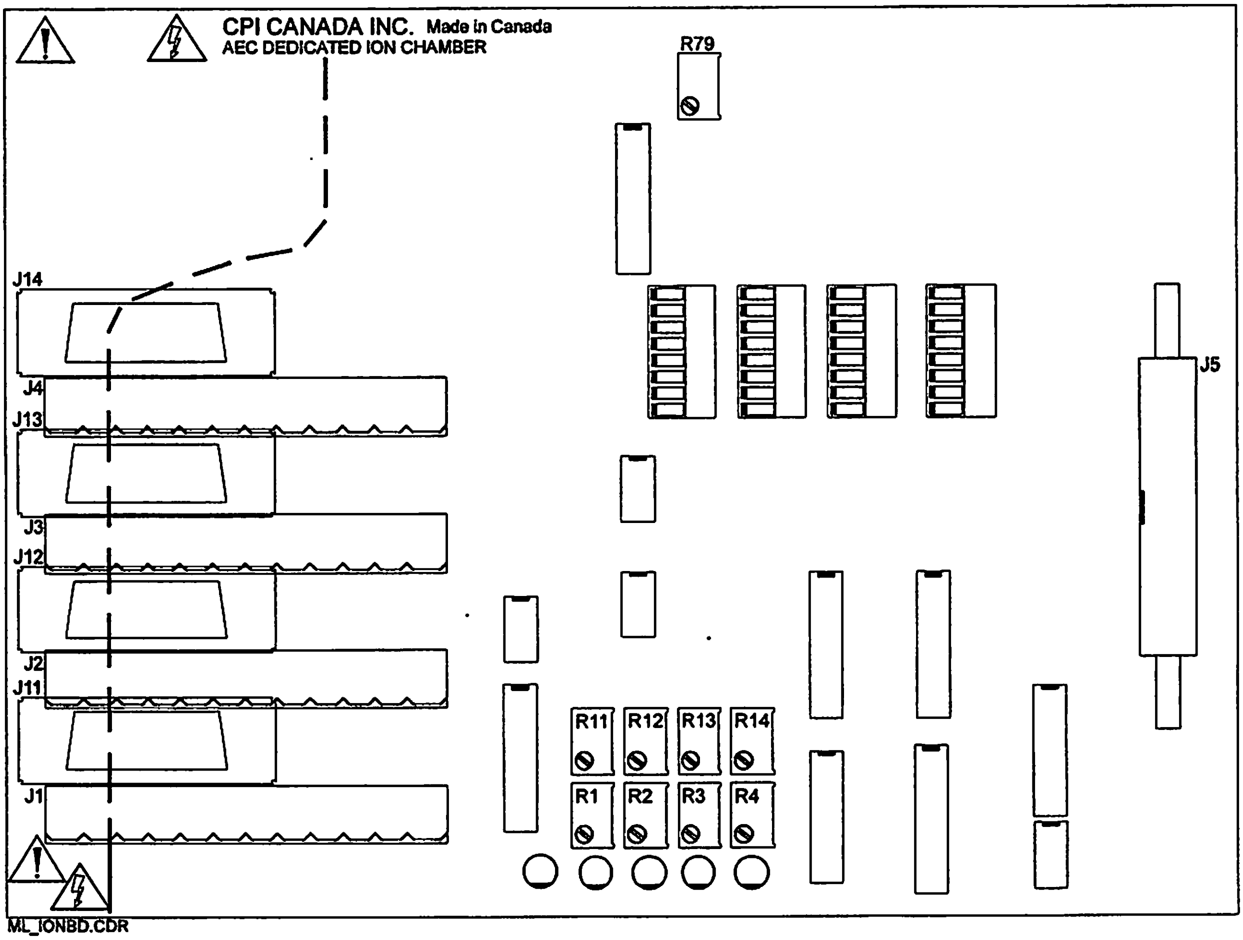


Figure 3D-9: Dedicated ion chamber AEC board

AEC board input assignment:

- Ch 1 = J1 / J11 - Table Radiographic Bucky.
- Ch 2 = J2 / J12 - Vertical Wall Bucky.
- Ch 3 = J3 / J13 - Spot Film Device
- Ch 4 = J4 / J14 - Aux. (Extra Bucky, Digital Acquisition, etc.)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R2 is used for channel 2 gain adjustment.
- R3 is used for channel 3 gain adjustment.
- R4 is used for channel 4 gain adjustment.

3D.2.6 AEC Board (Ion Chambers) Cont

The following potentiometers are used for short AEC exposure time compensation:

- R11 is used for channel 1 short exposure time compensation.
- R12 is used for channel 2 short exposure time compensation.
- R13 is used for channel 3 short exposure time compensation.
- R14 is used for channel 4 short exposure time compensation.

R79 adjusts the output of the high voltage bias supply. This is only fitted on versions of this board intended for use with ion chambers that require a separate high voltage bias supply. R79 adjusts the value of the +300 / +500 VDC, and the +45 VDC outputs, and should be set as per the ion chamber manufacturer specifications.

The following tables show the pin outs for both the 15 pin D connectors and for the 12 pin in-line connectors on the AEC board in figure 3D-9.

FUNCTION	PIN	NOTE
+300 *or* +500 VDC output	1	The +300 or +500 VDC, and +45 VDC outputs are provided on configurations of this board that are designed to interface to ion chambers requiring these voltage outputs only. Pin 1 will be wired to supply +300 VDC *OR* +500 VDC, as per the AEC chamber requirements.
Not used	2	
Right field select	3	
Start command output	4	
+45 VDC output	5	
-24 VDC output	6	
Signal input	7	
Ground	8	
Not used	9	
Not used	10	
Left field select	11	
Middle field select	12	
Ground	13	
+12 VDC output	14	
-12 VDC output	15	

Table 3D-6: Pin outs for 15 pin D connector

FUNCTION	PIN	NOTE
+500 VDC output	1	The +500, +300, and +45 VDC outputs are only provided on configurations of this board designed to interface to ion chambers requiring these voltage outputs. +12, -12, -24 VDC outputs are typically used as the DC supply for a pre-amplifier, often part of the ion chamber.
+300 VDC output	2	
+45 VDC output	3	
+12 VDC output	4	
-12 VDC output	5	
-24 VDC output	6	
Ground	7	
Start command output	8	
Left field select	9	
Middle field select	10	
Right field select	11	
Signal input	12	

Table 3D-7: Pin outs for 12 pin in-line connector

3D.2.7 AEC Board (Universal AEC Board)

The AEC board shown below is factory configured to be compatible with most makes / models of AEC chambers (ion and solid state) on the market. This assembly also contains a low current, high voltage supply for a photo multiplier tube (PMT). The PMT supply is located on the upper board, which also contains the connectors to interface to the AEC pickup device(s).

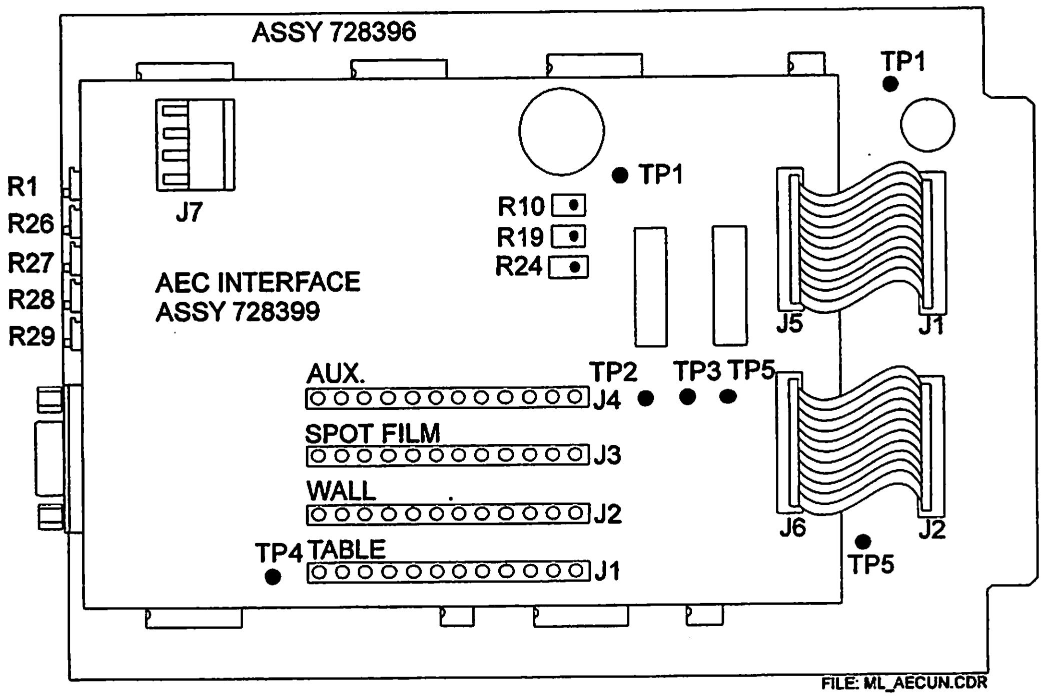


Figure 3D-10: Universal AEC board

AEC board input / output assignment:

- Ch 1 = J1 - Table Radiographic Bucky.
- Ch 2 = J2 - Vertical Wall Bucky.
- Ch 3 = J3 - Spot Film Device.
- Ch 4 = J4 - Aux. (Extra Bucky, Digital Acquisition, etc.).
- J7 = High voltage output for the PMT (if used)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R26 is used for channel 2 gain adjustment.
- R27 is used for channel 3 gain adjustment.
- R28 is used for channel 4 gain adjustment.

Refer to the end of subsection 3D.2.7 for the procedure for adjusting R10, R19, and R24.

3D.2.7 AEC Board (Universal AEC Board) Cont

The following table shows the pin outs for the 12 pin connectors J1 to J4 on the AEC board in figure 3D-10 and 3D-11. The pins on J7 are all connected in parallel, thus the PMT high voltage may be taken from any of the pins on that connector.

The connections to the AEC pickup chamber vary considerably between ion chambers and solid state chambers. For clarity two tables are shown below, the first for ion chambers and the second for solid state chambers.

<table>
<tr><th>FUNCTION</th><th>PIN</th><th>NOTE</th></tr>
<tr><td>+500 VDC output</td><td>1</td><td rowspan="12">+500, +300, +50 VDC outputs are provided for ion chamber use if required. +12, -12, -24 VDC outputs are typically used as the DC supply for a pre-amplifier, often part of the ion chamber.

The start command, and left, middle, right field select outputs are jumper configured to be active high or active low as per the AEC chamber requirements. The signal input is jumper configured to accept a positive going or negative going ramp or DC signal as per the AEC chamber output.</td></tr>
<tr><td>+300 VDC output</td><td>2</td></tr>
<tr><td>+50 VDC output</td><td>3</td></tr>
<tr><td>+12 VDC output</td><td>4</td></tr>
<tr><td>-12 VDC output</td><td>5</td></tr>
<tr><td>-24 VDC output</td><td>6</td></tr>
<tr><td>Ground</td><td>7</td></tr>
<tr><td>Start command output</td><td>8</td></tr>
<tr><td>Left field select</td><td>9</td></tr>
<tr><td>Middle field select</td><td>10</td></tr>
<tr><td>Right field select</td><td>11</td></tr>
<tr><td>Signal input</td><td>12</td></tr>
</table>

Table 3D-8: Ion chamber connections

<table>
<tr><th>FUNCTION</th><th>PIN</th><th>NOTE</th></tr>
<tr><td>+500 VDC output</td><td>1</td><td>Not used for solid state AEC chambers</td></tr>
<tr><td>+300 VDC output</td><td>2</td><td>Not used for solid state AEC chambers</td></tr>
<tr><td>+50 VDC output</td><td>3</td><td>Not used for solid state AEC chambers</td></tr>
<tr><td>+12 VDC output</td><td>4</td><td>Not used for solid state AEC chambers</td></tr>
<tr><td>-12 VDC output</td><td>5</td><td>Not used for solid state AEC chambers</td></tr>
<tr><td>-24 VDC output</td><td>6</td><td>Not used for solid state AEC chambers</td></tr>
<tr><td>Ground</td><td>7</td><td rowspan="5">Connect pin 8 to pin 7 (ground). Connect the common anodes for left, middle, right to pin 8. Connect cathode (left) to LEFT, cathode middle to MIDDLE, and cathode right to RIGHT. Cable shield (if used) connects to pin 8.</td></tr>
<tr><td>Start</td><td>8</td></tr>
<tr><td>Left</td><td>9</td></tr>
<tr><td>Middle</td><td>10</td></tr>
<tr><td>Right</td><td>11</td></tr>
<tr><td>Signal input</td><td>12</td><td>Not used for solid state AEC chambers</td></tr>
</table>

Table 3D-9: Solid state chamber connections

3D.2.7 AEC Board (Universal AEC Board) Cont

R10, R19 and R24 adjust the output voltage from the high voltage power supply on the AEC interface board (the upper board on the universal AEC board assembly in figure 3D-10 and 3D-11). This high voltage supply generates the PMT high voltage, up to approximately -1000 VDC available at J7, and also the nominal +500, +300 and +50 VDC supplies noted in table 3D-8. The +500, +300 and +50 VDC supplies are available to bias ion chambers if needed and are adjustable as defined below.

These potentiometers are switched into the circuit electronically by logic circuits connected to the AEC channel select commands. Only one potentiometer will be active at any given time, the condition under which each potentiometer is active is described below, along with the function of that potentiometer.

- R10 adjusts the high voltage supply output for the PMT when ABS operation is selected. This is described in chapter 3E.
- R24 adjusts the high voltage supply output when AEC channel 1, 2, or 3 is selected. AEC channels 1, 2, 3 are normally used with an AEC chamber.
  R24 will be used to adjust the +500, +300 and +50 VDC bias voltage outputs if required for ion chamber(s) connected to AEC channels 1, 2 or 3. Refer to the AEC chamber manufacturers recommendations to adjust this voltage.
- R19 adjusts the high voltage supply output when AEC channel 4 is selected. AEC channel 4 is normally used for digital acquisition or spot film work using a PMT pickup for AEC control. This will typically be the same PMT used for ABS control during fluoroscopy operation.
  Refer to 3D.4.0 for further details if using a PMT for AEC control on AEC channel 4.

3D.2.8 AEC Board (Universal AEC Board With Short AEC Time Compensation)

The AEC board shown below has short AEC time compensation, and is factory configured to be compatible with most makes / models of AEC chambers (ion and solid state) on the market. This assembly also contains a low current, high voltage supply for a photo multiplier tube (PMT). The PMT supply is located on the upper board, which also contains the connectors to interface to the AEC pickup device(s).

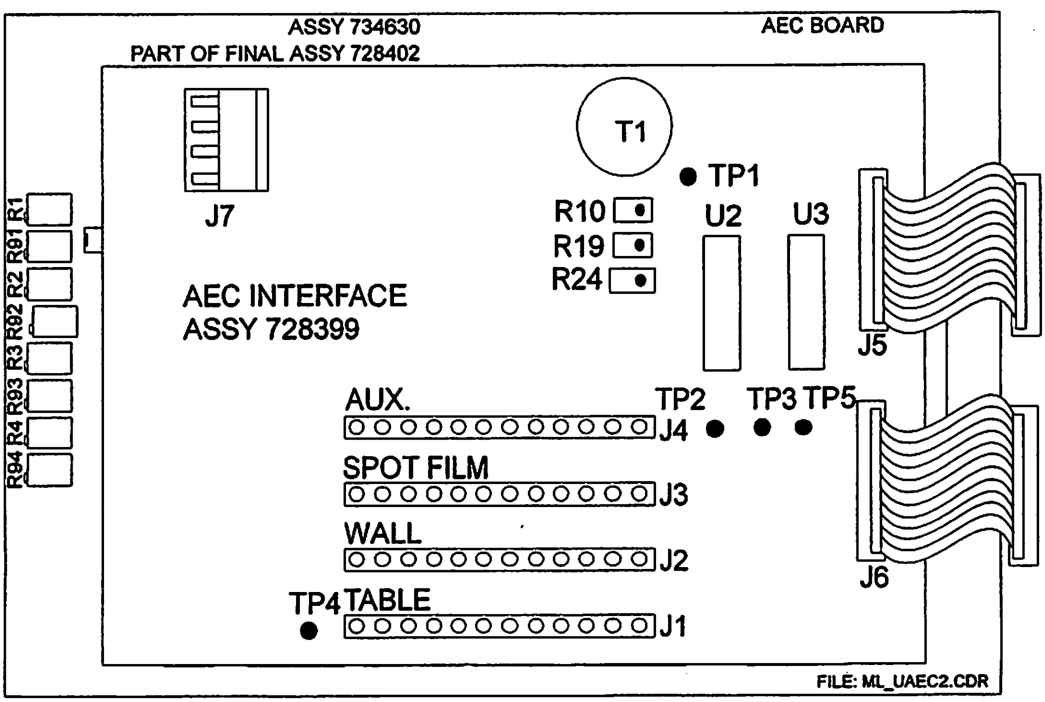


Figure 3D-11: Universal AEC board with short AEC time compensation

3D.2.8 AEC Board (Universal AEC Board With Short AEC Time Compensation) Cont

In order to clearly show the adjustment pots on the lower (AEC) board, the upper board which contains the AEC and PMT interface connectors and the high voltage supply is shown shifted from its actual position.

AEC board input / output assignment:

- Ch 1 = J1 - Table Radiographic Bucky.
- Ch 2 = J2 - Vertical Wall Bucky.
- Ch 3 = J3 - Spot Film Device.
- Ch 4 = J4 - Aux. (Extra Bucky, Digital Acquisition, etc.).
- J7 = High voltage output for the PMT (if used)

The following potentiometers are used for AEC gain adjustment:

- R1 is used for channel 1 gain adjustment.
- R2 is used for channel 2 gain adjustment.
- R3 is used for channel 3 gain adjustment.
- R4 is used for channel 4 gain adjustment.

The following potentiometers are used for short AEC exposure time compensation:

- R91 is used for channel 1 short exposure time compensation.
- R92 is used for channel 2 short exposure time compensation.
- R93 is used for channel 3 short exposure time compensation.
- R94 is used for channel 4 short exposure time compensation.

Refer to tables 3D-8 and 3D-9 for the connector pin outs. Refer to the end of subsection 3D.2.7 for the procedure for adjusting R10, R19, and R24.

3D.3.0 PRECALIBRATION NOTES:

This section contains information that must be understood and confirmed prior to and / or during AEC calibration.

CAUTION: ***THE PROCEDURES IN THESE SECTIONS REQUIRE X-RAY EXPOSURES. TAKE ALL SAFETY PRECAUTIONS TO PROTECT PERSONNEL FROM X-RADIATION.***

SHOULD AN IMPROPER TECHNIQUE BE SELECTED, OR AN AEC FAULT OCCUR CAUSING NO AEC FEEDBACK SIGNAL TO THE GENERATOR, THE EXPOSURE WILL TERMINATE IF THE RAMP VOLTAGE FAILS TO REACH 4% OF THE EXPECTED RAMP VOLTAGE WHEN THE EXPOSURE TIME REACHES 20% OF THE SELECTED BACK UP TIME.

- When using PMTs or photo diodes for AEC from the output of an image intensifier, there is normally no need to iterate all the kV break points. It is usually sufficient to use the 75 kV breakpoint calibration value for that film screen at all kV breakpoints. If doing this, the calibration values should be confirmed using the acquired digital images at all kV breakpoints.
- During AEC calibration, all AEC exposures should be done using mA values such that the exposures are in the 30 to 100 ms range UNLESS STATED OTHERWISE.
- During AEC calibration, always ensure that the central ray is centered relative to the image receptor.
- Prior to placing the absorbers, ensure that the collimator is opened sufficiently to irradiate ALL fields on the AEC pickup device.
- The recommended absorber in table 3D-12 is water. This should be in a plastic container of uniform thickness. Lexan of a similar thickness is also a suitable absorber.
- Ensure that the absorber is positioned to fully cover the X-ray field. The absorber must extend a minimum of 3/8 in. (10 mm) beyond the X-ray field.
- All components and assemblies used during AEC calibration must be those that will be used during procedures, and must be positioned as they will be in actual use of the X-ray room.
- The generator must be known to be calibrated before proceeding.
- During AEC calibration, if exposure times do not change if the mA is varied, it may be that the input signal level to the AEC board may be too high. If this is experienced, check the ramp voltage at the output of the first gain stage (the first operational amplifier output) on the AEC board for the subject AEC channel. This voltage must never exceed 10 V. If this voltage **does** exceed 10 V, reduce the input signal level as required.

3D.4.0 AEC USING A PMT

This section applies if a PMT is to be used for AEC control on AEC channel 4. It is suggested that the AEC calibration on AEC channels 1, 2, and 3 as applicable be done first (sections 3D.6.0 to 3D.12.0) before calibrating AEC channel 4.

WARNING: ***SWITCH OFF THE GENERATOR BEFORE CONNECTING A PMT, AND USE APPROPRIATE HIGH VOLTAGE PRECAUTIONS WHEN MEASURING THE PMT HIGH VOLTAGE.***

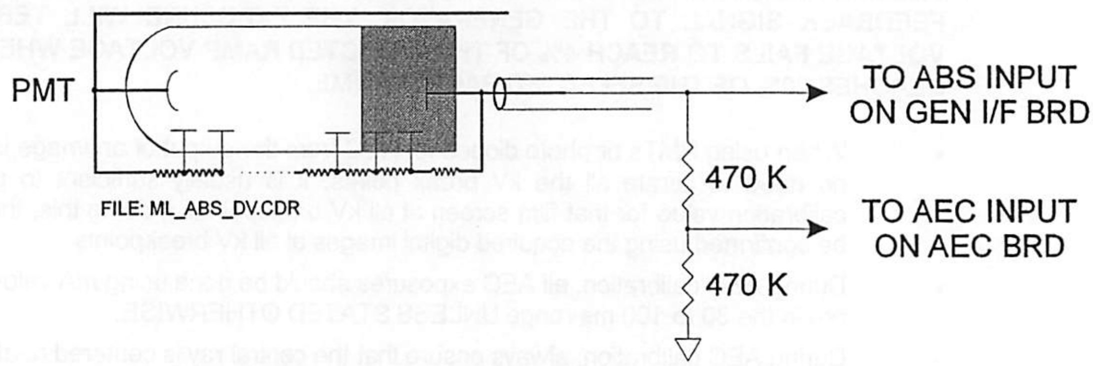


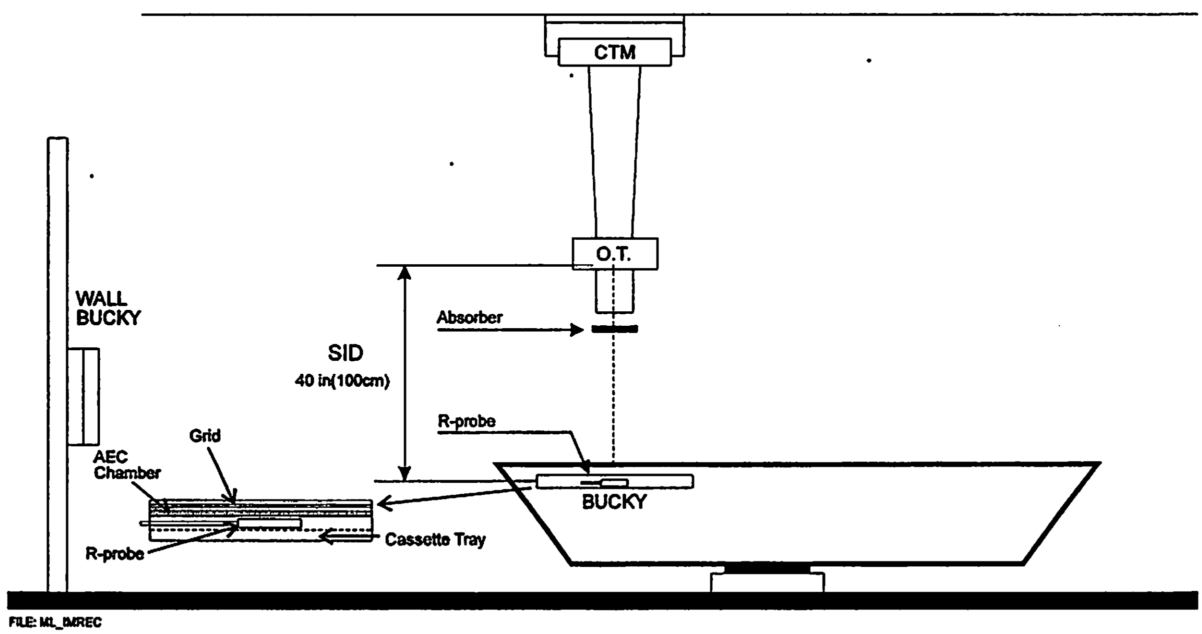
Figure 3D-12: Connections for PMT AEC

Step	Action
1.	Route the output signal from the PMT to AEC input channel 4 as per figure 3D-12. The resistor divider network will need to be provided by the installer. Appropriate high voltage shielded cable should be used for the PMT signal connections.
2.	Set the PMT voltage to approximately -650 VDC for AEC operation using R19 on the AEC interface board. Note that AEC channel 4 must be selected in order for R19 to be made active. ***USE ONLY TP5 ON THE AEC INTERFACE BOARD (FIGURE 3D-10, 3D-11) FOR THE HV METER GROUND WHEN MEASURING PMT HIGH VOLTAGE. CONNECT THE GROUND LEAD FIRST BEFORE MEASURING THE HIGH VOLTAGE.*** **DO NOT ATTEMPT TO MEASURE THIS WITHOUT A SUITABLE METER.**
3.	Configure AEC channel 4 as per 3D.6.0 steps 6 to 14, but use the following settings in the **AEC SETUP** menu: Select **ION** chamber, and enable **FILM SCREEN 1** only, and **CENTER FIELD** only. If **AEC SETUP** menu screen 2 is available, set **C FIELD COMP** to 0 (this is model dependent, refer to **AEC SETUP** in chapter 3C).
4.	Enter the calibration value **45** into EACH of the kV breakpoints. The procedure for setting the 75 kV knee breakpoint is detailed in 3D.6.0, step 16. The remaining breakpoints are set in a similar manner (refer to the balance of 3D.6.0 for details on accessing those breakpoint settings).
5.	Adjust the channel 4 gain adjustment potentiometer on the AEC board to achieve the desired I.I. input dose at the 75 kV knee breakpoint, using absorber thickness per table 3D-12.
6.	The PMT voltage that was set in step 2 may need to be adjusted up or down if the gain adjustment potentiometer does not provide the desired adjustment range in step 5.
7.	Repeat the exposures at other kV breakpoints that cover the desired kV operating range, checking the I.I. input dose at each kV breakpoint. Use absorber thickness per table 3D-12.
8.	Readjust the breakpoint calibration values in step 7, if necessary, to achieve the desired I.I. input dose at those kV values. DO NOT READJUST THE AEC GAIN POT OR PMT VOLTAGE.

3D.5.0 AEC FIELD BALANCE

If your generator does *NOT* have **AEC SETUP** menu 2 (see the section AEC SETUP in chapter 3C), follow the AEC chamber manufacturers recommendations for AEC field balancing. If your generator has **AEC SETUP** menu 2, follow the AEC chamber manufacturers recommendations for AEC field balancing if available. If the AEC chamber has no provision for AEC field balancing, follow the steps below.	
PERFORM THE FOLLOWING STEPS IMMEDIATELY BEFORE DOING AEC CALIBRATION AT THE 75 kV KNEE BREAKPOINT IN THE FOLLOWING SECTIONS:	
1.	Enter **AEC SETUP** menu 2, and ensure that each of the field compensation values is set to **0**.
2.	When set up to do dose measurements at the 75 kV knee breakpoint, evaluate the AEC field balance by measuring the dose at the film plane during an AEC exposure as each of the three AEC fields is individually selected.
3.	If the AEC chamber field balance is not acceptable, go to **AEC SETUP** menu 2 and adjust the right or left compensation values up or down as required. Do not adjust the middle field (**C**) compensation value.
4.	Repeat steps 2 and 3. The right and left AEC field compensations are adjusted to match the middle field. This process may need to be repeated several times until the three AEC fields are suitably balanced.

3D.6.0 AEC CALIBRATION (TABLE BUCKY)



TYPICAL TABLE BUCKY IMAGE RECEPTOR

Figure 3D-13: Equipment setup for table Bucky AEC calibration

3D.6.0 AEC CALIBRATION (TABLE BUCKY) Cont

Step	Action
	SETUP FOR AEC CALIBRATION
IF THE AEC BOARD BEING CALIBRATED HAS SHORT AEC TIME COMPENSATION (FIGURE 3D-9 OR 3D-11), THE SHORT EXPOSURE TIME COMPENSATION MUST FIRST BE DISABLED. **TO DO THIS, ADJUST ALL SHORT AEC EXPOSURE TIME COMPENSATION POTENTIOMETERS TO ZERO, I.E. SUCH THAT THE WIPERS ON EACH POT ARE GROUNDED. VERIFY THE CORRECT SETTINGS BY USING AN OHMMETER ON LOW OHMS RANGE AND ENSURING A NEAR ZERO OHMS READING FROM THE WIPER OF EACH SHORT AEC TIME COMPENSATION POT TO GROUND. REFER TO TABLE 3D-14 FOR THE SHORT AEC TIME COMPENSATION POTENTIOMETER DESIGNATIONS.** **FAILURE TO PRESET THESE POTS WILL RESULT IN DIFFICULTY IN PERFORMING AEC CALIBRATION.**	
1.	Set up the X-ray tube stand as shown in figure 3D-13.
2.	Align the tube stand and table Bucky such that the central ray is centered relative to the image receptor.
3.	Open up the collimator to expose all three fields of the AEC pickup. Ensure that the central ray remains centered relative to the image receptor.
4.	Place the R probe at the film plane, i.e. behind the grid. If this cannot be done, then place the probe on the table top. Ensure that the R-probe is located as close as possible to the central ray, but not blocking any pickup areas on the AEC device. The R meter must be set to measure in the micro-R range.
5.	Place the absorber (with thickness selected for 75 kV per table 3D-12) in the X-ray field, ensuring that the radiation is COMPLETELY blocked by the absorber.
6.	Place the generator into the programming mode. Refer to section 3C.1.1.
7.	From the **GENERATOR SETUP** menu select **GEN CONFIGURATION.**
8.	From the **GEN CONFIGURATION** menu select **AEC SETUP.**
9.	Set up the AEC parameters in the **AEC SETUP** menu *FOR EACH ACTIVE AEC CHANNEL*. Refer to **AEC SETUP** in chapter 3C.
10.	Set up the image receptors in the **RECEPTOR SETUP** menu such that each receptor has the desired AEC channel assigned to it. Refer to **RECEPTOR SETUP** in chapter 3C.
11.	In the **RECEPTOR SETUP** menu, set **MEMORY** to **NO** for each image receptor. This will ensure that the next receptor being calibrated will not remember the techniques from the previous receptor. The **MEMORY** function may be reset as desired after AEC calibration is completed.
12.	In the **RECEPTOR SETUP** menu, ensure that the **AEC BACKUP MAS** and **AEC BACKUP MS** are set sufficiently high that the generator backup timer will not terminate the exposure.
13.	From the **GEN CONFIGURATION** menu select **AEC CALIBRATION.**
14.	From the **AEC CALIBRATION** menu select **FILM SCREEN 1** (the slowest film screen combination).

CAUTION: ***DURING THE FOLLOWING CALIBRATION PROCEDURE, BE SURE THAT THE SELECTED TECHNIQUES WILL NOT OVERLOAD THE X-RAY TUBE. USE CAUTION WHEN REPEATING EXPOSURES AS THIS MAY QUICKLY OVERLOAD THE X-RAY TUBE. MOST X-RAY TUBE MANUFACTURERS RECOMMEND NO MORE THAN TWO HIGH SPEED STARTS PER MINUTE.***

NOTE: ***BE SURE TO USE THE SAME CASSETTE FOR EACH EXPOSURE AT THAT FILM SPEED.***

3D.6.0 AEC CALIBRATION (TABLE BUCKY) Cont

NOTE:	*FOR THE INDICO 100 RAD-ONLY CONSOLE, LCD SCREEN DETAILS NOT RELEVANT TO AEC CALIBRATION WILL DIFFER SLIGHTLY FROM THE EXAMPLES IN THIS SECTION. HOWEVER, THE AEC CALIBRATION MENUS WILL APPEAR AS SHOWN IN THIS SECTION.*

The following screens are used for AEC calibration

```
                    * AEC CALIBRATION *
FILM SCREEN 1                                   DENSITY SETUP
FILM SCREEN 2
FILM SCREEN 3

     EXIT
```

```
*TUBE?     0%HU         AEC CAL, F/S 1*
50KV: 84.0:                                       85KV: 42.8
55KV: 78.0:                                       95KV: 38.0
65KV: 66.0:                                                +
75KV: 54.0                                                 -
3200MS   <<                                    >>
```

```
*TUBE?     0%HU         AEC CAL, F/S 1*
110KV: 34.0:
130KV: 28.0:
RLF COMPENSATION                                           +
MULT. SPOT COMP:        0%                                 -
3200MS   <<
```

Step	Action
	75 KV KNEE BREAKPOINT CALIBRATION:
15.	Select the table Bucky image receptor.
16.	Select the **75 kV** knee breakpoint and enter the value **45** using the **+** or **-** buttons adjacent to the LCD display.
17.	Select the appropriate mA for the first film speed being calibrated per table 3D-12, *remembering that the slowest film screen used in that installation must be calibrated first* (example 320 mA for 100 speed film). Select large focus, center field.
18.	Make an exposure and note the dose and mAs.
19.	Referring to table 3D-11, select the estimated dose required for the film speed being calibrated i.e. 1025 ± 25 μR (see note on next page regarding conversion of μR to μGy if desired) at the 75 kV knee breakpoint for 100 speed film. **Note that the dose values in the table are based on the R-probe being located at the film plane. If the probe was placed in front of the grid the dose values shown in the tables must be increased accordingly. The dose in front of the grid will typically be approximately double the dose at the film plane.**
20.	Adjust the required gain potentiometer on the AEC board (see note below) while taking exposures until the dose noted in the previous step is obtained. • **CHANNEL 1 ON THE AEC BOARD IS TYPICALLY USED FOR THE TABLE BUCKY AEC CHAMBER. YOUR INSTALLATION <u>MAY</u> USE A DIFFERENT CHANNEL ON THE AEC BOARD.** • **REFER TO TABLE 3D-10 FOR THE AEC BOARD GAIN POTENTIOMETER (GAIN POT) DESIGNATIONS FOR THE VARIOUS AEC BOARDS.**

3D.6.0 AEC CALIBRATION (TABLE BUCKY) Cont

AEC BOARD	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4
Solid State (Fig 3D-8)	R1	R2	R3	R4
Ion Chamber (Fig 3D-9)	R1	R2	R3	R4
Universal (Fig 3D-10)	R1	R26	R27	R28
Universal (Fig 3D-11)	R1	R2	R3	R4

Table 3D-10: AEC board gain pot designations

FILM SPEED	FILM PLANE DOSE @ 75 kV
100	1025 ± 25 uR
200	550 ± 25 uR
400	260 ± 12 uR
800	135 ± 12 uR

Table 3D-11: Film speed vs. approximate dose @ 75 kV

These are APPROXIMATE dose inputs to the film cassette plane at an SID of 40 in. (100 cm), using a grid with a 12:1 ratio.

***NOTE:** To convert from μR to μGy divide the value in μR by 114.5. This will give the value in μGy (for example 114.5 μR = 1 μGy).*

Step	Action
21.	Load a test cassette with fresh film and install it in the image receptor. Using the same technique as in the previous step, expose the film and develop it.
22.	Measure the optical density. The desired value should have been previously recorded in a copy of table 3D-1.
23.	If the measured O.D. is not within 5% of the desired value, adjust the gain pot (as per step 20) to increase or decrease the density, then repeat the previous two steps.
24.	Once the desired film density is achieved, record the mAs, dose, calibration number and O.D. in a copy of table 3D-13.
FOR EACH BREAKPOINT IN THE REMAINDER OF THIS SECTION, START WITH THE APPROXIMATE DOSE AS PER TABLE 3D-12. AFTER THAT DOSE IS ACHIEVED, A FILM MUST BE EXPOSED AND THE O.D. VERIFIED. FURTHER DOSE ITERATIONS MAY BE REQUIRED TO ACHIEVE THE DESIRED OPTICAL DENSITY. ***DO NOT READJUST THE AEC BOARD GAIN POT AFTER THE 75KV KNEE BREAKPOINT IS CALIBRATED.*** **DOSE / DENSITY ADJUSTMENTS WILL ONLY BE DONE BY ADJUSTING THE CALIBRATION VALUES FOR THE OTHER KV BREAKPOINTS.**	

	55 KV BREAKPOINT CALIBRATION:
25.	Change the absorber thickness per table 3D-12. As before, ensure that the absorber fully blocks the X-ray field.
26.	Select the **55 kV** breakpoint.
27.	Make an exposure and note the dose. Use mA values as per table 3D-12.
28.	Adjust the 55 kV calibration numbers using the **+** or **-** buttons such that the actual dose is equal to the target dose at 55 kV for the selected film speed per table 3D-12. **DO NOT READJUST THE AEC BOARD GAIN POT.**

3D.6.0 AEC CALIBRATION (TABLE BUCKY) Cont

100 speed film screen					
Break point	Absorber	Dose	mAs	Generator mA	Generator BUT mAs
75 kV knee pt.	15 cm H_2O	1025 μR	59.2 mAs	320 mA	320 mAs (MAX)
55 kV	10 cm H_2O	1808 μR	54 mAs	320 mA	320 mAs (MAX)
50 kV	10 cm H_2O	1832 μR	128 mAs	320 mA	320 mAs (MAX)
65 kV	10 cm H_2O	1436 μR	44 mAs	320 mA	320 mAs (MAX)
110 kV	20 cm H_2O	1088 μR	24 mAs	200 mA	320 mAs (MAX)
130 kV	25 cm H_2O	848 μR	16 mAs	200 mA	320 mAs (MAX)
85 kV	20 cm H_2O	1060 μR	54 mAs	320 mA	320 mAs (MAX)
95 kV	20 cm H_2O	1008 μR	44 mAs	320 mA	320 mAs (MAX)

200 speed film screen					
Break point	Absorber	Dose	mAs	Generator mA	Generator BUT mAs
75 kVp knee pt.	15 cm H_2O	518 μR	30 mAs	250 mA	250 mAs (MAX)
55 kVp	10 cm H_2O	904 μR	26 mAs	250 mA	250 mAs (MAX)
50 kVp	10 cm H_2O	916 μR	64 mAs	250 mA	250 mAs (MAX)
65 kVp	10 cm H_2O	718 μR	22 mAs	250 mA	250 mAs (MAX)
110 kVp	20 cm H_2O	544 μR	12 mAs	250 mA	250 mAs (MAX)
130 kVp	25 cm H_2O	484 μR	8 mAs	250 mA	250 mAs (MAX)
85 kVp	20 cm H_2O	530 μR	27 mAs	250 mA	250 mAs (MAX)
95 kVp	20 cm H_2O	504 μR	22 mAs	250 mA	250 mAs (MAX)

400 speed film screen					
Break Point	Absorber	Dose	mAs	Generator mA	Generator BUT mAs
75 kVp knee pt.	15 cm H_2O	259 μR	14.8 mAs	200 mA	200 mAs (MAX)
55 kVp	10 cm H_2O	452 μR	13 mAs	200 mA	200 mAs (MAX)
50 kVp	10 cm H_2O	458 μR	32 mAs	200 mA	200 mAs (MAX)
65 kVp	10 cm H_2O	359 μR	11 mAs	200 mA	200 mAs (MAX)
110 kVp	20 cm H_2O	272 μR	6 mAs	200 mA	200 mAs (MAX)
130 kVp	25 cm H_2O	424 μR	4 mAs	200 mA	200 mAs (MAX)
85 kVp	20 cm H_2O	265 μR	13.5 mAs	200 mA	200 mAs (MAX)
95 kVp	20 cm H_2O	252 μR	11 mAs	200 mA	200 mAs (MAX)

800 speed film screen					
Break Point	Absorber	Dose	mAs	Generator mA	Generator BUT mAs
75 kVp knee pt.	15 cm H_2O	129 μR	7.4 mAs	100 mA	120 mAs (MAX)
55 kVp	10 cm H_2O	226 μR	6.5 mAs	100 mA	120 mAs (MAX)
50 kVp	10 cm H_2O	229μR	16 mAs	100 mA	120 mAs (MAX)
65 kVp	10 cm H_2O	179 μR	5.5 mAs	100 mA	120 mAs (MAX)
110 kVp	20 cm H_2O	136 μR	3 mAs	100 mA	120 mAs (MAX)
130 kVp	25 cm H_2O	212 μR	2 mAs	100 mA	120 mAs (MAX)
85 kVp	20 cm H_2O	132 μR	6.7 mAs	100 mA	120 mAs (MAX)
95 kVp	20 cm H_2O	126 μR	5.5 mAs	100 mA	120 mAs (MAX)

Table 3D-12: Breakpoint calibration factors

For SID's other than 40 in. (100 cm) multiply the dose by the factor [new SID / 40 in. (100 cm)]^2

3D.6.0 AEC CALIBRATION (TABLE BUCKY) Cont

3D.6.1 Break point calibration worksheet

Record the final measurements in a copy of the table below. The final measurements are those obtained AFTER films have been developed to verify the correct O.D. at each breakpoint.

FILM SCREEN 1	SPEED =			
#1 BK. POINT = 75 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	DOSE =	CAL. NO. =	O.D. =

FILM SCREEN 2	SPEED =			
#1 BK. POINT = 75 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	DOSE =	CAL. NO. =	O.D. =

FILM SCREEN 3	SPEED =			
#1 BK. POINT = 75 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#2 BK. POINT = 55 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#3 BK. POINT = 50 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#4 BK. POINT = 65 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#5 BK. POINT = 110 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#6 BK. POINT = 130 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#7 BK. POINT = 85 kV	mAs =	DOSE =	CAL. NO. =	O.D. =
#8 BK. POINT = 95 kV	mAs =	DOSE =	CAL. NO. =	O.D. =

Table 3D-13: Breakpoint worksheet

3D.6.0 AEC CALIBRATION (TABLE BUCKY) Cont

Step	Action
29.	Load the test cassette with fresh film and install it in the image receptor. Using the same technique, expose the film and develop it.
30.	Measure the optical density. The optical density should be as per step 22.
31.	If the measured O.D. is not within 5% of the desired value, adjust the 55 kV calibration number using the + or - buttons, then repeat the previous two steps. **DO NOT READJUST THE AEC BOARD GAIN POT.**
32.	Once the desired film density is achieved, record the required values in a copy of table 3D-13.

	50 KV BREAKPOINT CALIBRATION:
33.	If special techniques are NOT used which require the 50 kV range, simply enter the 55 kV calibration number into the 50 kV breakpoint using the + and - buttons. Note that at approximately 55 kV and under, the screen film sensitivity becomes too low for practical AEC operation when used with a Bucky.
34.	If the 50 kV range IS used, the 50 kV breakpoint must be calibrated. To do this, select the 50 kV breakpoint. The 50 kV step will use the same absorber as used for the 55 kV step.
35.	Repeat steps 27 to 32 to calibrate the 50 kV breakpoint if desired, *substituting 50 kV where applicable in place of 55 kV.*

	65 KV BREAKPOINT CALIBRATION:
36.	Select the 65 kV breakpoint. Use absorber thickness per table 3D-12 for the 65 kV breakpoint.
37.	Repeat steps 27 to 32 to calibrate the 65 kV breakpoint, *substituting 65 kV where applicable in place of 55 kV.*
38.	IN THE FOLLOWING STEPS, SELECT >> AND << AS REQUIRED TO NAVIGATE BETWEEN THE TWO BREAKPOINT SCREENS (SCREEN 1 LISTS BREAKPOINTS 50 KV TO 95 KV, SCREEN 2 SHOWS BREAKPOINTS 110 AND 130 KV).

	110 KV BREAKPOINT CALIBRATION:
39.	Select the 110 kV breakpoint. Use absorber thickness per table 3D-12 for the 110 kV breakpoint. Use the appropriate mA for this breakpoint as per table 3D-12.
40.	Repeat steps 27 to 32 to calibrate the 110 kV breakpoint, *substituting 110 kV where applicable in place of 55 kV.*

	130 KV BREAKPOINT CALIBRATION:
41.	If special high kV techniques are NOT used which require the 130 kV range, enter the 110 kV calibration number into the 130 kV breakpoint using the + and - buttons.
42.	If the 130 kV range IS used, the 130 kV breakpoint must be calibrated. To do this, select the 130 kV breakpoint. Use absorber thickness per table 3D-12 for the 130 kV breakpoint.
43.	Repeat steps 27 to 32 to calibrate the 130 kV breakpoint if desired, *substituting 130 kV where applicable in place of 55 kV.*

	85 KV BREAKPOINT CALIBRATION:
44.	Select the 85 kV breakpoint. Use absorber thickness per table 3D-12 for the 85 kV breakpoint.
45.	Repeat steps 27 to 32 to calibrate the 85 kV breakpoint, *substituting 85 kV where applicable in place of 55 kV.*

3D.6.0 AEC CALIBRATION (TABLE BUCKY) Cont

Step	Action
	95 KV BREAKPOINT CALIBRATION:
46.	Select the 95 kV breakpoint. Use absorber thickness per table 3D-12 for the 95 kV breakpoint.
47.	Repeat steps 27 to 32 to calibrate the 95 kV breakpoint, *substituting 95 kV where applicable in place of 55 kV.*
48.	Select << to return to the **AEC CALIBRATION** menu.

Step	Action
	FILM SCREEN 2 BREAKPOINT CALIBRATION:
49.	Select **FILM SCREEN 2.**
50.	Repeat steps 16 to 48 as described for film screen 1 ***except***: **WHEN CALIBRATING THE 75 KV KNEE BREAKPOINT FOR FILM SCREEN 2, DO NOT ADJUST THE AEC BOARD GAIN POT. DOSE ADJUSTMENTS MUST ONLY BE MADE BY VARYING THE BREAKPOINT CALIBRATION NUMBERS.** **FILM SCREEN 2 MUST BE THE NEXT HIGHEST FILM SPEED AFTER FILM SCREEN 1.**

Step	Action
	FILM SCREEN 3 BREAKPOINT CALIBRATION:
51.	Select **FILM SCREEN 3.**
52.	Repeat steps 16 to 48 as described for film screen 1 except: **WHEN CALIBRATING THE 75 KV KNEE BREAKPOINT FOR FILM SCREEN 3, DO NOT ADJUST THE AEC BOARD GAIN POT. DOSE ADJUSTMENTS MUST ONLY BE MADE BY VARYING THE BREAKPOINT CALIBRATION NUMBERS.** **FILM SCREEN 3 MUST BE THE HIGHEST FILM SPEED.**

3D.7.0 SHORT AEC TIME COMPENSATION (IF APPLICABLE)

Step	Action
	THIS SECTION ONLY APPLIES FOR AEC BOARDS WITH SHORT AEC EXPOSURE TIME COMPENSATION (FIGURE 3D-9 OR 3D-11) *IF AEC EXPOSURES LESS THAN APPROXIMATELY 15 MS ARE REQUIRED.*
1.	Select the image receptor to be short AEC time compensated, i.e. table Bucky.
2.	Select the highest film speed used on the selected receptor, and then select the **75 kV** breakpoint.
3.	Set the mA per table 3D-12 for the film speed being used. Reinstall the absorber as per table 3D-12 for the 75 kV breakpoint.
4.	Make an exposure and confirm the dose (or mAs) readings as previously recorded in table 3D-13.
5.	Reduce the absorber thickness such as to decrease the AEC exposure time to approximately 10 ms.
6.	Adjust the short AEC time compensation pot for the AEC channel being calibrated such that the dose (or mAs) is approximately the same as previously recorded (step 4). The short AEC time compensation potentiometer designations are given in table 3D-14.

3D.7.0 SHORT AEC TIME COMPENSATION (IF APPLICABLE) Cont

AEC BOARD	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4
Ion Chamber (Fig 3D-9)	R11	R12	R13	R14
Universal (Fig 3D-11)	R91	R92	R93	R94

Table 3D-14: Short AEC time compensation pot designations

Step	Action
7.	Reduce the absorber thickness again such as to decrease the AEC exposure time to approximately 6 ms (but not less).
8.	Adjust the short AEC time compensation pot for the AEC channel being calibrated such that the dose (or mAs) is approximately the same as it was in step 6.
9.	The short AEC time compensation adjustments affect the AEC calibration at longer exposure times. Therefore, it may now be necessary to readjust the gain pot for the AEC channel being calibrated to restore the dose (or mAs) values to the values previously recorded in table 3D-13. Ensure that the absorber thickness and mA values are as per table 3D-12 when readjusting the AEC gain pot.
10.	Films should be exposed and developed, and the O.D. checked at the 75 kV breakpoint at AEC exposure times of approximately 6 ms and approximately 100 ms. If the film density is not acceptable at both short and long AEC exposure times, it will be necessary to iterate the adjustments of both the short AEC time compensation pot and the AEC gain pot by repeating steps 3 to 8.
11.	Repeat steps 1 to 10 for each image receptor (AEC channel) to be short AEC time compensated.

3D.8.0 AEC DENSITY CALIBRATION

The following screens are used for density calibration

```
                    * AEC CALIBRATION *
FILM SCREEN 1                                DENSITY SETUP
FILM SCREEN 2
FILM SCREEN 3

   EXIT
```

```
*TUBE?      0%HU        *DENS.  SETUP*
-8:  -
-7:  -
-6:  -                                                   +
-5:  62%                                                 -
3200MS  EXIT                                  >>
```

```
*TUBE?      0%HU        *DENS.  SETUP*
-4:  50%
-3:  37%
-2:  25%                                                 +
-1:  12%                                                 -
3200MS   <<                                   >>
```

3D.8.0 AEC DENSITY CALIBRATION (Cont)

```
*TUBE?     0%HU        *DENS.  SETUP*
+1:  12%
+2:  25%
+3:  37%                                     +
+4:  50%                                     -
3200MS  <<                          >>
```

```
*TUBE?     0%HU        *DENS.  SETUP*
+5:  62%
+6:  -
+7:  -                                       +
+8:  -                                       -
3200MS  <<                          RETURN
```

Please note the following points regarding density calibration:

- Up to eight density plus and eight density minus steps are available. If ± 8 density steps are not required, the unwanted density steps may be programmed out per the procedure below. For example, if only ± 5 density steps are desired, then density steps ± 6, 7, 8 may be deprogrammed.
- Once the desired number of ± density steps are known, the relative minimum and maximum dose values must be determined. Typically the minimum density step will result in half (50%) of the nominal dose and the maximum density step will typically give double the nominal dose (100% increase). The nominal dose is the value that was recorded at **0** density in table 3D-13.
- The relative dose change per density step must be determined next. To do this, note the relative minimum and maximum dose as determined above (i.e. 50% at min density and 100% increase at max density), then calculate the number of - density steps and the number of + density steps that will be required.

  The relative dose change between density steps will then be the minimum density (i.e. 50) divided by the number of density minus steps or the maximum density (i.e. 100) divided by the number of density plus steps. This will yield the required dose increment for each density minus step and for each density plus step respectively.

  For ± 8 density steps, this gives a dose decrease of 6.25% per density minus step (8 steps x 6.25% per step = 50% dose at -8 density) or a dose increase of 12.5% per density plus step (8 steps x 12.5% per step = 100% dose increase at +8 density).

  Refer to table 3D-15 for two typical examples of density steps vs. calibration numbers. For 8 minus density steps the dose decrease is 6.25% per step, and for 8 + density steps the dose increase is 12.5% per step as per the example calculation above.

  For 5 minus density steps the dose decrease is 10% per step, and for 5 + density steps the dose increase is 20% per step.

3D.8.0 AEC DENSITY CALIBRATION (Cont)

DENSITY STEP	CALIBRATION NUMBER (- 8 DENSITY = HALF THE DOSE, +8 DENSITY = DOUBLE THE DOSE)	DENSITY STEP	CALIBRATION NUMBER (- 5 DENSITY = HALF THE DOSE, +5 DENSITY = DOUBLE THE DOSE)
-8	50		
-7	44		
-6	38		
-5	31	-5	50
-4	25	-4	40
-3	19	-3	30
-2	13	-2	20
-1	6	-1	10
0 DENSITY: SHOWN FOR REFERENCE ONLY.			
+1	13	+1	20
+2	25	+2	40
+3	38	+3	60
+4	50	+4	80
+5	63	+5	99
+6	75		
+7	88		
+8	99		

Table 3D-15: Example density values

Step	Action
1.	Reselect **FILM SCREEN 1.** Use absorber thickness per table 3D-12 for the 75 kV breakpoint.
2.	Reselect the 75 kV knee breakpoint.
3.	Select << to return to the **AEC CALIBRATION** menu.
4.	Select **DENSITY SETUP.**
5.	Referring to table 3D-13, note the dose at 75 kV for film screen 1. This will be referred to as the **0** density dose.
6.	Select the highest density minus step desired i.e. **- 8** from the density setup menu. If it is not intended to use this step, select the highest density minus step to be used i.e. **- 5,** then set the unused steps to **-** to disable those steps. To disable density steps, press the **-** button to scroll down until the **-** symbol is displayed.
7.	Set the calibration number for the highest density minus step to the desired relative density value (example **50,** this will give approximately 1/2 the 0 density dose).
8.	Make an exposure and confirm that the measured dose is approximately the desired value.
9.	If the measured dose is not as expected, adjust the calibration number for that density step and repeat step 8.
10.	Select the next density step (i.e. **- 7**) and enter the appropriate calibration number for that step. Refer to table 3D-15 and the notes preceding table 3D-15. Repeat steps 8 and 9.
11.	Repeat the previous step for each remaining density minus step. Use the >> and << buttons to navigate through the **DENS SETUP** menu in order to access all the density steps in this procedure.

3D.8.0 AEC DENSITY CALIBRATION (Cont)

Step	Action
12.	Set the calibration number for the highest density plus step to the desired relative density value (example **100,** this will result in approximately double the 0 density dose).
13.	Repeat step 8 and 9.
14.	Select the next lowest density step (i.e. 7) and enter the appropriate calibration number for that step. Refer to table 3D-15 and notes preceding table 3D-15. Repeat steps 8 and 9.
15.	Repeat the previous step for each remaining density plus step. Use the **>>** and **<<** buttons to navigate through the **DENS SETUP** menu in order to access all the density steps.
16.	When the density setup is complete and verified via dose measurements, use the **<<** and **EXIT** buttons to return to the **AEC CALIBRATION** menu.

3D.9.0 RLF COMPENSATION

The following points should be noted regarding RLF compensation. RLF compensation is normally only needed if special techniques are used which result in AEC exposures greater than 100 ms.

- If perfect, film would provide linear density changes with linearly increasing exposure times. In reality, at longer exposures, film effectively becomes slower. This effect is known as reciprocity law failure. To compensate, exposure times must be increased at longer exposures.
  This compensation is achieved by increasing the AEC reference voltage at longer exposure times. RLF compensation is applied to three ranges (50-500 ms, 500-1000 ms, and 1000- 1500 ms) as shown below.
  The examples below are not meant to represent actual RLF compensation percentages in your installation. Actual values will need to be determined per the procedure following.

- Between 0 and 50 ms no RLF compensation is applied. Per figure 3D-14, the AEC reference voltage is constant at 1 unit between 0 and 50 ms.

- At 50 ms, RLF compensation = **10%** is applied. This means that the reference voltage will increase by 10% between 50 ms and 500 ms in a linear fashion. At 500 ms the reference voltage is then 1.0 X 1.10 = 1.10 units.

- At 500 ms, RLF compensation = **20%** is applied. This means that the reference voltage will increase by 20% between 500 ms and 1000 ms in a linear fashion. At 1000 ms the reference voltage is then 1.10 X 1.20 = 1.32 units.

- At 1000 ms, RLF compensation = **30%** is applied. This means that the reference voltage will increase by 30% between 1000 ms and 1500 ms in a linear fashion. At 1500 ms the reference voltage is then 1.32 X 1.30 = 1.72 units

- The rate of increase of the reference voltage beyond 1500 ms will be constant, up to limit of the B.U.T. (backup timer).

- The compensation curve resulting from the RLF values described above is depicted in the graph below.

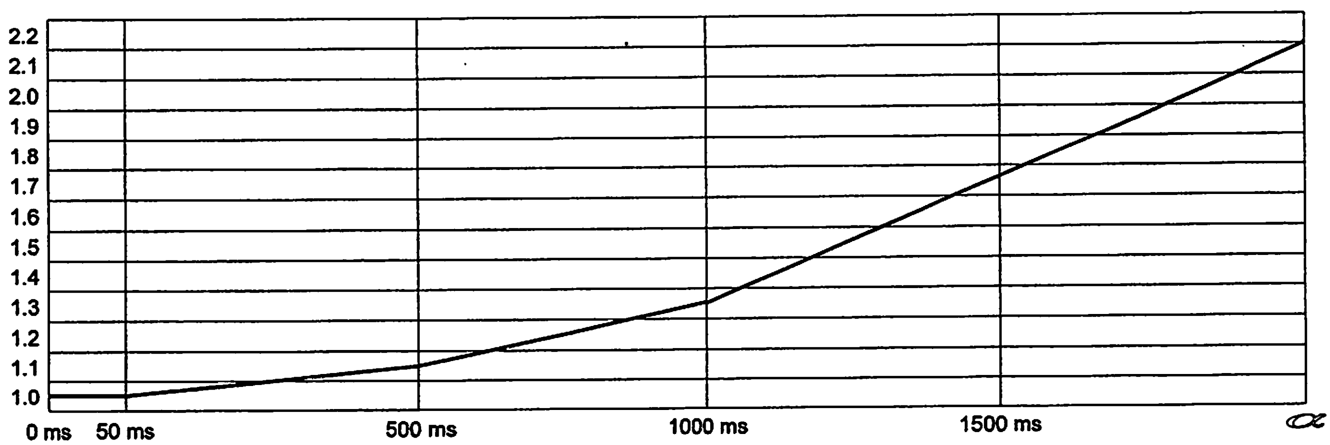


Figure 3D-14: Example RLF compensation curve

3D.9.0 RLF COMPENSATION (Cont)

The following screens are used for RLF compensation

```
                    * AEC CALIBRATION *
FILM SCREEN 1                                 DENSITY SETUP
FILM SCREEN 2
FILM SCREEN 3

     EXIT
```

```
*TUBE?      0%HU          AEC CAL, F/S 1*
50KV:  84.0:                                   85KV:  42.8
55KV:  78.0:                                   95KV:  38.0
65KV:  66.0:                                             +
75KV:  54.0                                              -
3200MS   <<                                  >>
```

```
*TUBE?      0%HU          AEC CAL, F/S 1*
110KV:  34.0:
130KV:  28.0:
RLF COMPENSATION                                         +
MULT.  SPOT  COMP:        0%                             -
3200MS   <<
```

```
*TUBE?      0%HU          RLF COMP, F/S 1*
50MSEC:    0%
500MSEC:    4%
1000MSEC:    0%                                          +
                                                         -
3200MS   <<
```

3D.9.0 RLF COMPENSATION (Cont)

Step	Action
1.	Place the absorber (with thickness selected for 75 kV per table 3D-12) in the X-ray field, ensuring that the radiation is COMPLETELY blocked by the absorber.
2.	Select the slowest film screen combination to compensate. This will normally be **FILM SCREEN 1.**
3.	Select >>.
4.	Select **RLF COMPENSATION.**
5.	From the **LF COMP** menu, select **50MSEC** and set the value to **0** using the **+** or **-** buttons.
6.	Select mA appropriate to the film speed i.e. 100 mA for 100 speed film.
7.	Make an exposure and adjust the mA if necessary to give an exposure time of approximately 50 ms.
8.	Load a test cassette with fresh film and install it in the image receptor.
9.	Make an exposure using the same techniques. Record the mAs, then develop the film.
10.	Note the O.D. This should be within 10% of the O.D. that was noted during AEC calibration.
11.	Make an exposure and reduce the mA to give an exposure time of approximately 500 ms.
12.	Make an exposure using the same techniques. Record the mAs.
13.	Enter an RLF offset at **50MSEC** to give a mAs increase of approximately 10%.
14.	Load a test cassette with fresh film and install it in the image receptor. Make an exposure and develop the film.
15.	If the measured O.D. is not within 5% of the value in step 10, adjust the 50 ms RLF offset value as appropriate using the **+** and **-** buttons.
16.	Repeat steps 14 and 15 until the required O.D. is achieved.
17.	Make an exposure and reduce the mA to give an exposure time of approximately 1000 ms.
18.	Select the **500MSEC** RLF adjustment and set the value to **0** using the **+** or **-** buttons.
19.	Make an exposure using the same techniques. Record the mAs.
20.	Enter an RLF offset at **500MSEC** to give a mAs increase of approximately 20%.
21.	Load the test cassette with fresh film and install it in the image receptor. Make an exposure and develop the film.
22.	If the measured O.D. is not within 5% of the value in step 10, adjust the 500 ms RLF offset value as appropriate using the **+** and **-** buttons.
23.	Repeat steps 21 and 22 until the desired density is achieved.
	THE FOLLOWING STEPS ONLY APPLY IF TECHNIQUES ARE USED RESULTING IN AEC EXPOSURE TIMES GREATER THAN APPROXIMATELY 1500 MS.
24.	Make an exposure and reduce the mA such as to give an exposure time of approximately 1500ms.
25.	Select the **1000MSEC** RLF adjustment and set the value to **0** using the **+** or **-** buttons.
26.	Make an exposure using the same techniques. Record the mAs.
27.	Enter an RLF offset at **1000MSEC** to give an mAs increase of approximately 30%.
28.	Load the test cassette with fresh film and install it in the image receptor. Make an exposure and develop the film.
29.	If the measured O.D. is not within 5% of the value in step 10, adjust the 1000 ms RLF offset value as appropriate using the **+** and **-** buttons.
30.	Repeat steps 28 and 29 until the desired density is achieved.
31.	Select << as required to return to the **AEC CALIBRATION** menu.
32.	Repeat steps 2 to 31 for **FILM SCREEN 2** and **FILM SCREEN 3** if required.

3D.10.0 MULTIPLE SPOT COMPENSATION

The following screens are used for multiple spot compensation

```
                    * AEC CALIBRATION *
FILM SCREEN 1                                DENSITY SETUP
FILM SCREEN 2
FILM SCREEN 3

    EXIT
```

```
*TUBE?     0%HU        AEC CAL, F/S 1*
50KV: 84.0:                                   85KV: 42.8
55KV: 78.0:                                   95KV: 38.0
65KV: 66.0:                                            +
75KV: 54.0                                             -
3200MS  <<                                  >>
```

```
*TUBE?     0%HU        AEC CAL, F/S 1*
110KV: 34.0:
130KV: 28.0:
RLF COMPENSATION                                       +
MULT. SPOT COMP:        0%                             -
3200MS  <<
```

- Multiple spot compensation may be required when doing multiple exposures on a single film. In this mode of serial recording, the X-ray field is usually coned down to a small area. Due to the lack of scatter and possible AEC field cutoff, an AEC density offset may be added if required. This offset is known as multiple spot compensation.
- In order to activate the multiple spot compensation feature, the R & F table must supply a closed dry contact when the SFD is operated in multi-spot mode. The multi-spot input to the generator is at TB5 pins 11 and 12 on the room interface board.

3D.10.0 MULTIPLE SPOT COMPENSATION (Cont)

Step	Action
1.	Place the absorber (with thickness selected for 85 kV per table 3D-12) in the X-ray field, ensuring that the radiation is COMPLETELY blocked by the absorber.
2.	Select the slowest film screen combination to compensate. This will normally be **FILM SCREEN 1.**
3.	Select >>.
4.	Select **MULT SPOT COMP.**
5.	Enter the value **0%** using the **+** and **-** buttons.
6.	Select 85 kV via the kV **+** or **-** buttons in the radiography section of the console.
7.	Select mA appropriate to the film speed per table 3D-13.
8.	Load the test cassette with fresh film and install it in the SFD.
9.	Make an exposure and record the mAs, then develop the film.
10.	Verify that the film is evenly exposed, and that the O.D. is the desired value
11.	Enable the SFD multi-spot function, then make several exposures and record the mAs.
12.	Develop the film and record the O.D. for each exposure.
13.	If the measured optical densities are not within 5% of the desired value, enter a multi-spot compensation offset percentage that increases or decreases the mAs as appropriate using the **+** and **-** buttons.
14.	Repeat steps 8 to 13 until the desired O.D. is achieved on all exposures.
15.	Select << as required to return to the **AEC CALIBRATION** menu.
16.	Repeat steps 2 to 15 for **FILM SCREEN 2** and **FILM SCREEN 3** if required.
17.	Select **EXIT** to return to the **GEN CONFIGURATION** menu.
18.	Select **EXIT**, then **EXIT SETUP** to return to the normal operating mode.

3D.11.0 AEC CALIBRATION (WALL BUCKY)

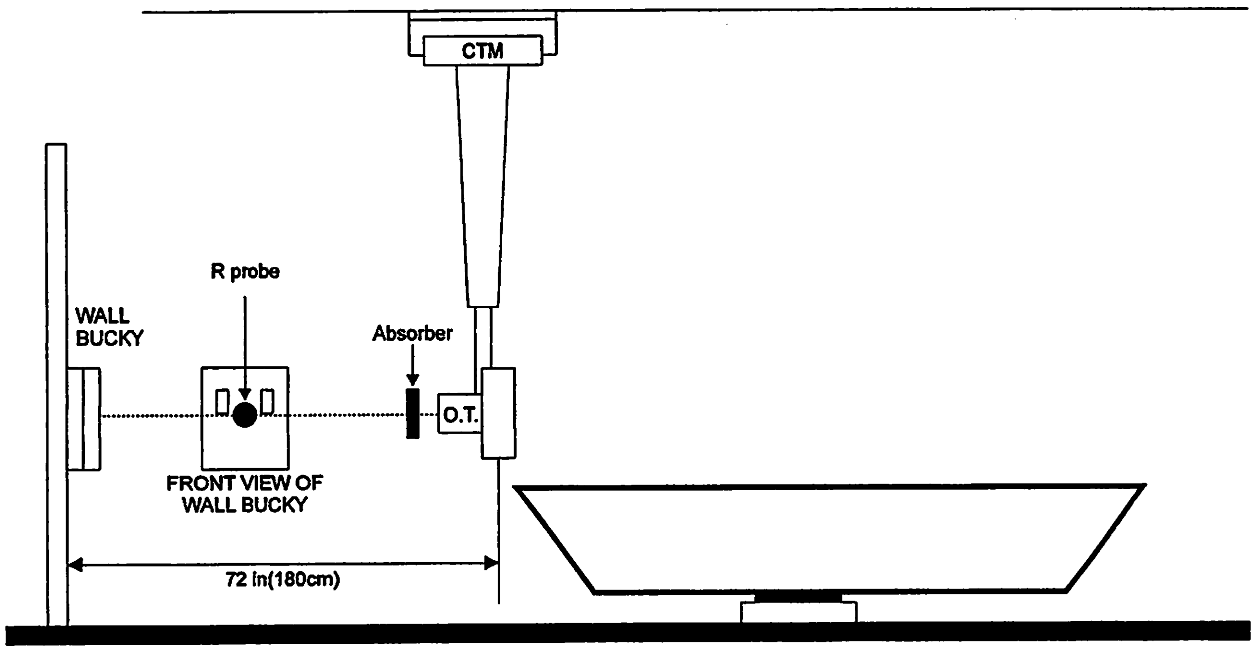


Figure 3D-15: Equipment setup for wall Bucky AEC calibration

Please note the following points regarding wall Bucky calibration:

- If the wall Bucky is dedicated to chest radiography, a focused grid with a 10:1 or 12:1 ratio should be used along with an SID of 72 in. (180 cm).
- If the wall Bucky will be used for conventional as well as chest radiography, then two grids should ideally be used. See the note at the bottom of this page.

A reasonable compromise if a single grid must be used is a 10:1 ratio, 60 in. (150 cm) grid.

NOTE:	***SINCE MOST WALL BUCKYS ARE USED AT 40 AND 72 IN. (100 AND 180 CM) SID, THE GRID MUST BE CHOSEN WITH CARE WITH RESPECT TO CUT-OFF. A TYPICAL GRID WILL HAVE AN 8:1 RATIO, WITH 85 LINE PAIR / INCH OR 10:1 RATIO WITH 150 LINE PAIR / INCH (STATIONARY). TYPICALLY, 400 SPEED FILM SCREEN WILL BE USED WITH 90 SECOND PROCESSING.***

3D.11.0 AEC CALIBRATION (WALL BUCKY) Cont

Grid Absorption

The following information may aid in selecting a grid and / or estimating doses in front of the Bucky if required: The percentages listed are approximate.

* A 10:1 ratio 60 in. (150 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center: At 72 in. (180 cm) absorption = 18%
  At 40 in. (100 cm) absorption = 40%

* A 12:1 ratio 60 in. (150 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center: At 72 in. (180 cm) absorption = 20%
  At 40 in. (100 cm) absorption = 50%

* A 10:1 ratio 72 in. (180 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center: At 40 in. (100 cm) absorption = 65%

* A 12:1 ratio 72 in. (180 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center: At 40 in. (100 cm) absorption = 75%

* A 10:1 ratio 40 in. (100 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center: At 72 in. (180 cm) absorption = 65%

* A 12:1 ratio 40 in. (100 cm) focused grid will exhibit the following absorption when measured 5 in. (13 cm) from center: At 72 in. (180 cm) absorption = 75%

NOTE: *BREAKPOINT CALIBRATIONS MAY HAVE BEEN DONE FOR ALL THREE FILM SCREEN COMBINATIONS DURING TABLE BUCKY AEC CALIBRATION. IF SO, THE REMAINING IMAGE RECEPTORS MUST USE THE CALIBRATION CURVES PREVIOUSLY ESTABLISHED FOR THOSE FILM SCREENS.*

IF AN UNUSED FILM SCREEN COMBINATION IS AVAILABLE FOR WALL BUCKY USE, IT IS SUGGESTED THAT TWO RECEPTOR SELECTOR BUTTONS ON THE CONSOLE BE ASSIGNED TO SELECT THE WALL BUCKY. THE FIRST WALL BUCKY SELECTOR SHOULD BE USED FOR 40 IN. (100 CM) SID'S WITH THE APPROPRIATE PREVIOUSLY CALIBRATED FILM SCREEN. THE SECOND WALL BUCKY SELECTOR SHOULD THEN BE USED WITH THE PREVIOUSLY UNCALIBRATED FILM SCREEN AT 72 IN. (180 CM) SID'S.

THIS METHOD WILL ALLOW THE GRID TO BE OPTIMIZED FOR EACH SID, AS A SEPARATE DEDICATED FILM SCREEN WITH ITS OWN CALIBRATION CURVE CAN BE ASSIGNED TO THE 72 IN. (180CM) SID.

3D.10.0 AEC CALIBRATION (WALL BUCKY) Cont

Step	Action
	USE OF ONE FILM SCREEN FOR BOTH SID'S USING PREVIOUSLY CALIBRATED FILM SCREENS
1.	Set up the X-ray tube stand as shown in figure 3D-15.
2.	Align the tube stand and wall Bucky such that the central ray is centered relative to the image receptor.
3.	Open up the collimator to expose all three fields of the AEC pickup. Ensure that the central ray remains centered relative to the image receptor.
4.	Place the R probe at the film plane, i.e. behind the grid. If this cannot be done, then attach the probe to the front of the Bucky. Ensure that the R-probe is located directly under the central ray. The R meter must be set to measure in the micro-R range.
5.	Place the absorber (with thickness selected for 75 kV per table 3D-12) in the X-ray field, ensuring that the radiation is COMPLETELY blocked by the absorber.
6.	Select the wall Bucky image receptor.
7.	Select the slowest film screen used for the wall Bucky, then select the appropriate mA for that film screen per table 3D-12 (example 320 mA for 100 speed film). Select 75 kV, large focus, center field.
8.	Make an exposure and note the dose and mAs.
9.	Referring to table 3D-13, select the previously established dose required at the 75 kV knee breakpoint for the film speed being calibrated. **Note that the dose values in the table are based on a specific R-probe placement during table Bucky calibration (either at the film plane, or alternately in front of the Bucky). If the probe placement for wall Bucky calibration is not the same as it was for table Bucky calibration, use the estimated dose correction factor in this subsection under *GRID ABSORPTION.***
10:	Adjust the required gain potentiometer on the AEC board (see note below) while taking exposures until the dose noted in the previous step is obtained. • **CHANNEL 2 ON THE AEC BOARD IS TYPICALLY USED FOR THE WALL BUCKY AEC CHAMBER. YOUR INSTALLATION <u>MAY</u> USE A DIFFERENT CHANNEL ON THE AEC BOARD. *DO NOT READJUST THE GAIN POT FOR THE CHANNEL THAT WAS PREVIOUSLY CALIBRATED (FOR TABLE BUCKY).*** • **REFER TO TABLE 3D-10 FOR THE AEC BOARD GAIN POTENTIOMETER (GAIN POT) DESIGNATIONS FOR THE VARIOUS AEC BOARDS.**
11.	Load the test cassette with fresh film and install it in the image receptor. Using the same technique, expose the film and develop it.
12.	Measure the O.D. The desired value should have been previously recorded in a copy of table 3D-1.
13.	If the measured O.D. is not within 5% of the desired value, adjust the gain pot (as per step 10) to increase or decrease the density, then repeat the previous two steps.
14.	Change the SID to 40 in. (100 cm) and repeat steps 11 to 13. Adjust the gain pot if necessary to achieve an acceptable compromise between both SID's.
14.	Verify the O.D. at a range of different kV's.

	USE OF TWO FILM SCREENS (ONE FOR EACH SID) USING ONE PREVIOUSLY CALIBRATED FILM SCREEN AND ONE UNCALIBRATED FILM SCREEN
15.	Select the wall bucky image receptor via the selector configured for the 40 in. (100 cm) SID.
16.	Repeat steps 1 to 13 at the 40 in. (100 cm) SID position using the appropriate previously calibrated film screen.

3D.11.0 AEC CALIBRATION (WALL BUCKY) Cont

Step	Action
17.	Verify the O.D. at a range of different kV's.
18.	Switch the generator OFF. Re-enter the programming mode as detailed in the TABLE BUCKY AEC calibration section.
19.	Select the wall Bucky image receptor via the selector configured for the 72 in. (180 cm) SID.
20.	Calibrate the film screen assigned to this SID as per the table Bucky procedure. The calibration pot is NOT to be adjusted during this procedure (this was calibrated in the preceding procedure). All breakpoints, including the 75 kV knee breakpoint, are to be calibrated by adjusting the calibration numbers ONLY.
21.	When complete, exit the **AEC CALIBRATION** and **GEN CONFIGURATION** menu.

3D.12.0 AEC CALIBRATION (AUX, SFD, ETC)

The remaining image receptors are calibrated in a similar manner to the table Bucky receptor. Only the gain pot for that channel is to be adjusted at the slowest film screen used on that receptor. DO NOT READJUST THE GAIN POT FOR PREVIOUSLY CALIBRATED RECEPTORS, AND DO NOT READJUST THE CALIBRATION VALUES IN THE AEC CALIBRATION MENU FOR PREVIOUSLY CALIBRATED FILM SCREENS.

Refer to 3D.4.0 if a PMT is to be used for AEC during digital acquisition or spot film work.

THE *MEMORY FUNCTION* THAT WAS TEMPORARILY CHANGED TO *OFF* EARLIER IN THIS CHAPTER MAY NOW BE RESET TO THE DESIRED VALUE.

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CHAPTER 3

SECTION 3E

ABS CALIBRATION

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3E.1.0 INTRODUCTION

3E.1.1 Overview of ABS Operation

Refer to figure 3E-1, this is a block diagram of the ABS system.

X-rays pass through the patient and excite the input cesium phosphor of the image intensifier (I.I.). This will cause the output of the I.I. to fluoresce and project the image to the TV camera via the collimating lens. A sample of the light output is then sensed by a photodiode or photomultiplier tube (PMT), or composite or proportional video will be fed back from the camera.

The feedback signal is processed by the ABS circuits on the generator interface board. The result, regardless of the type of ABS sensor used, will be a DC voltage proportional to the brightness of the image. This DC signal is then processed by the generator CPU board. The CPU compares the feedback voltage with a reference value determined by dose rate, mA, kVp, and mA ranges set during ABS calibration. The CPU will attempt to maintain constant image brightness by varying the kVp and / or mA output of the power supply according to a predetermined algorithm.

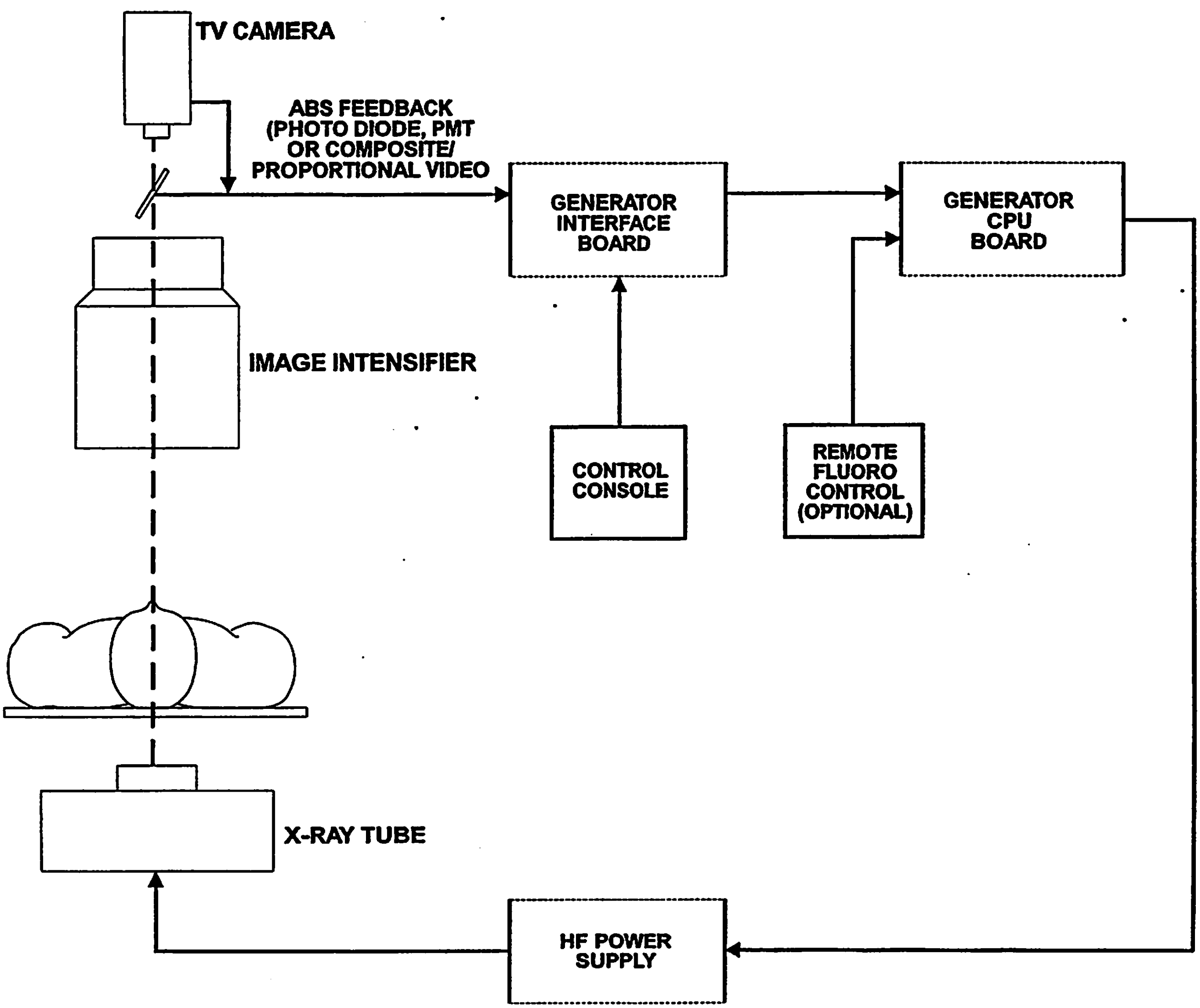


Figure 3E-1: ABS block diagram

3E.1.2 Image Intensifier Light Output

The following variables affect the transmitted light output of an I.I. tube.

- Image Intensifier gain.
- Field size - input to output.
- System components.
- Choice of X-ray techniques.

Image Intensifier Gain.

Image tube gain is affected by two different factors, the ratio of the input to output phosphor area and the electron gain due to the electron acceleration from the cathode to anode. A third effect that slowly reduces the I.I. tube's gain is age. The emissivity of the cesium cathode decays with time and usage.

Gain = Area of input divided by the area of the output multiplied by the energy of a photon ($E = hc/\lambda$ [where h = Plank's constant, c = speed of light and λ is the light wavelength])

Example: Consider the difference of I.I. tube gain when a 12 inch I.I. tube is switched between 6 inches and 12 inches.

Gain with tube in NORMAL mode:
Gain $=(6 \times 6 \times \pi)/(.5 \times .5 \times \pi) = 144 \times E$

Gain with tube in the MAG mode:
Gain $=(3 \times 3 \times \pi)/(.5 \times .5 \times \pi) = 36 \times E$

Field Size - Input to Output.

Most modern I.I. tubes are the multi-mode type where the effective input area may be changed per the nature of the procedure. To change the field size of an I.I. tube when a MAG mode is selected, the electron beam over-scans the output target. This in effect reduces the ratio of input size to output size and reduces the gain or light output of the I.I. tube.

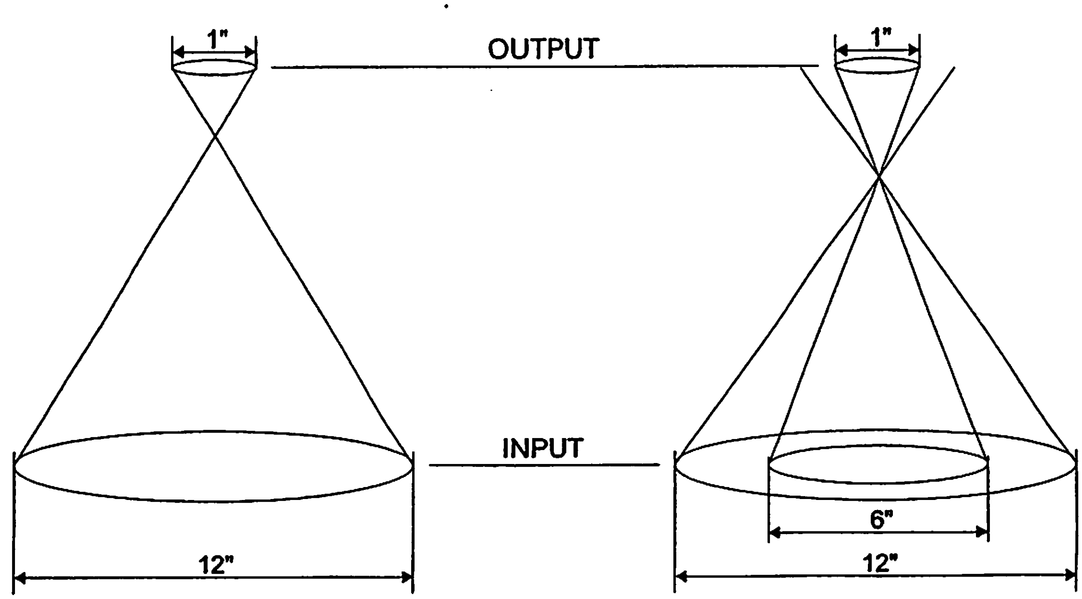


Figure 3E-2: I.I. input and output area

3E.1.3 ABS Pickup Devices

Shown below are pictorial representations of the three basic types of light sensors that generate the DC reference signal used by the generator. These are simplified schematics only; refer to section 3E.2.0 for actual wiring of the ABS pickup device.

Photo-multiplier tube

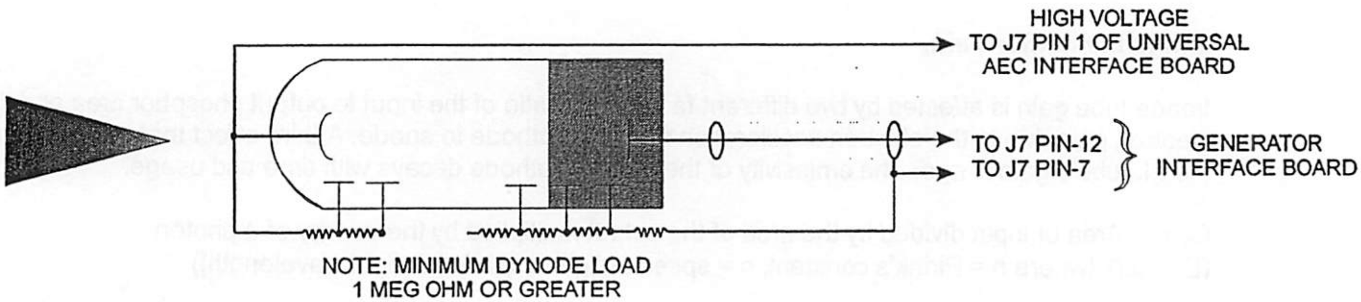
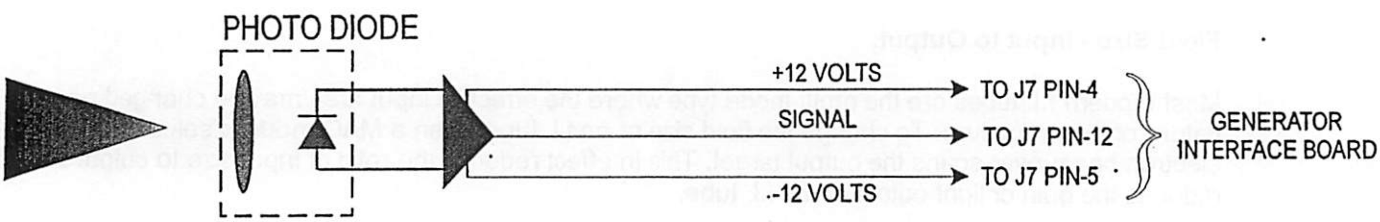


Photo Diode



Composite Video or Proportional DC

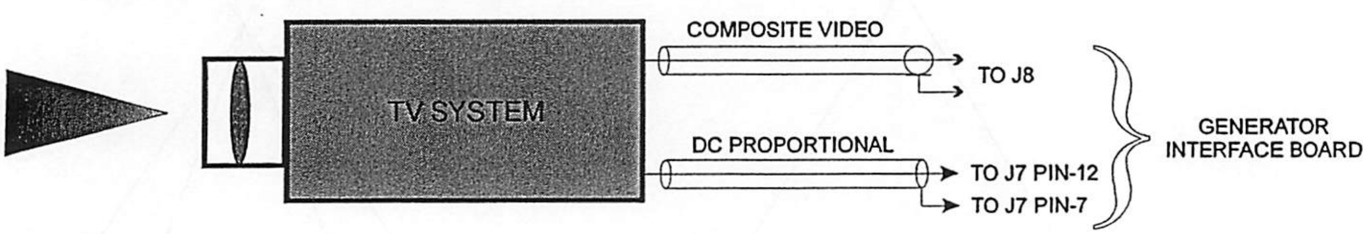


Figure 3E-3: ABS Pickup Devices

3E.1.4 Required Test Equipment

The following test equipment is required for ABS calibration.

- Resolution test pattern for imaging focusing.
- Central ray alignment fixture.
- Collimator centering test pattern.
- A selection of Al filters for HVL determination.
- Water or lexan (or equivalent) absorbers in various thickness. Water should be in a plastic container of uniform thickness.

3E.2.0 ABS PICKUP INSTALLATION / WIRING

Sections 3E.1.3 and 3E.2.1 present an overview of the various ABS pickup types that may be used with the Millenia and Indico 100 family of generators. The generator must be specifically configured to accept each pickup type as per table 3E-2 and sections 3E.2.3, 3E.2.4, 3E.2.5 and 3E.2.6.

NOTE THAT THE GENERATOR IS FACTORY CONFIGURED FOR ONE SPECIFIC TYPE OF ABS PICKUP ONLY. REFER TO THE COMPATIBILITY STATEMENT / CUSTOMER PRODUCT DESCRIPTION FORM IN CHAPTER 1D FOR THE FACTORY CONFIGURED ABS COMPATIBILITY OF THIS GENERATOR.

3E.2.1 Overview

The generator has been factory configured to be compatible with one of the following ABS pickup types. Field reconfiguration to accept other ABS pickup types, listed below, is possible if required.

- PMT (photo multiplier tube).
- Light sensitive optical diode. The output may be 0 to +5 VDC, 0 to -5 VDC, or +/- VDC centered at 0 VDC.
- A proportional (to the brightness of the I.I.) DC voltage. The output polarity may be 0 to +5 VDC or 0 to -5 VDC.
- A terminated or non - terminated composite video signal.

Refer to chapter 1E for the AEC board and generator interface board location in your generator.

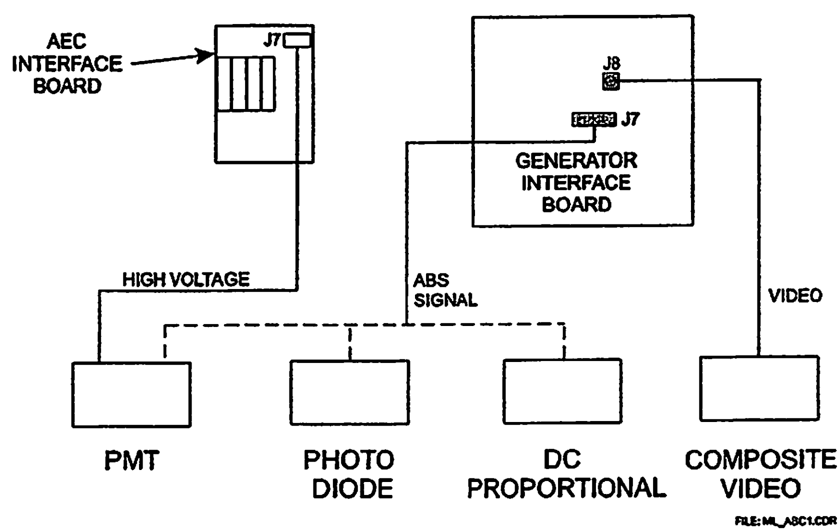


Figure 3E-4: ABS interface to the generator (overview)

3E.2.2 ABS Jumper Matrix.

The table below details the generator interface board jumper positions as required to be compatible with the listed ABS pickups. Refer to the generator interface board schematic, or to the ABS functional drawing in conjunction with this table. This table should be used in conjunction with sections 3E.2.3, 3E.2.4 3E.2.5, and 3E.2.6.

ABS PICKUP TYPE	GENERATOR INTERFACE BOARD INPUTS & JUMPER CONFIGURATIONS								
	INPUT	JW4	JW5	JW11	JW12	JW13	JW19	JW20	JW21
Photo Multiplier Tube	J7	OUT	*	PINS 1-2	OUT	OUT	*	*	PINS 2-3
Photo Multiplier Tube	J8	OUT	*	PINS 1-2	OUT	OUT	PINS 1-2	IN	PINS 2-3
Photo Diode (negative output)	J7	OUT	*	PINS 1-2	OUT	OUT	*	*	PINS 2-3
Photo Diode (positive output)	J7	OUT	*	PINS 2-3	OUT	OUT	*	*	PINS 2-3
Photo Diode 0-5 VDC neg/pos	J7	OUT	*	PINS 2-3	OUT	OUT	*	*	PINS 2-3
Proportional DC 0-5 VDC positive	J7	OUT	*	PINS 2-3	OUT	OUT	*	*	PINS 2-3
Proportional DC 0-5 VDC positive	J8	OUT	*	PINS 2-3	OUT	OUT	PINS 1-2	OUT	PINS 2-3
Proportional DC 0-5 VDC negative	J7	OUT	*	PINS 1-2	OUT	OUT	*	*	PINS 2-3
Proportional DC 0-5 VDC negative	J8	OUT	*	PINS 1-2	OUT	OUT	PINS 1-2	OUT	PINS 2-3
Composite video terminated 75 Ω	J8	OUT	IN	PINS 3-4	OUT	IN	PINS 2-3	IN	PINS 2-3
Composite video high impedance	J8	IN	OUT	PINS 3-4	OUT	IN	PINS 2-3	IN	PINS 2-3
Via optional expansion board in digital system	Via J13	OUT	*	*	*	*	*	*	PINS 1-2

* = Don't care i.e. jumper may be in any position

Table 3E-1: ABS jumper matrix

THE TABLE ABOVE SHOWS THE OPTION OF CONNECTING THE OUTPUTS FROM A PMT OR PROPORTIONAL DC TO J8 INSTEAD OF J7. THIS ALTERNATE CONNECTION IS <u>NOT</u> SHOWN IN THE SIMPLIFIED PICTORIAL DIAGRAMS, FIGURES 3E-3 OR 3E-4.

WARNING: *SWITCH OFF THE GENERATOR AND ENSURE THAT ALL CAPACITORS ARE DISCHARGED BEFORE CONNECTING ANY ABS PICKUP DEVICES.*

3E.2.3 PMT (Photo Multiplier Tube)

The generator must be fitted with the "Universal AEC Board" assembly if using a PMT. The high voltage supply for the PMT is located on this assembly.

1. Dress the PMT cable from the imaging system such as to allow the dynode high voltage lead to plug into the "universal AEC interface board" at J7. Refer to figure 3E-4. J7 is the high voltage output for the PMT; all pins on this connector are connected in parallel and thus any of the 4 pins on J7 may be used. Ensure that the high voltage lead is rated at 1000 VDC minimum.
   NOTE: The total resistive load of all dynodes must be greater than 1 megohm to prevent excess PMT power supply loading.

2. Dress the signal (coax) cable from the PMT to allow it to connect to J7 on the generator interface board. Wire to J7 as per figure 3E-3. Alternately, the PMT output may be connected to BNC connector J8 on the generator interface board.

3. Ensure that there is sufficient slack in the cables such that the cabinet door (Millenia generators) does not strain these cables when opening and closing. Secure the cables in place such as to prevent mechanical stress on the connections.

4. The signal ground must be at the generator interface board only to avoid ground loops.

5. Position the jumpers on the generator interface board as per table 3E-1 for ***Photo Multiplier Tube***, selecting the correct configuration depending on whether the input is at J7 or J8.

6. The PMT high voltage calibration will be done at a later step.

3E.2.4 Photo Diode

1. Dress the signal cable from the photo diode circuit to allow it to connect to J7 on the generator interface board. Connect the photodiode to J7 as follows: Output signal to pin 12, ground to pin 7, +12 VDC to pin 4, and -12 VDC if used to pin 5.

2. Ensure that there is sufficient slack in the cable such that the cabinet door (Millenia generators) does not strain this cable when opening and closing. Secure the cables in place such as to prevent mechanical stress on the connections.

3. Note that there are three types of photo diodes for this application with outputs as listed below:

   - a zero to positive DC voltage for increasing light flux
   - a zero to negative DC voltage for increasing light flux
   - a negative DC voltage to positive DC voltage for increasing light flux. The required dose is set for 0 volts. The output will be negative for reduced light due to increased patient absorption, then swinging positive for increased light due to reduced patient absorption.

4. Position the jumpers on the generator interface board as per table 3E-1 for ***Photo Diode.*** Please ensure that the correct configuration is selected per your photo diode type as detailed above.

3E.2.5 DC Proportional

1. Dress the signal cable from the camera to allow it to connect to J7 on the generator interface board. Wire to J7 as per figure 3E-3. Alternately, the DC proportional signal output may be connected to BNC connector J8 on the generator interface board.
2. Ensure that there is sufficient slack in the cable such that the cabinet door (Millenia generators) does not strain this cable when opening and closing. Secure the cable in place such as to prevent mechanical stress on the connections.
3. Position the jumpers on the generator interface board as per table 3E-1 for ***Proportional DC***, selecting the correct configuration depending on whether the input is at J7 or J8 and whether the polarity is negative or positive.

3E.2.6 Composite Video

1. Dress the composite video output from the camera to allow it to connect to J8 on the generator interface board.
2. Ensure that there is sufficient slack in the cable such that the cabinet door (Millenia generators) does not strain this cable when opening and closing. Secure the cable in place such as to prevent mechanical stress on the terminations.
3. Position the jumpers on the generator interface board as per table 3E-1 for ***Composite Video***, selecting the correct configuration depending on whether the video is 75 ohm-terminated or high impedance (it must be determined beforehand whether the 75 ohm termination must be made at the generator).

Composite video ABS is not recommended with pulsed fluoro applications.

3E.3.0 FLUORO SETUP AND CALIBRATION

Before the ABS system can be calibrated, the imaging system must be functional and properly set up. Please verify the following:

- Image intensifier and its power supply are functional.
- TV camera is calibrated for this application.
- All beam attenuating devices are in place.
- Table top is in position.
- Fluoro grid is in path of X-ray beam.
- Imaging system is in the operational position.
- Imaging collimator functional.
- Collimator opening varies as S.I.D. is changed. (S.I.D. = source-image distance).
- Collimator opening varies as the image intensifier's MAG mode switch is changed.
- The ABS pickup device (as per the previous section) must be installed and functional.
- Sufficient filters are added to the X-ray tube to provide the required HVL.
- The fluoro imaging and receptor devices have been programmed. Refer to chapter 3C.
- kVp and mA must be in calibration. Refer to chapter 4.
- Ensure that JW22 on the generator interface board is set properly for the application: Jumper JW22 pins 1-2 to provide line frequency sync pulses (for conventional imaging systems), or jumper JW22 pins 2-3 for external sync input (for digital imaging systems).

3E.3.1 Fluoro Setup Menu Structure

Figures 3E-5 and 3E-6 show the fluoro setup menu structure. Figure 3E-5 is used for generators without optional pulsed fluoro, and figure 3E-6 is used on generators with pulsed fluoro. Information on the top and bottom lines of the LCD display, such as tube number, I.I. magnification, dose setting, etc is omitted on these figures for clarity.

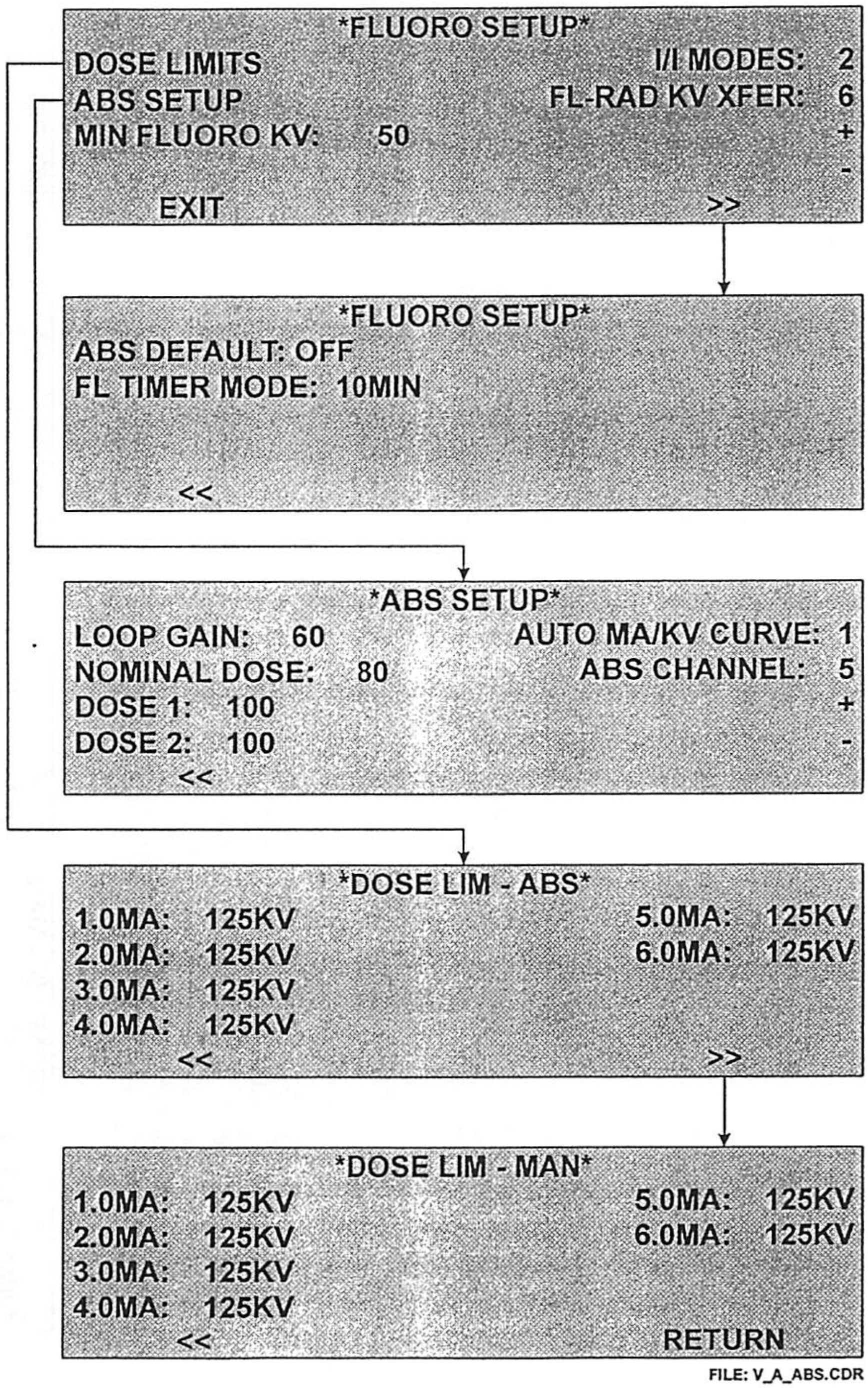


Figure 3E-5: Fluoro setup menus, non - pulsed fluoro generators

3E.3.1 Fluoro Setup Menu Structure (Cont)

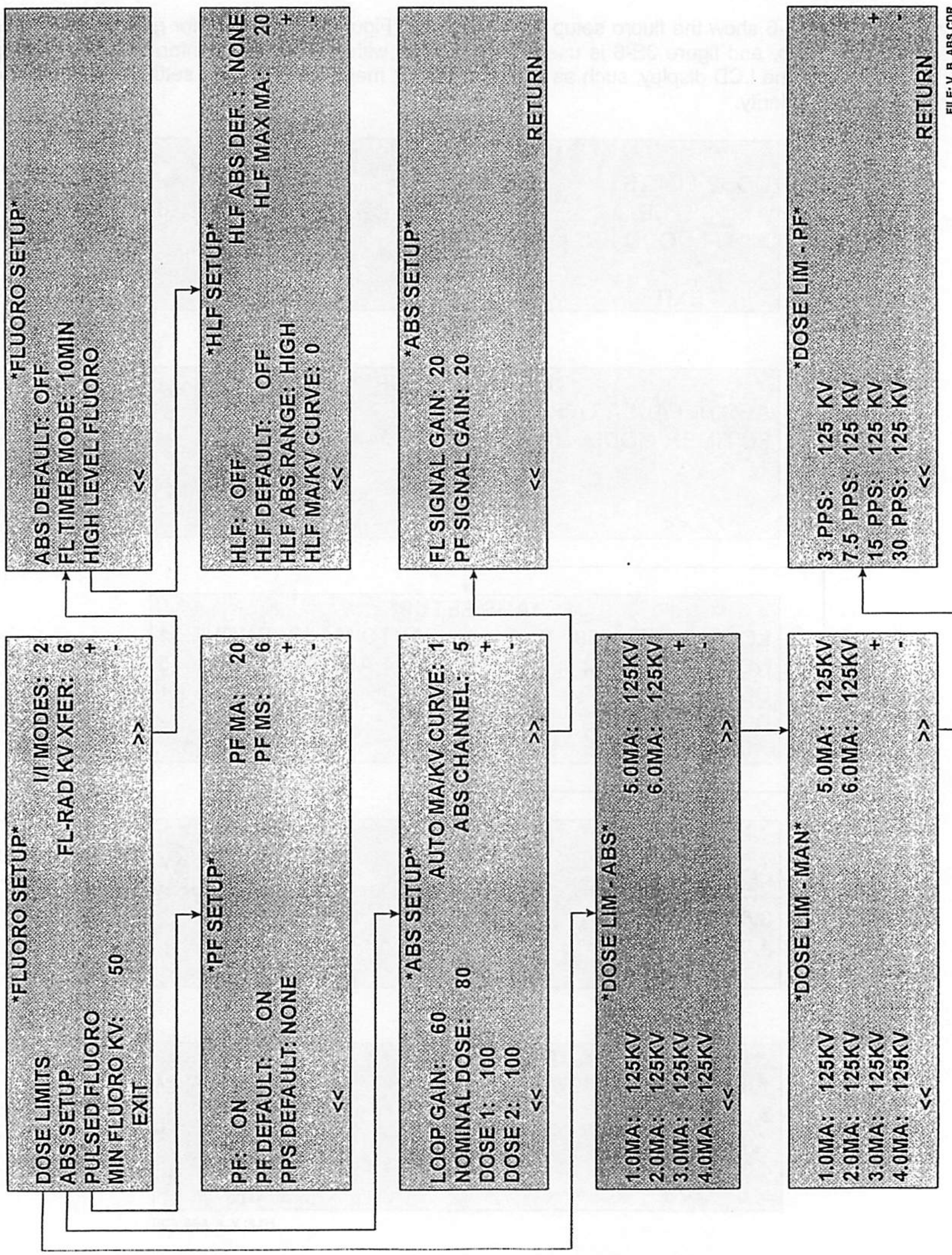


Figure 3E-6: Fluoro setup menus, pulsed fluoro generators

3E.3.2 High Level Fluoro (HLF)

High level fluoro (HLF) is optional, and is intended for use with therapy simulators only. High level fluoro operates at mA levels up to 20 mA, resulting in higher than normal patient dose. Please observe the note below.

<u>*WARNING:*</u>	***HIGH LEVEL FLUOROSCOPY IS COMPATIBLE WITH THERAPY SIMULATORS ONLY. HIGH LEVEL FLUORO MUST NOT BE ENABLED FOR OTHER APPLICATIONS***

<u>*WARNING:*</u>	***USE OF HIGH LEVEL FLUORO MAY CAUSE INCREASED TUBE HEATING. PLEASE ENSURE THAT THE X-RAY TUBE THERMAL SWITCH IS FUNCTIONING PROPERLY, THAT THE THERMAL SWITCH IS PROPERLY CONNECTED TO THE GENERATOR, AND THAT THE GENERATOR THERMAL INTERLOCK CIRCUITS ARE FUNCTIONING NORMALLY.***

Definitions of **HLF SETUP** menu items.

- **HLF**

  Selects or deselects HLF mode.

  OFF: HLF mode is disabled.

  ON: HLF mode is enabled.

- **HLF DEFAULT**

  Determines the HLF mode when a fluoroscopic receptor is selected.

  OFF: HLF defaults to *OFF* when a fluoro receptor is selected.

  ON: HLF defaults to *ON* when a fluoro receptor is selected.

- **HLF ABS RANGE**

  Determines the HLF mode of operation for ABS.

  OFF: ABS mode is disabled when HLF is on.

  HIGH: ABS will operate between 5.0 mA and the **HLF MAX MA** value, a maximum of 20 mA.

  FULL: ABS will operate between 0.5 mA and the **HLF MAX MA** value, a maximum of 20 mA.

- **HLF MA/KV CURVE**

  This allows selection of one-of-three mA / kV curves for HLF ABS operation.

  0 deselects this function. The ABS will only vary the fluoro kV during HLF operation, holding the mA constant.

  1, 2, or 3 selects one of the mA / kV curves on page 3E-13. The ABS will vary the mA and the kV as per the selected curve during HLF operation. Note that there are two sets of curves, one for the HIGH ABS range, and one for the FULL ABS range.

- **HLF ABS DEF**

  Determines whether ABS will default to ON or OFF when a fluoroscopic receptor is selected.

  NONE: ABS will remain at its previous setting when HLF mode is selected.

  OFF: ABS will default to OFF when HLF mode is selected.

  ABS: ABS will default to ON when HLF mode is selected.

- **HLF MAX MA**

  Sets the maximum allowed HLF mA. The maximum HLF mA range is 10 to 20 mA. This may be used to set the maximum HLF dose limit.

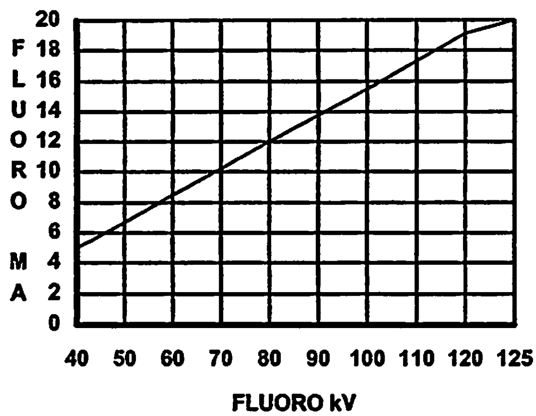
3E.3.2 High Level Fluoro (HLF) Cont

Use these steps to set the **HLF SETUP** menu items.

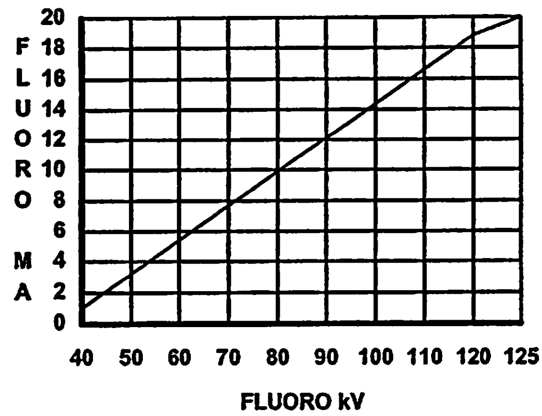
Step	Action
1.	From the **FLUORO SETUP** menu, select **HIGH LEVEL FLUORO.**
2.	In the **HLF SETUP** menu, set the HLF parameters described on the previous page as required. The parameters **HLF, HLF DEFAULT, HLF ABS RANGE,** and **HLF ABS DEF** are set by toggling the buttons adjacent to these functions. **HLF MA/KV CURVE** and **HLF MAX MA** are set by pressing the adjacent button to select these functions, then by using the **+** or **-** buttons to select the desired value.

3E.3.2 High Level Fluoro (HLF) Cont

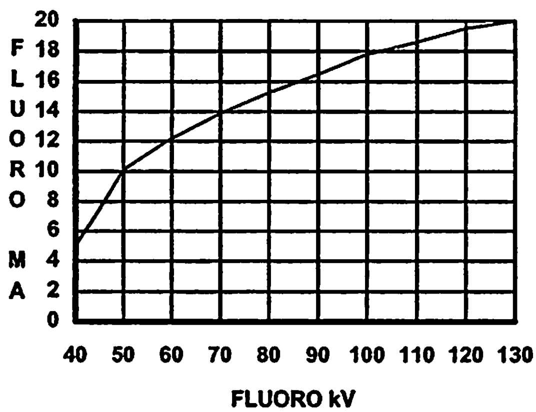
Curve 1 - HLF ABS Range = High



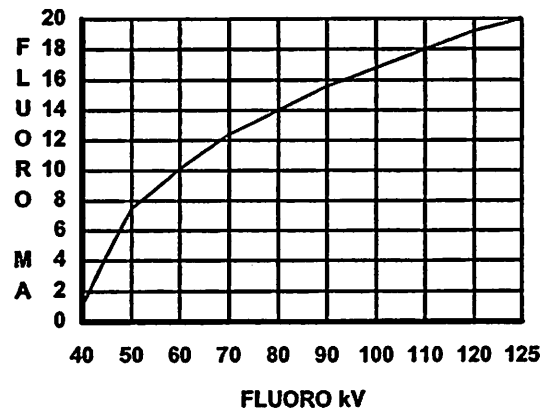
Curve 1 - HLF ABS Range = Full



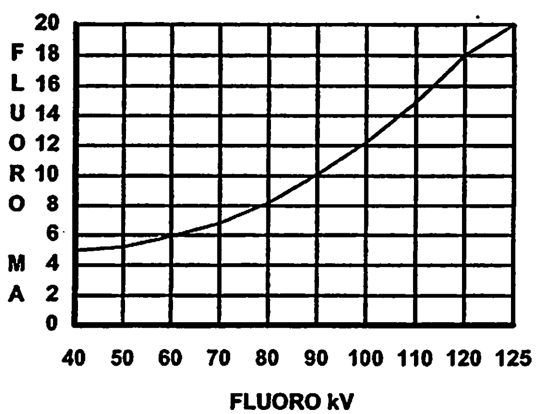
Curve 2 - HLF ABS Range = High



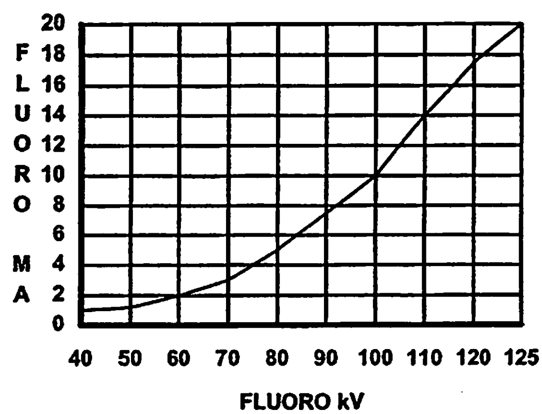
Curve 2 - HLF ABS Range = Full



Curve 3 - HLF ABS Range = High



Curve 3 - HLF ABS Range = Full



3E.3.3 Dose Limits / PF Setup

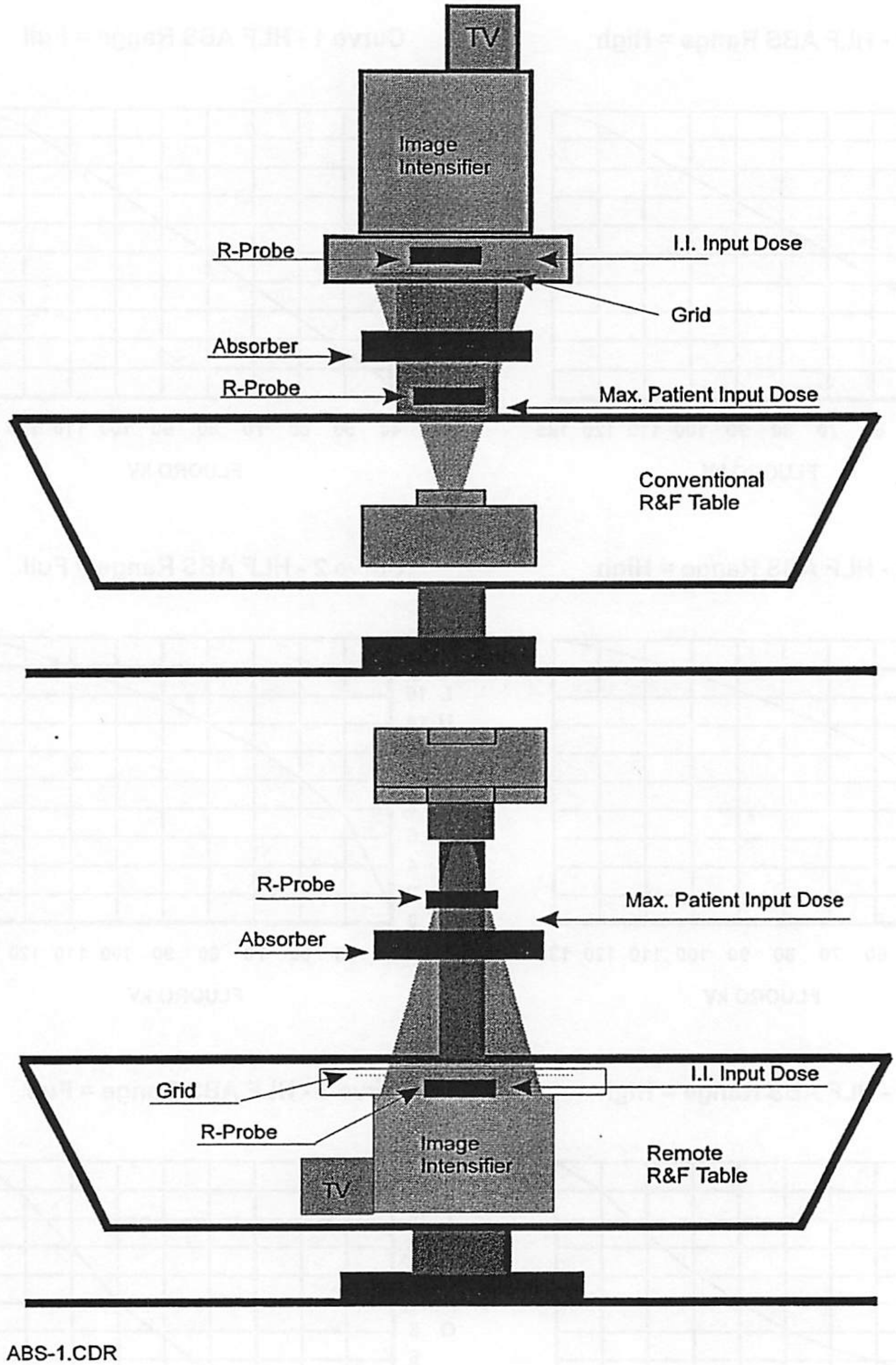


Figure 3E-7: Dose limits test setup

3E.3.3 Dose Limits / PF Setup (Cont)

This procedure sets the maximum kV allowed for each mA step in both manual and ABS mode of operation, and sets the maximum kV allowed for each PPS rate (for optional pulsed fluoro).

CAUTION:	***MAXIMUM INPUT DOSE VALUE IS USUALLY GOVERNED BY LOCAL, STATE OR COUNTRY REGULATIONS. THESE LIMITS MUST BE DETERMINED IN ADVANCE OF ATTEMPTING DOSE LIMITS SETUP, AND ADHERED TO DURING GENERATOR CALIBRATION.***

NOTE:	***REFER TO LOCAL REGULATIONS TO DETERMINE THE REQUIRED DISTANCE BETWEEN THE FOCAL SPOT AND RADIATION DETECTOR. THIS FOCAL SPOT TO DETECTOR DISTANCE MUST BE USED WHEN SETTING UP THE RADIATION DETECTOR FOR DOSE LIMITS CALIBRATION.***

CAUTION:	***PROCEDURES IN THE FOLLOWING SECTIONS REQUIRE THE PRODUCTION OF X-RAYS. IT IS THE RESPONSIBILITY OF THE INSTALLER TO FOLLOW ESTABLISHED GUIDELINES TO PROTECT ALL PERSONNEL FROM RADIATION EXPOSURE.***

Use these steps to set the **DOSE LIMITS**.

Step	Action
3.	Set up the radiation probe as per figure 3E-7 in the position indicated **Max. Patient Input Dose.** Refer to the note above re focal spot to radiation probe distance. No absorber is required at this point in the setup.
4.	Temporarily unplug the ABS pickup at J7 or J8 of the generator interface board.
5.	Temporarily de-energize the I.I. power supply, or cover the I.I. with approximately 1/16 in. (1.6 mm) lead.
6.	Enter into the generator programming mode. Refer to chapter 3C, section 3C.1.1.
7.	From the **GENERATOR SETUP** menu select **GEN CONFIGURATION.**
6.	From the **GEN CONFIGURATION** menu select **FLUORO SETUP.** Select a fluoroscopic image receptor.
7.	Select **ABS SETUP.** Select **AUTO MA/KV CURVE,** then use the **+** or **-** buttons to select auto mA/kV curve **1.**
8.	Select << to return to the **FLUORO SETUP** menu.

3E.3.3 Dose Limits / PF Setup (Cont)

IT IS RECOMMENDED THAT COPIES BE MADE OF ALL PAGES WHERE RESULTS ARE TO BE RECORDED. THE RESULTS SHOULD THEN BE RECORDED ON THE COPIES, LEAVING THE ORIGINALS BLANK.

Step	Action	Result
9.	Record the maximum permissible input dose values for ABS, non-ABS (manual), and PF (optional) modes of fluoroscopy as per local regulations.	Maximum permitted input dose: ABS mode:____________ R/Min. Non ABS mode:_________ R/Min. PF mode:____________ R/Min.
10.	From the **FLUORO SETUP** menu, select **DOSE LIMITS.**	The **DOSE LIM. - ABS** menu will be displayed.
11.	From the **DOSE LIM - ABS** menu, select >>.	The **DOSE LIM. - MAN** menu will be displayed.
12.	Ensure that ABS is switched OFF via the console. Also, ensure that PF is switched OFF via the console (if applicable).	
13.	Set the default kV for each mA station in the **DOSE LIM - MAN** menu to the maximum permissible value (110 or 125 kV) as per local regulations. To do this, select the desired mA in the LCD display, then use the + or - buttons adjacent to the LCD display to set the maximum kV.	
14.	Enter the value **6.0** mA in the fluoro control section of the console.	
15.	While observing the dosimeter, make a fluoroscopy exposure. Adjust the kV via the fluoro section of the console such that the maximum permitted dose as recorded in step 9 for ABS mode is not exceeded.	
16.	Record the kV value as determined in the previous step for the **6.0** mA setting.	Max kV limit for 6.0 mA = ______(ABS)
17.	Repeat steps 14 to 16 for **5.0** mA.	Max kV limit for 5.0 mA = ______(ABS)
18.	Repeat steps 14 to 16 for **4.0** mA.	Max kV limit for 4.0 mA = ______(ABS)
19.	Repeat steps 14 to 16 for **3.0** mA.	Max kV limit for 3.0 mA = ______(ABS)
20.	Repeat steps 14 to 16 for **2.0** mA.	Max kV limit for 2.0 mA = ______(ABS)
21.	Repeat steps 14 to 16 for **1.0** mA.	Max kV limit for 1.0 mA = ______(ABS)
22.	Re-enter the value **6.0** mA in the fluoro control section of the console.	

3E.3.3 Dose Limits / PF Setup (Cont)

Step	Action	Result
23.	While observing the dosimeter, make a fluoroscopy exposure. Adjust the kV via the fluoro section of the console such that the maximum permitted dose as recorded in step 9 for non-ABS mode is not exceeded.	
24.	Record the kV value as determined in the previous step for the **6.0** mA setting.	Max kV limit for 6.0 mA = ______(MAN)
25.	Repeat steps 22 to 24 for **5.0** mA.	Max kV limit for 5.0 mA = ______(MAN
26.	Repeat steps 22 to 24 for **4.0** mA.	Max kV limit for 4.0 mA = ______(MAN
27.	Repeat steps 22 to 24 for **3.0** mA.	Max kV limit for 3.0 mA = ______(MAN
28.	Repeat steps 22 to 24 for **2.0** mA.	Max kV limit for 2.0 mA = ______(MAN
29.	Repeat steps 22 to 24 for **1.0** mA.	Max kV limit for 1.0 mA = ______(MAN)
30.	Enter the kV limit for non-ABS mode as recorded in step 24 for the 6.0 mA station into the 6.0 mA dose limit step in the LCD display by selecting the 6.0 mA step in the **DOSE LIM - MAN** menu, then entering the required kV value using the **+** or **-** buttons adjacent to the LCD display.	
31.	Repeat the previous step for the **5.0** mA to **1.0** mA stations (non-ABS kV limits).	
32.	Select **<<** to return to the **DOSE LIM-ABS** menu.	
33.	Enter the kV limit for ABS mode as recorded in step 16 for the 6.0 mA station into the 6.0 mA dose limit step in the LCD display by selecting the 6.0 mA step in the **DOSE LIM - ABS** menu, then entering the required kV value using the **+** or **-** buttons adjacent to the LCD display.	
34.	Repeat the previous step for the **5.0** to **1.0** mA stations (ABS kV limits).	
35.	Select **<<** to return to the **FLUORO SETUP** menu. If PF is not available, go to section 3E.3.4. If the PF option is available, continue with the next step.	
36.	From the **FLUORO SETUP** menu, select **PULSED FLUORO**.	The **PF SETUP** menu will be displayed.

3E.3.3 Dose Limits / PF Setup (Cont)

Definitions of **PF SETUP** menu items.

- **PF** — **OFF** disables pulsed fluoro operation.

  ON allows pulsed fluoro to be selected via the console.

- **PF DEFAULT** — Determines the fluoro mode when a fluoroscopic receptor is selected.

  NONE defaults fluoroscopy to the previously selected mode. If PF was ON when fluoro was last used, PF will default to ON when fluoro is re-selected.

  OFF defaults to continuous fluoro mode when a fluoro receptor is selected.

  ON defaults to pulsed fluoro mode when a fluoro receptor is selected.

- **PPS DEFAULT** — Determines the PPS rate when pulsed fluoroscopy mode is selected.

  NONE defaults the PPS rate to the last selected value. If the last used PPS was 15, the PPS will default to 15 when PF is reselected.

  Selecting one of the available PPS rates (3, 7.5, 15, or 30 PPS) will default the PPS to that value when PF is selected.
  The PF SETUP menu displays 60 Hz based PPS rates only. For systems with 50 Hz based sync input, select the PPS rate nearest to the desired PPS (2.5, 6.25, 12.5, or 25 PPS).

- **PF MA** — Sets the pulsed fluoro mA. Typical pulsed fluoro mA is 15 to 20 mA.

- **PF MS** — Sets the PF pulse width in milliseconds. Typical pulse widths are 5 to 8 ms.

Step	Action	Result
37.	Set **PF**, **PF DEFAULT**, and **PPS DEFAULT** as appropriate. These items are set by selecting the button adjacent to the desired parameter, then toggling the button to make the desired selection.	
38.	Set the **PF MA** and **PF MS** by pressing the button adjacent to the desired selection, then setting the desired value using the + or - buttons adjacent to the LCD display.	Use care in choosing these parameters. High mA and / or high ms settings may require that the kV be limited to an unsuitably low value.
39.	Select << to return to the **FLUORO SETUP** menu.	
40.	From the **FLUORO SETUP** menu, select **DOSE LIMITS.**	The **DOSE LIM - ABS** menu will be displayed.
41.	From the **DOSE LIM - ABS** menu, press >> *two times.*	The **DOSE LIM - PF** menu will be displayed.
42.	Select a fluoroscopic image receptor. Ensure that pulsed fluoro is ON.	

3E.3.3 Dose Limits / PF Setup (Cont)

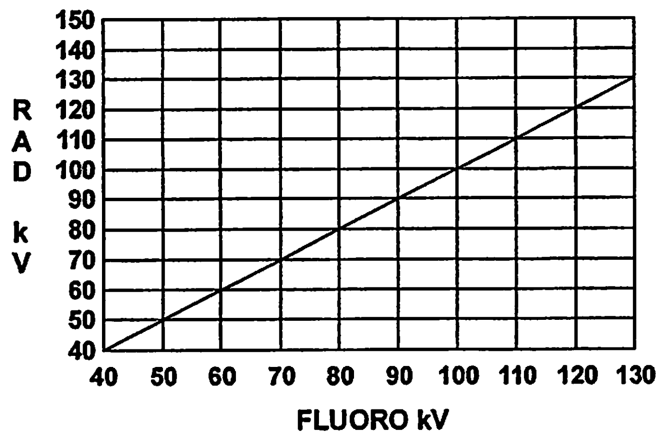
Step	Action	Result
43.	Set the default kV for each PPS station in the **DOSE LIM - PF** menu to the maximum permissible value as per local regulations. To do this, select the desired PPS in the LCD display, then use the **+** or **-** buttons adjacent to the LCD display to set the maximum kV.	
44.	Select **3** PPS in the fluoro control section of the console.	
45.	While observing the dosimeter, make a pulsed fluoroscopy exposure. Adjust the kV via the fluoro section of the console such that the maximum permitted dose as recorded in step 9 for PF mode is not exceeded.	
46.	Record the kV value as determined in the previous step for the **3** PPS setting.	Max kV limit for 3 PPS = _______(PF)
47.	Repeat steps 44 to 46 for the **7.5** PPS step.	Max kV limit for 7.5 PPS = _______(PF)
48.	Repeat steps 44 to 46 for the **15** PPS step.	Max kV limit for 15 PPS = _______(PF)
49.	Repeat steps 44 to 46 for the **30** PPS step.	Max kV limit for 30 PPS = _______(PF)
50.	Enter the kV limit as recorded in step 46 for 3 PPS into the 3 PPS dose limit step in the LCD display by selecting the 3 PPS step in the **DOSE LIM - PF** menu, then entering the required kV value using the **+** or **-** buttons adjacent to the LCD display.	
51.	Repeat the previous step for the **7.5** to **30** PPS settings.	
IF *PF MA* OR *PF MS* ARE CHANGED AS PER STEP 38, THE PULSED FLUORO DOSE LIMITS MUST BE RECALIBRATED, AS THESE WILL INFLUENCE THE MAXIMUM PERMISSIBLE KV.		
52.	Select << as required to return to the **FLUORO SETUP** menu.	The **FLUORO SETUP** menu will be displayed.

3E.3.4 ABS Defaults

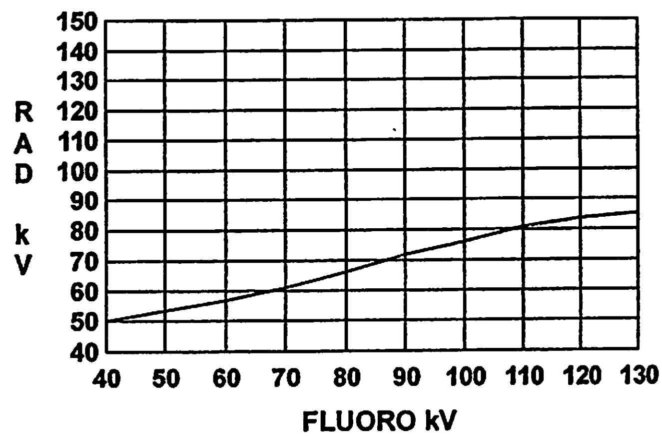
Step	Action
1.	From the **FLUORO SETUP** menu, select **MIN FLUORO KV.** Press the + or - buttons to select the minimum kV to be allowed in fluoro.
2.	Select **I/I MODES.** Press the + or - buttons to select the number of magnification modes in the I.I. (2 corresponds to 2 mag modes plus normal mode). If this is set to **0,** the console and remote fluoro control will not display the mag status. This may be desired if an external mag mode control and display are used.
3.	Select **FL-RAD KV XFER.** Press the + or - buttons to select the desired fluoro - rad kV transfer curve. This allows selection of one-of-seven fluoro to rad kV transfer curves (Millenia) or one-of-ten fluoro to rad kV transfer curves (Indico 100). When in fluoro operation with ABS on, the fluoro kV value is transferred to the RADIOGRAPHY section of the console at the end of the fluoro exposure. This presets the rad kV in preparation for a rapid follow-on radiographic exposure for digital acquisition or spot film work. Selecting **0** disables this function. Graphs of the fluoro kV to rad kV transfer function are shown on the next two pages.

3E.3.4 ABS Defaults (Cont)

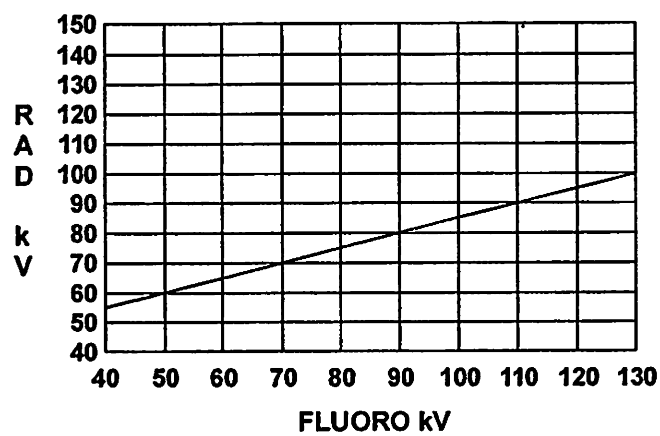
CURVE 1



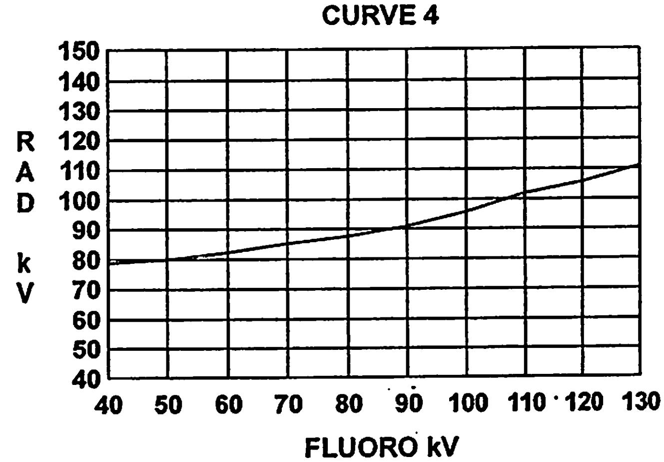
CURVE 2



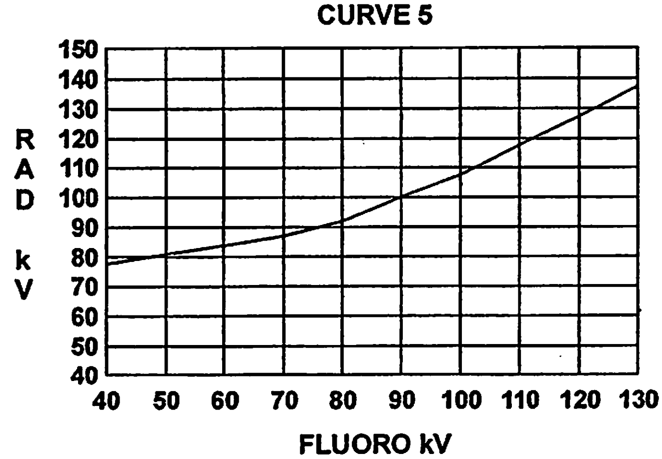
CURVE 3



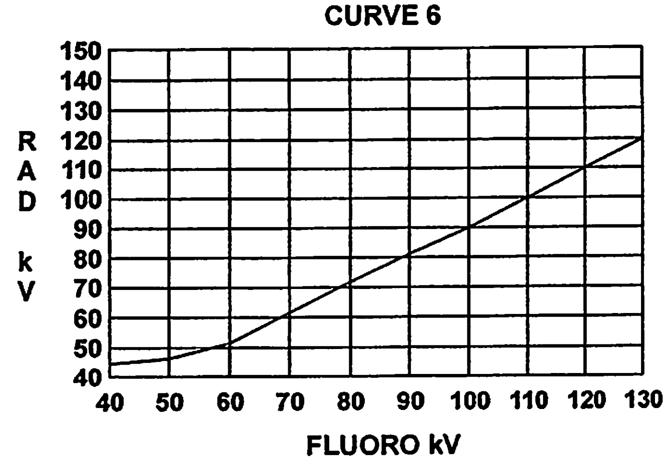
CURVE 4



CURVE 5

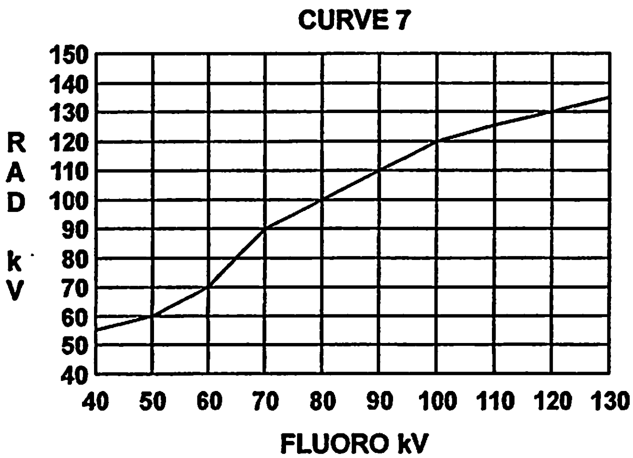


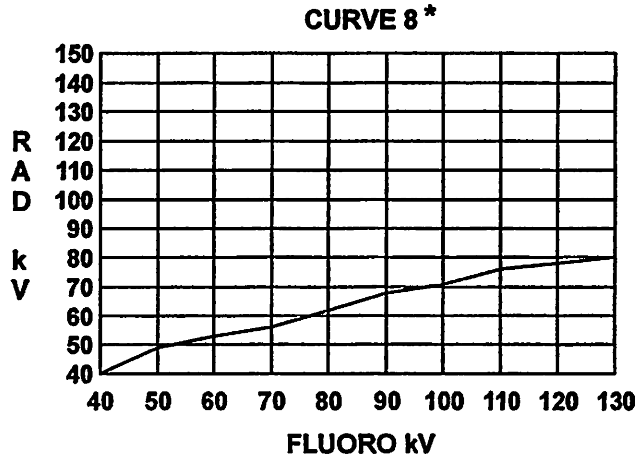
CURVE 6

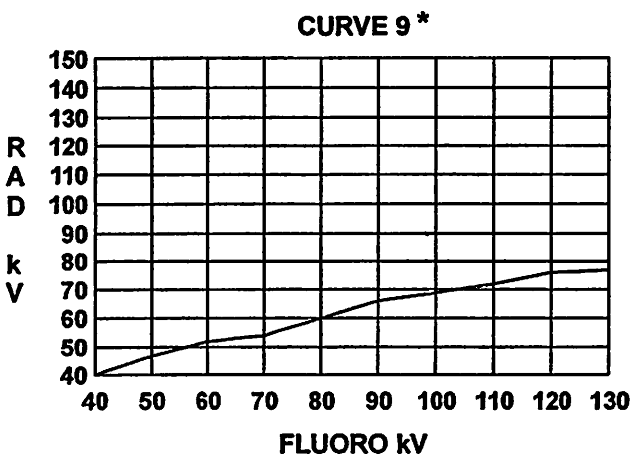


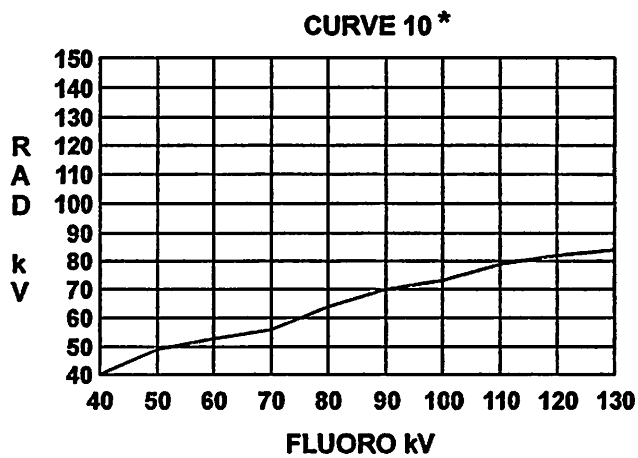
FILE: ABS_CURVES1.CDR

3E.3.4 ABS Defaults (Cont)







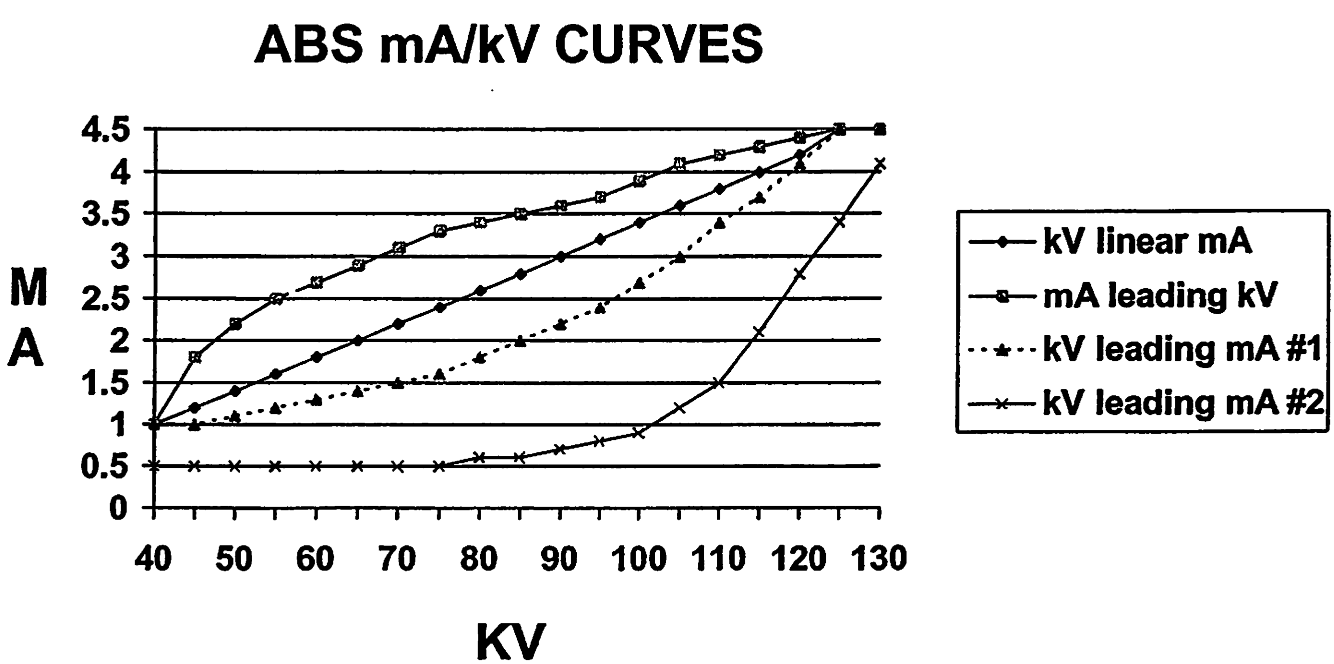


*** Fluoro - Rad kV curves 8 to 10 only apply to Indico 100**

FILE: ABS_CURVES2.CDR

3E.3.4 ABS Defaults (Cont)

Step	Action
4.	From the **FLUORO SETUP** menu select >>. The above menu will display.
5.	Select **ABS DEFAULT.** Toggle to select **NONE, OFF,** or **ABS.** **NONE:** No default selected, ABS remains at its last setting. **OFF:** Defaults to ABS OFF. **ABS:** Defaults to ABS ON.
6.	Select **FL TIMER MODE.** Toggle to select **5MIN** or **10MIN.** **5MIN:** Alarms at 5.0 minutes, and stops incrementing the timer. Fluoro exposures will continue. **10MIN:** Alarms at 5.0 minutes, stops incrementing the timer at 9.6 minutes. Fluoro exposures will be inhibited at 9.6 minutes.
7.	Select << to return to the **FLUORO SETUP** menu.
8.	Select **ABS SETUP.** The **ABS SETUP** menu will display as shown below.
9.	Select **ABS CHANNEL.** This selects the hardware ABS input. This must be set to **5.**
10.	Select **AUTO MA/KV CURVE.** Press the **+** or **-** buttons to select the desired fluoro mA / kV curve. This sets how the kV and mA change during ABS operation. **0:** Changes kV only (mA set manually). **1:** kV linear mA. **2:** mA leading kV. **3:** kV leading mA #1. **4:** kV leading mA #2 (reduced dose). Refer to the graph of these curves as shown below.



3E.3.5 I.I. Input Dose Calibration

This procedure sets the actual operating input dose to the I.I. Please note the following:

- Ensure that the collimator is adjusted to only expose the I.I. input.
- The central ray from the X-ray tube must coincide with the center of the I.I.
- The required I.I. input dose must be known before proceeding.

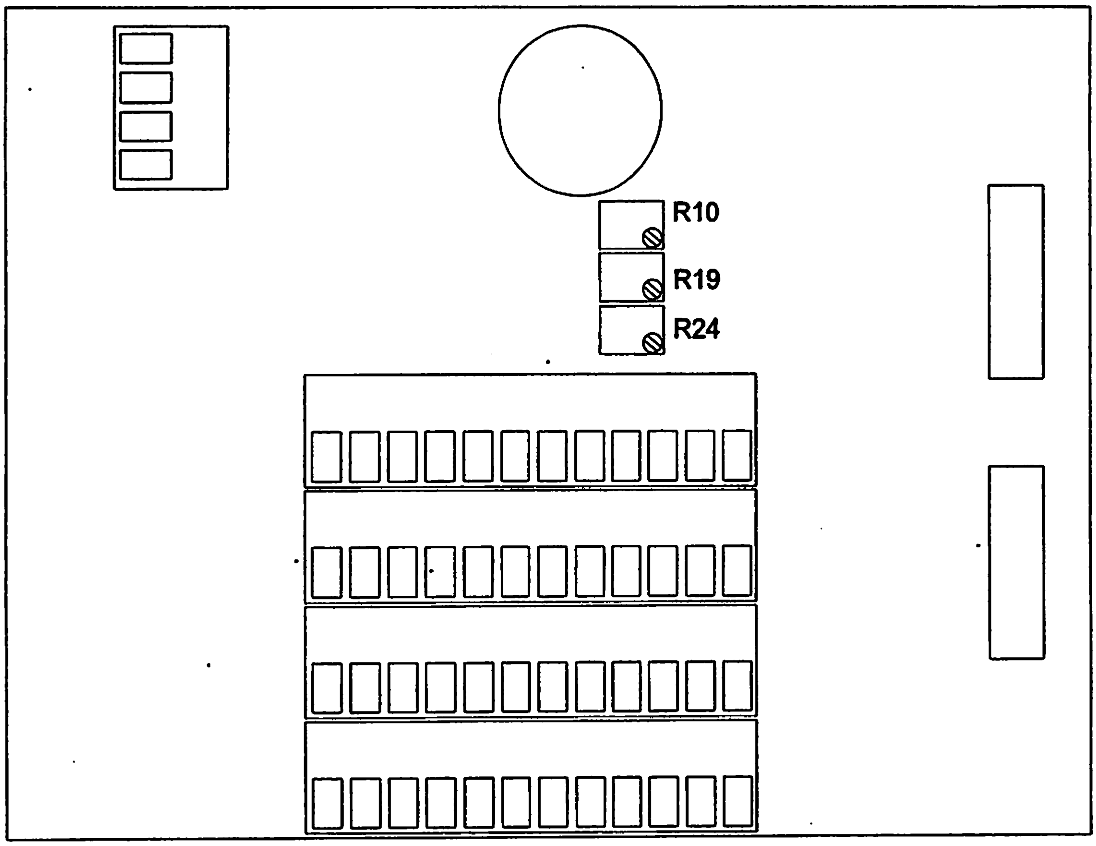


Figure 3E-8: PMT high voltage adjustment (AEC interface board)

- R10 adjusts the PMT high voltage during ABS operation.
- R19 and R24 adjust the ion chamber bias voltage and PMT high voltage during AEC operation. Refer to chapter 3D for details.

3E.3.5 I.I. Input Dose Calibration (Cont)

Step	Action
1.	Reconnect the ABS pickup plug that was temporarily disconnected from J7 or J8 of the generator interface board in an earlier step.
2.	Re-energize the I.I. power supply or remove the lead that was temporarily installed in an earlier step.
3.	Set up the radiation probe as per figure 3E-7 in the position indicated **I.I. Input Dose.** This must be able to read dose values as low as 2 to 3 mR / min.
4.	Set up the absorber as shown in figure 3E-7. 1 1/2" (40 mm) of aluminum or 20 cm of water is recommended. Ensure that the absorber covers the full input field of the I.I.
5.	Ensure that the ABS is switched off. Select 75 kV and 1.5 mA.
6.	Ensure that the I.I. is in the NORMAL mode (MAG = 0). Ensure that an anti-scatter grid, if used, is properly installed.
7.	Make a fluoro exposure and measure the I.I. input dose.
8.	Adjust the fluoro kV to achieve the desired input dose.
9.	Connect a DVM or 'scope to TP8 and ground of the generator interface board.
10.	***FOR GENERATOR INTERFACE BOARDS WITH ABS GAIN ADJUST POTENTIOMETER R48 (no pulsed fluoro option):*** Adjust **R48** on the generator interface board to achieve 1.50 VDC at the test points connected to in the previous step. ***FOR GENERATOR INTERFACE BOARDS WITH DIGITAL ABS GAIN ADJUST POT (units with pulsed fluoro option):*** • From the **ABS SETUP** menu, select >>. • Select **FL SIGNAL GAIN**, then use the **+** or **-** buttons to adjust the digital gain pot to achieve 1.50 VDC at the test points connected to in the previous step. • Select **PF SIGNAL GAIN**, then use the **+** or **-** buttons to adjust the I.I. input dose to achieve the desired ***frame rate*** dose. Setting the PF signal gain to **0** causes the generator to use the FL SIGNAL GAIN setting with PF. This may be used when a conditioned ABS signal is provided to the generator where the continuous and PF signal levels are scaled to be equal. • Select **<<** to return to the **ABS SETUP** menu.
11.	From the **ABS SETUP** menu, select **LOOP GAIN.** Press the **+** or **-** buttons to select the initial value of **100.**
	ENSURE THAT THE DOSE IS SET TO 0 ON THE CONSOLE.
12.	From the **ABS SETUP** menu, select **NOMINAL DOSE.** Press the **+** or **-** buttons to select a value of 200.
13.	Switch the ABS on. The LED adjacent to the ABS switch will light.
	NOTE: STEPS 14 TO 16 APPLY ONLY IF USING A PMT. IGNORE THESE STEPS FOR OTHER ABS PICKUP DEVICES **WARNING: SWITCH OFF THE GENERATOR AND ENSURE THAT ALL CAPACITORS ARE DISCHARGED BEFORE MAKING AND REMOVING THE PMT CURRENT MEASURING EQUIPMENT**

3E.3.5 Dose1/Dose2 Calibration (Cont)

Step	Action	
14.	Connect a micro ammeter in series with the PMT signal output. Alternately, if a micro ammeter is not available, follow this procedure: • Temporarily connect a resistor of known value (100K is suggested) from either end of R61 on the generator interface board to ground. A DVM can then be used to measure the voltage developed by the PMT current across this resistor. However, this is not the preferred method of measurement.	
15.	Adjust the PMT high voltage using **R10** (refer to figure 3E-6) on the AEC interface board while pressing the fluoro footswitch such that the PMT current is 20 ± 5 uA at the desired I.I. input dose. This corresponds to a voltage of 2.00 ± 0.50 VDC for a 100K resistor if using the voltmeter method in the above step. The high voltage should be approximately -750 VDC at this point. *The PMT high voltage is adjusted to yield the PMT **current** noted in this step. The approximate value of PMT voltage is stated for reference only. The PMT voltage does not normally need to be measured in this step, however, if it is desired to do so for troubleshooting purposes please note the following:* ***USE TP5 ONLY ON THE AEC INTERFACE BOARD FOR THE HV METER GROUND WHEN MEASURING PMT HIGH VOLTAGE. CONNECT THE GROUND FIRST BEFORE MEASURING THE HIGH VOLTAGE.*** **DO NOT ATTEMPT TO MEASURE THIS WITHOUT A SUITABLE METER.**	
16.	Disconnect the meter (and resistor if applicable) that was connected in step 3. Reconnect the PMT signal lead if required.	
17.	Verify stability of the ABS system with continuous fluoroscopy. Check stability with and without the absorber. The ABS should quickly stabilize without hunting or settling on the wrong kV value. If the ABS is unstable, try reducing the sensitivity of the ABS pickup device first. If this does not work, try reducing the **LOOP GAIN**. However, be aware that reducing the loop gain increases the hysterisis ("deadband"), consequently the kV may stabilize on any value within the deadband range.	
18.	Initiate fluoro operation and measure the input dose to the I.I. If this value is not as desired adjust the **NOMINAL DOSE** using the + or - buttons as required. Record the nominal dose calibration value as indicated in the LCD display in the next step.	
19.	Record the **NOMINAL DOSE** calibration value as determined in the previous step.	Nominal Dose (cal value): _______
20.	Record the desired dose 1 and dose 2 input values.	Desired dose values: Dose 1:____________ mR / Min Dose 2:____________ mR / Min
	To disable the ability to make incremental dose changes, set the **DOSE 1** and **DOSE 2** calibration values the same as the nominal dose value. If doing so, skip steps 21 to 25.	
21.	Initiate fluoro operation and measure the input dose to the I.I. Adjust to the desired dose 1 value by altering the **NOMINAL DOSE** calibration value as required using the + or - buttons.	
22.	When the desired dose 1 value has been achieved, enter the new NOMINAL DOSE value in the **DOSE 1** location using the + or - buttons.	

3E.3.5 Dose1/Dose2 Calibration (Cont)

Step	Action
23.	Initiate fluoro operation and measure the input dose to the I.I. Adjust to the desired dose 2 value by altering the **NOMINAL DOSE** calibration value as required using the **+** or **-** buttons.
24.	When the desired dose 2 value has been achieved, enter the new NOMINAL DOSE value in the **DOSE 2** location using the **+** or **-** buttons.
25.	Reset the original NOMINAL DOSE value by entering the value recorded in step 19 of this table into the **NOMINAL DOSE** location using the **+** or **-** buttons.
26.	Verify each dose (nominal, dose 1, and dose 2) by initiating fluoro operation and measuring the I.I. input dose.
27.	Press **<<**, then **EXIT** to exit out of FLUORO SETUP mode. Press **EXIT**, then **EXIT SETUP** to return to the normal operating mode. This completes the fluoro calibration.

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CHAPTER 4

ACCEPTANCE TESTING

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4.1.0 INTRODUCTION

This section details acceptance testing, which verifies that the generator is performing within limits. It is recommended that this be done whenever the generator is reconfigured, or component(s) are replaced which may affect the X-ray output. Examples of such components are the X-ray tube, HT tank, generator CPU board, generator interface board, AEC board, control board 1 and control board 2 in the HF power supply (Millenia) or the control board (Indico 100), and the filament supply board(s).

WARNING:	***1. USE EXTREME CARE IN MEASURING HIGH VOLTAGES. ACCIDENTAL CONTACT MAY CAUSE INJURY OR DEATH.*** ***2. EVEN WITH THE GENERATOR SWITCHED OFF AT THE CONSOLE, (OR THE LOCKOUT SWITCH INSIDE THE MAIN CABINET LOCKED OUT), MAINS VOLTAGE IS STILL PRESENT INSIDE THE GENERATOR CABINET. THIS VOLTAGE IS EXTREMELY DANGEROUS; USE EXTREME CAUTION.*** ***3. THE ELECTROLYTIC CAPACITORS, LOCATED ON THE BASE OF THE HF POWER SUPPLY, PRESENT A HAZARD FOR A MINIMUM OF 5 MINUTES AFTER THE POWER HAS BEEN SWITCHED OFF. VERIFY THAT THESE CAPACITORS ARE DISCHARGED BEFORE SERVICING OR TOUCHING ANY PARTS.***

WARNING:	***THE PROCEDURES IN THIS CHAPTER REQUIRE THE PRODUCTION OF X-RAYS. TAKE ALL SAFETY PRECAUTIONS TO PROTECT PERSONNEL FROM X-RADIATION.***

WARNING:	***1. ALWAYS ENSURE THAT THE EQUIPMENT UNDER TEST AND ALL ASSOCIATED TEST EQUIPMENT IS PROPERLY GROUNDED.*** ***2. ENSURE THAT THE HIGH VOLTAGE CABLES ARE INTACT / UNDAMAGED AND PROPERLY CONNECTED BEFORE ATTEMPTING EXPOSURES.***

ENSURE THAT THE FOLLOWING ITEMS ARE COMPLETED PRIOR TO PERFORMING THE ACCEPTANCE TESTING:

- The generator is interfaced to room equipment noted in the product description.
- The tube auto calibration has been done as per chapter 2 of this manual.
- The receptors have been programmed as per chapter 3C of this manual.
- If the installation has AEC, verify that all receptors have been calibrated as per chapter 3D of this manual.
- If the installation has ABS, verify that the imaging system has been calibrated as per chapter 3E of this manual.
- Acceptance testing shall only be started after the installation is complete i.e.; generator in final position and installed as per the previous chapters of this manual.

4.2.0 REQUIRED TEST EQUIPMENT FOR GENERATOR VERIFICATION.

- kV measuring device such as a Dynalyzer (or equivalent). This will be required for verifying kV and mA calibration during preventative maintenance or if recalibration is necessary, for example after replacing the generator CPU board or control board 1 in the HF power supply. See note on page 11 regarding use of a Dynalyzer on Indico 100 generators.
- Storage oscilloscope.
- mA / mAs meter.
- Radiation meter 0-1000 mR and 1-15 R/min.
- Lead diaphragm or equivalent to collimate the beam.
- General purpose DVM.
- Strobe or reed tachometer.
- Current probe 0 to 20 amps AC.
- A set of HVL filters.
- Calculator.

4.3.0 ACCEPTANCE TESTS (BASIC FUNCTIONS)

4.3.1 Console Rad Tests

Step	Action	Result	Check
1.	Press the power ON then power OFF buttons on the console.	Unit switches on and off.	
2.	Press power ON again to switch the unit on.	Unit switches on.	
3.	Press each of the receptor buttons that are active (those that have been enabled during generator configuration).	Verify that the adjacent LED lights for each receptor. For receptor 6 on the 23 X 56 cm console (adjacent to the power ON button) only the top LED will light.	
Note: The TECHNIQUE / MODE SELECT button used to select AEC / mAs / mA/ms in steps 4, 5, 6 will only be functional if APR mode has been disabled during generator configuration (the TECHNIQUE SELECT function is disabled if APR mode is enabled).			
4.	Select an active radiographic receptor that has AEC programmed. Press the technique select button to select AEC. Verify the following displays:	A: The AEC LED lights. B: kV value is displayed. C: mA value is displayed. D: "AEC", mAs value or ms value is displayed depending on the AEC backup mode selected. E: Density value is displayed.	
5.	Press the technique select button to select **mAs.** Verify the following displays:	A: The **mAs** LED lights. B: kV value is displayed. C: mAs value is displayed.	
6.	Press the technique select button to select **mA/ms.** Verify the following displays:	A: The **mA/ms** LED lights. B: kV value is displayed. C: mA value is displayed. D: ms value is displayed.	
7.	Press the kV **+/-** buttons.	kV increases if kV **+** is pressed. kV decreases if kV **-** is pressed.	
8.	Ensure that three-point operation is selected **(mA/ms).** Press the mA **+/-** buttons.	mA increases if mA **+** is pressed. mA decreases if mA **-** is pressed.	
9.	Ensure that three-point operation is selected **(mA/ms).** Press the ms **+/-** buttons.	ms increases if ms **+** is pressed. ms decreases if ms **-** is pressed.	
10.	Ensure that AEC is selected. Press the DENSITY **+/-** buttons.	Density increases if density **+** is pressed. Density decreases if density **-** is pressed.	
11.	Press the focus select button.	The large and small focal spot LED's alternately light as the switch is toggled.	
12.	Ensure that AEC is selected. Press the film-screen select button.	The three film-screen LED's (I, II, III) alternately light as the switch is toggled.	
13.	Select 60 kV, 50 mA, 100 ms. Press the PREP button.	The adjacent LED lights.	

4.3.1 Console Rad Tests (Cont)

Step	Action	Result	Check
14.	Press the X-ray button.	The X-ray warning indicator lights during an X-ray exposure, and an audible tone is heard from the console.	
15.	Ensure that AEC is selected. Press the **FIELD** select button (23 X 56 cm console) or press the individual AEC field select buttons in sequence (all other consoles).	The three field indicator LED's light to indicate field selection [L+C+R], [R], [C], [R+C], [L], [L+R], [L+C] as the switch is toggled (23 X 56 cm console). For other consoles, the LEFT, CENTER, and RIGHT field selection LED's should light as each field is selected.	
16.	Press the power OFF button on the console.	The unit switches off.	

4.3.2 Console Fluoro Tests

This section applies only to R&F units.

BEFORE CONTINUING, ENSURE THAT THE REMOTE FLUORO CONTROL IS CONNECTED (IF USED WITH THIS INSTALLATION).

Step	Action	Result	Check
1.	Press the power ON button on the console.	Unit switches on.	
2.	Select an active fluoro receptor.	A: The fluoro display area of the console lights. B: The remote fluoro control panel lights (if used).	
3.	Press the DOSE button.	The dose display on the LCD display changes as the switch is toggled.	
4.	Press the MAG button on the console. Press the MAG +/- buttons on the remote fluoro control if used.	A: The MAG display on the console LCD and remote fluoro display changes (IF **I/I** MODES IS ENABLED DURING GENERATOR CONFIGURATION) as the MAG button is toggled. B: The Mag display on the console LCD and remote fluoro display increases if MAG + button is pressed, decreases if MAG - button on the remote fluoro control is pressed (IF **I/I MODES** IS ENABLED DURING GENERATOR CONFIGURATION.	

4.3.2 Console Fluoro Tests (Cont)

Step	Action	Result	Check
5.	Press the ABS button on the console to enter ABS mode.	A: The LED adjacent to the button lights. B: The LED adjacent to the **ABS** button on the remote fluoro control (if used) lights.	
6.	Press the **ABS** button on the remote fluoro control if used, else press the ABS button on the console.	The ABS indicator LED's adjacent to the ABS buttons on the console and the remote fluoro control (if used) switch off.	
7.	Press the fluoro kV **+/-** buttons on the console and remote fluoro control if used.	kV increases if kV **+** is pressed. kV decreases if kV **-** is pressed. Confirm tracking of the kV displays on the console and the remote fluoro control.	
8.	Press the fluoro mA **+/-** buttons on the console and remote fluoro control if used.	mA increases if mA **+** is pressed. mA decreases if mA **-** is pressed. Confirm tracking of the mA displays on the console and the remote fluoro control.	
9.	Press the ACCUMULATED TIME button on the console.	The accumulated time indicator will light, then extinguish on the console as the switch is toggled.	
10.	Press the ACCUMULATED TIME button on the remote fluoro control if used.	The **ACC** indicator will light, then extinguish on the remote fluoro control as the switch is toggled.	
11.	Press the pulse fluoro button on the console (if the pulse fluoro option is fitted).	The pulse fluoro indicator will light, then extinguish as the switch is toggled.	
12.	Press the power OFF button on the console.	Unit switches off.	

4.3.3 Generator Preliminary Tests

WARNING: ***USE EXTREME CAUTION WHEN MEASURING HIGH VOLTAGES.***

NOTE: ***VERIFY THE POSITION OF EACH OF THE SWITCHES OF SW1 ON THE GENERATOR CPU BOARD FOR THE GENERATOR UNDER TEST AS PER THE FOLLOWING TABLE. THESE SWITCHES MUST BE SET CORRECTLY PRIOR TO CONTINUING. REFER TO THE COMPATIBILITY STATEMENT / PRODUCT DESCRIPTION (SECTION 1D) AS NECESSARY FOR THE PRODUCT DEFINITION.***

4.3.3 Generator Preliminary Tests (Cont)

For GENERATOR POWER, refer to copy of the compatibility statement / product description (PD) form in Chapter 1D			
GENERATOR POWER	**SW1-3**	**SW1-2**	**SW1-1**
30 kW (350 Series) ***Millenia only***	ON	ON	OFF
32 kW (***Indico 100 only***)	ON	ON	OFF
40 kW (***Indico 100 only***)	ON	OFF	ON
50 kW (650 Series)	OFF	ON	ON
65 kW (850 Series)	OFF	ON	OFF
80 kW (1050 Series)	OFF	OFF	ON
100 kW (***Indico 100 only***)	OFF	OFF	OFF
SW1-4: OFF for two filament boards, ON for one filament board.			
SW1-5: OFF for 150 max kV, ON for 125 max kV.			
SW1-6: OFF for dual speed, ON for low speed.			
SW1-7: OFF for 2 tube, ON for 1 tube.			
SW1-8: ON. Do not inadvertently switch this to OFF! Setting to OFF resets to the factory defaults (calibration, configuration, etc).			

Step	Action	Result	Check
1.	Ensure unit is switched OFF.	DS1 on generator interface board is lit.	
2.	Press the power ON button on the console.	One or more LED's on the driver/auxiliary board in HF power supply are lit. *Millenia generators only.*	
3.	Switch OFF the console. Switch the NORMAL/LOCKOUT switch on the generator interface board to **LOCKOUT**. Switch the console ON.	The generator will not switch on with the switch in the lockout position.	
4.	Switch the NORMAL/LOCKOUT switch to the **NORMAL** position. Switch the console ON.	The unit switches on.	
5.	Verify that each active receptor (those that have been enabled during generator configuration) displays the desired X-ray tube on the LCD display.	Receptor 1 Tube # _____ Receptor 2 Tube # _____ Receptor 3 Tube # _____ Receptor 4 Tube # _____ Receptor 5 Tube # _____ Receptor 6 Tube # _____	

4.3.3 Generator Preliminary Tests (Cont)

6.	Verify that each active receptor selects the desired AEC channel. This must be done by measuring the voltage at specified pins on the AEC board edge connector. Logic low (approx. 1 VDC) means CHANNEL ENABLED, logic high (approx. 11.5 VDC) means CHANNEL DISABLED. Refer to figure 4-1 for pin assignments on the AEC board: CHANNEL 1 = PIN 8 CHANNEL 2 = PIN 7 CHANNEL 3 = PIN 6 CHANNEL 4 = PIN 5	Receptor 1 Ch # ______ Receptor 2 Ch # ______ Receptor 3 Ch # ______ Receptor 4 Ch # ______ Receptor 5 Ch # ______ Receptor 6 Ch # ______	
7.	Switch OFF the console.	N/A	

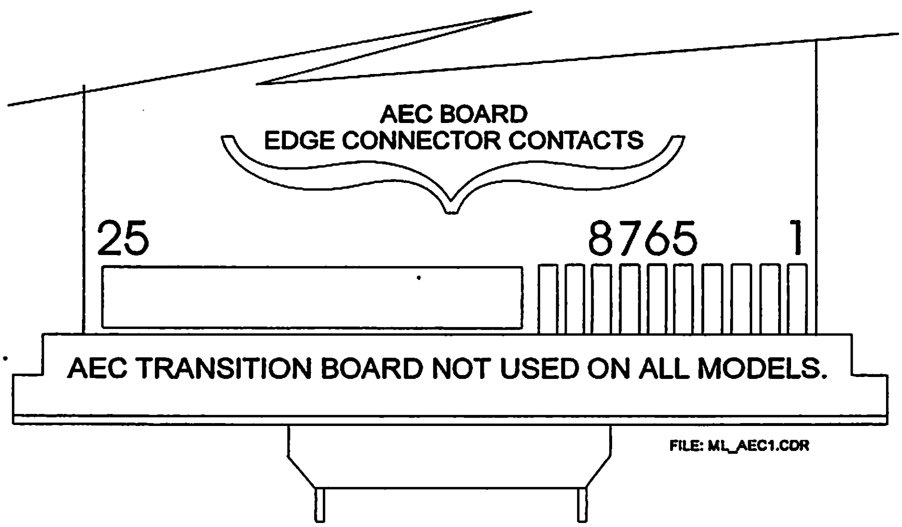


Figure 4-1: AEC board pin assignments

THE MILLENIA AND INDICO 100 FAMILY OF GENERATORS ARE FITTED WITH A LOW SPEED STARTER, OR OPTIONAL DUAL SPEED STARTER. USE SECTION 4.3.4 OR 4.3.5, AS APPLICABLE, FOR YOUR GENERATOR.

4.3.4 Low Speed Starter Verification

Step	Action	Result	Check
1.	Connect a current probe to the common lead of tube 1. Switch ON the console. Press and hold the PREP button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
2.	Measure the rotor boost time.	Should be approximately 1.5 sec.	
3.	Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at the end of boost.	Speed $\geq$ 3300 RPM.	
FOLLOW STEPS 4 TO 6 IF TUBE 2 IS USED (LOW SPEED STARTER)			

4.3.4 Low Speed Starter Verification (Cont)

4.	Connect a current probe to the common lead of tube 2. Press and hold the PREP button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
5.	Measure the rotor boost time.	Should be approximately 1.5 sec.	
6.	Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at the end of boost.	Speed ≥ 3300 RPM.	
7.	Switch OFF the console.	N/A	

4.3.5 Dual Speed Starter Verification

From the product description, be sure the actual tube being used is correctly selected at the dual speed starter. Refer to the dual speed starter table in chapter 2.

Tube 1 selection verified _______
Tube 2 selection verified _______

THE GENERATOR MUST BE PROGRAMMED FOR DUAL SPEED STARTER OPERATION IN ORDER TO BE ABLE TO VERIFY BOTH MODES OF OPERATION IN THIS SECTION.

******* PLEASE OBSERVE A MAXIMUM OF 2 HIGH SPEED BOOSTS PER MINUTE *******

Step	Action	Result	Check
1.	Connect a current probe to the common lead of tube 1. Switch ON the console. Select 70 kVp, minimum mA, 50 ms. Press and hold the PREP button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
2.	Measure the rotor boost time.	Should agree with the value in the dual speed starter table in chapter 2.	
3.	Select 100 kVp, maximum mA, 50 ms, small focus. Press and hold the PREP button.	A 180 Hz waveform dropping to less than half amplitude after prep complete.	
4.	Measure the rotor boost time.	Should agree with the value in the dual speed starter table in chapter 2.	
5.	Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at end of boost. Use the techniques in steps 1 and 3 to select low and high-speed modes respectively.	Low Speed ≥ 3300 RPM. High Speed ≥ 9500 RPM.	
6.	After a high-speed prep, verify that the dynamic brake is applied.	Will hear the X-ray tube slow down to 60 Hz.	
FOLLOW STEPS 7 TO 12 IF TUBE 2 IS USED (DUAL SPEED STARTER)			
7.	Connect a current probe to the common lead of tube 2. Select 70 kVp, minimum mA, 50 ms. Press and hold the PREP button.	A 60 Hz waveform dropping to less than half amplitude after prep complete.	
8.	Measure the rotor boost time.	Should agree with the value in the dual speed starter table in chapter 2.	

4.3.5 Dual Speed Starter Verification (Cont)

Step	Action	Result	Check
9.	Select 100 kVp, maximum mA, 50 ms, small focus. Press and hold the PREP button.	A 180 Hz waveform dropping to less than half amplitude after prep complete.	
10.	Measure the rotor boost time.	Should agree with the value in the dual speed starter table in chapter 2.	
11.	Use a strobe or reed tachometer and verify that the tube(s) reach operating speed at end of boost. Use the techniques in steps 7 and 9 to select low and high-speed modes respectively.	Low Speed ≥ 3300 RPM. High Speed ≥ 9500 RPM.	
12.	After a high-speed prep, verify that the dynamic brake is applied.	Will hear the X-ray tube slow down to 60 Hz.	
13.	Switch OFF the console	N/A	

4.4.0 ACCEPTANCE TESTS (KVP, TIME, MA AND MAS)

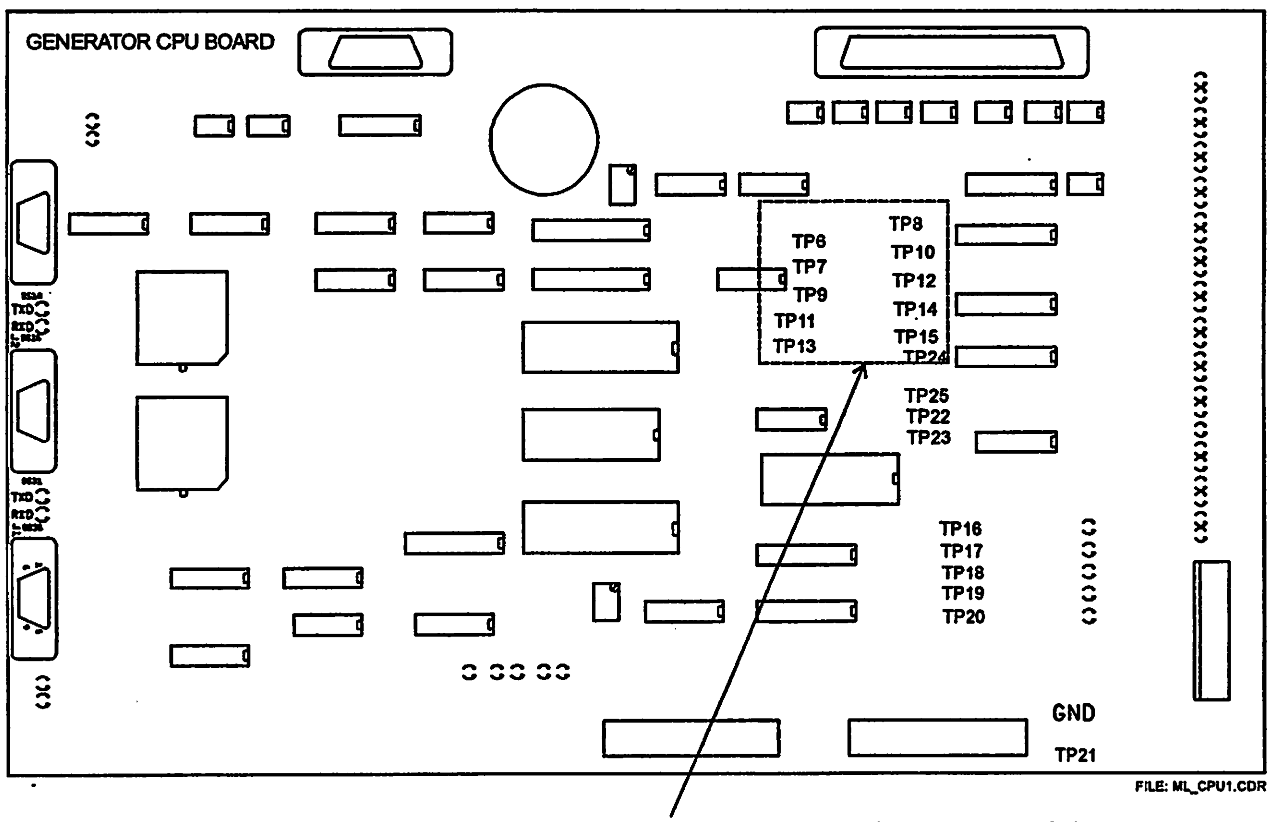
4.4.1 Generator Rad Tests

Measurement of kVp, mA, and time may be done via test points at the generator CPU board as per figure 4-2. These are direct feedback voltages and are scaled to represent the actual kVp and X-ray tube current **AS LONG AS THE GENERATOR IS CALIBRATED.**

REFER TO NOTES ON PAGE 11.

> ***NOTE:*** ***TEST EQUIPMENT TOLERANCES MUST BE ALLOWED FOR IN THE MEASUREMENTS IN THE FOLLOWING SECTIONS. LIMITS STATED ARE THE MAXIMUM ALLOWED LIMITS, INCLUDING EQUIPMENT TOLERANCES AND MEASUREMENT ERROR.***

4.4.1 Generator Rad Tests (Cont)



KVP TP6 ●- +●TP8 1VOLT = 20 KV

RAD mA TP7 ●- +● TP10 1 VOLT = 100 mA

AEC RAMP TP9. ●- +● TP12

FLUORO mA TP11 ●- +● TP14 1 VOLT = 2.5 mA

TP13 ●+ -● TP15

ABS

THE SCALING FACTORS LISTED ABOVE ARE NOMINAL VALUES.

NOTE: THIS DIAGRAM IS TYPICAL, ACTUAL GENERATOR CPU BOARDS MAY DIFFER IN DETAIL

Figure 4-2: Test point locations

4.4.1 Generator Rad Tests (Cont)

CAUTION: ***THE FOLLOWING TESTS REQUIRE THE PRODUCTION OF X-RADIATION. USE APPROPRIATE SAFETY PRECAUTIONS TO PROTECT PERSONNEL.***

NOTE: ***IF USING TEST POINTS TP6 & 8, TP7 & 10, TP11 & 14 IN FIGURE 4-2 FOR ACCEPTANCE TESTING, THE SCALING FACTORS SHOWN MUST BE VERIFIED USING AN APPROPRIATE CALIBRATED REFERENCE STANDARD. THE ACTUAL MEASURED SCALING VALUES SHOULD THEN BE USED IN THIS PROCEDURE.***

NOTE: ***A DYNALYZER IS NOT RECOMMENDED FOR MA MEASUREMENTS WITH INDICO 100 GENERATORS. BANDWIDTH LIMITATIONS OF THE DYNALYZER WILL RESULT IN INACCURATE MA MEASUREMENTS AT MA VALUES LESS THAN APPROXIMATELY 100 MA. MA MEASUREMENTS SHOULD BE MADE WITH AN MA / MAS METER CONNECTED TO THE MA TEST JACKS ON THE HT TANK. EXPOSURE TIMES MUST BE GREATER THAN 100 MS TO ENSURE ACCURATE MEASUREMENTS.***

Refer to figure 4-2 for test point locations referenced in the following section(s).

Step	Action	Result	Check
1.	**SEE NOTE ABOVE RE USE OF TEST POINTS FOR VERIFYING CALIBRATION** Connect 'scope probe channel 1 input to TP6 and TP8 (kVp) Connect 'scope probe channel 2 input to TP7 and TP10 (Rad mA). Adjust 'scope gains as required. Use the KV signal to trigger the 'scope.	N/A	
2.	Switch ON the generator and after initialization select the following radiographic technique: kVp = 100, mA = 100, Time = 50 ms Select an off-table receptor.	N/A	
3.	Make an exposure and measure the kVp at TP6 and TP8 and the Rad mA at TP7 and TP10. Using scaling factors in figure 4-2, verify the following results:	kVp = 100 KV ± 3%. mA = 100 mA ± 4% (Millenia). mA = 100 mA ± 5% (Indico 100). Time = 50 ms ± 2 ms.	
4.	Repeat step 3 but set the values to kVp = 65, mA = 200.	kVp = 65 KV ± 3%. mA = 200 mA ± 4% (Millenia). mA = 200 mA ± 5% (Indico 100). Time = 50 ms ± 2 ms.	

4.4.1 Generator Rad Tests (Cont)

Step	Action	Result	Check
5.	Repeat step 3 but set the values to kVp = 125, mA = 200.	kVp = 125 KV ± 3%. mA = 200 mA ± 4% (Millenia). mA = 200 mA ± 4% (Indico 100). Time = 50 ms ± 2 ms.	
6.	Select 75 kVp, 200 mA. Select the exposure times shown below (3 point operation). (Measure time and mA on the 'scope and check that their product is as per the RESULT column). Measure time at 75% of the peak kVp waveform. A: 10 ms (2 mAs) B: 20 ms (4 mAs) C: 63 ms (12 mAs) D: 100 ms (20 mAs)	A: 2 mAs ± 5%. B: 4 mAs ± 5%. C: 12 mAs ± 5%. D: 20 mAs ± 5%.	
7.	Select 75 kVp. Select the mAs shown below (2 point operation). Measure time at 75% of the peak kVp waveform. A: 2 mAs (time per LCD display) B: 8 mAs (time per LCD display) C: 25 mAs (time per LCD display) D: 63 mAs (time per LCD display)	NOTE: The time associated with each mAs setting will vary depending on generator configuration. Use the time displayed in the LCD window as the reference for the measurements below. time per LCD disp ± (2% + 1ms). time per LCD disp ± (2% + 1ms). time per LCD disp ± (2% + 1ms). time per LCD disp ± (2% + 1ms).	
8.	Select 200 mA, 50 ms (3 point operation). Select the kVp values shown below. The measurements may be done non-invasively or from TP6 and TP8 using the 'scope. A: 50 kVp B: 60 kVp C: 80 kVp D: 100 kVp E: 125 kVp	A: 50 kVp ± (3% + 1 kVp). B: 60 kVp ± (3% + 1 kVp). C: 80 kVp ± (3% + 1 kVp). D: 100 kVp ± (3% + 1 kVp). E: 125 kVp ± (3% + 1 kVp).	

4.4.1 Generator Rad Tests (Cont)

Step	Action	Result	Check
9.	Select 75 kVp, 50 ms (3 point operation). Select the mA values shown below. Measure mA at 75% of the peak kVp waveform. A: 50 mA B: 100 mA C: 200 mA D: 400 mA E: 800 mA Note: The higher mA values will not be available on all generator models and / or programmed tube types.	A: 50 mA ± (5% + 1 mA). B: 100 mA ± (5% + 1 mA). C: 200 mA ± (5% + 1 mA). D: 400 mA ± (5% + 1 mA). E: 800 mA ± (5% + 1 mA).	

4.4.2 Generator Fluoro Tests

This section applies only to R&F units.

Step	Action	Result	Check
1.	Place the generator into the fluoro mode of operation. Connect 'scope probe channel 1 input to TP6 and TP8 (kVp). Connect 'scope probe channel 2 input to TP11 and TP14 (fluoro mA). Use the kV signal to trigger the 'scope.	N/A	
2.	Place imaging system into non-ABS mode or cover the I.I. input with lead.	N/A	
3.	Set 3 mA fluoro. Select the kV values shown below using the remote fluoro control if fitted, or the fluoro section of the console. A: 50 KV B: 65 KV C: 80 KV D: 100 KV E: 110 KV Measure the kVp at TP6 and TP8. Using scaling factors in figure 4-2 verify kV values per the RESULTS column:	A: 50 kVp ± (10% + 1 kVp). B: 65 kVp ± (5% + 1 kVp). C: 80 kVp ± (5% + 1 kVp). D: 100 kVp ± (5% + 1 kVp). E: 110 kVp ± (5% + 1 kVp).	

4.4.2 Generator Fluoro Tests (Cont)

Step	Action	Result	Check
4.	Select 70 kVp fluoro. Select the fluoro mA values shown below: A: 1.0 mA B: 2.0 mA C: 4.0 mA D: 6.0 mA Measure the fluoro mA at TP11 and TP14. Using scaling factors in figure 4-2 verify mA values per the RESULTS column:	A: 1.0 mA ± 20%. B: 2.0 mA ± 20%. C: 4.0 mA ± 15%. D: 6.0 mA ± 15%.	
5.	Press the PPS + and - buttons (if the pulse fluoro option is fitted).	Verify that the pulsed fluoro rate increases and decreases.	
6.	Run a sufficiently long fluoro exposure to accumulate some time on the console fluoro display, and on the remote fluoro control if used Press the ZERO button on the console and on the remote fluoro control if applicable.	Verify that the accumulated time is reset to zero after pressing each of the ZERO buttons.	

4.5.0 ACCEPTANCE TESTS (OPTIONAL INTERFACES)

Refer to separate supplements in this manual for further information IF APPLICABLE.

4.6.0 ACCEPTANCE TESTS (AEC)

This section applies only to generators with AEC.

- Review Section 3D: AEC Calibration.
- Recheck the mAs, Dose, and O.D. as recorded during initial installation. Follow the appropriate steps in section 3D to verify the AEC calibration.

4.7.0 ACCEPTANCE TESTS (ABS)

This section applies only to non-digital R&F generators with ABS.

- Review section 3E: ABS calibration.
- Recheck the dose limits and input dose as described in the procedure.

4.8.0 ACCEPTANCE TESTS (DAP)

This section applies only to Indico 100 X-ray generators with DAP.

- Review Section 3F: DAP SETUP AND CALIBRATION.
- Follow the appropriate steps in section 3F to verify the DAP calibration.

4.9.0 ACCEPTANCE TESTS (HVL, LINEARITY AND REPRODUCIBILITY)

The procedure for performing reproducibility, linearity and HVL testing is contained in a separate document, part number 740917 that immediately follows this page.

SUPPLEMENT

REPRODUCIBILTY, LINEARITY, & HVL TESTING

CONTENTS:

1.0 INTRODUCTION 2
2.0 EQUIPMENT SETUP 3
3.0 REPRODUCIBILITY 3
4.0 LINEARITY 7
5.0 H.V.L. EVALUATION 9

1.0 INTRODUCTION

This supplement describes reproducibility, linearity, and half - value layer (HVL) tests which may be used to verify performance of medical X-ray generators.

> ***NOTE:*** *THIS SUPPLEMENT DETAILS TYPICAL REPRODUCIBILITY, LINEARITY, AND HVL TESTS. LOCAL REGULATIONS SHOULD ALWAYS BE CONSULTED PRIOR TO PERFORMING THESE TESTS, AS DETAILS MAY VARY IN SOME JURISDICTIONS, OR ADDITIONAL TESTS MAY NEED TO BE PERFORMED.*

> ***WARNING:*** *SOME EXPOSURES IN THIS SECTION MUST BE TAKEN AT THE MAXIMUM GENERATOR KVP. THE X-RAY TUBE MUST BE KNOWN TO BE CAPABLE OF OPERATION AT THAT KVP VALUE, AND THE TUBE SHOULD FIRST BE SEASONED TO ENSURE THAT OPERATION AT HIGH KVP VALUES WILL NOT BE PROBLEMATIC.*

2.0 EQUIPMENT SETUP

1. Place the radiation probe above the table approximately 25 cm (10"). Select an SID of approximately 100 cm (40").

2. Place a lead diaphragm over the detector and adjust its height so that the X-ray beam covers the detector but does not over radiate the sides of the 'R' probe. Refer to figure 1.

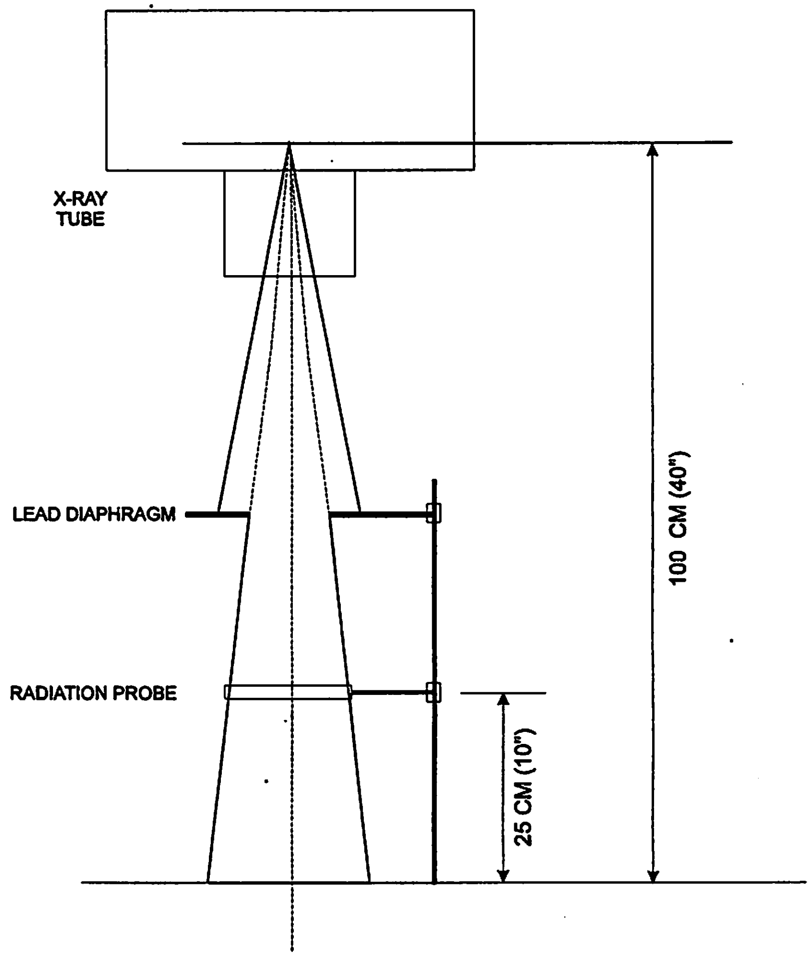


Figure 1: mR measurement setup

3.0 REPRODUCIBILITY

Calculate reproducibility as follows:

1. Using kV and mA/ms or mAs values per tables 1 to 4, make a series of 5 exposures.

2. Record each of the measured mR values in the appropriate table. Refer to step 3 before beginning step 2.

3. Record the preselected mAs for each series of exposures in the header of each table. For 3 point generators, this is the calculated mAs value where mAs = mA X time in seconds (example for 160 mA and 125 ms, mAs = 160 X 0.125 = 20 mAs).

3.0 REPRODUCIBILITY (Cont)

4. Calculate and record the average dose $\overline{mR}$.

5. Calculate the difference mR - $\overline{mR}$ for each exposure.

6. Square each difference from the previous step.

7. Calculate the sum of the differences squared.

8. Calculate the standard deviation (S) by using the formula.

$$S = \sqrt{\frac{\text{SUM OF DIFFERENCES}^2}{\text{N-1 SAMPLES}}}$$

9. Calculate reproducibility by dividing S by $\overline{mR}$.

10. Table 5 shows example reproducibility calculations.

11. If linearity is to be measured, it is suggested that dose measurements be taken at this time for entry into tables 6 and 7. Refer to 4.0 LINEARITY for details.

IN TABLES 1 TO 4, 3 POINT MEANS THAT FOR GENERATORS WHERE KV, MA, AND TIME SELECTION IS AVAILABLE, THE KV, MA AND MS VALUES SHOWN SHOULD BE USED. FOR GENERATORS WHERE 2 POINT OPERATION ONLY IS AVAILABLE, THE KV AND MAS VALUES SHOWN SHOULD BE USED.

3 point = Minimum kV, maximum mA, 100 ms. 2 point = Minimum kV, maximum mAs. mAs = __________			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = ________	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = ________
Calculate standard deviation (S) using formula at beginning of this section: S = __________ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = ________ (not to exceed 0.045)			

Table 1: Reproducibility

3.0 REPRODUCIBILITY (Cont)

3 point = Maximum kV, minimum mA, 100 ms. 2 point = Maximum kV, minimum mAs. mAs = ________			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = ________	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = ________
Calculate standard deviation (S) using formula at beginning of this section: S = ________ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = ________ (not to exceed 0.045)			

Table 2: Reproducibility

3 point = 50% of maximum kV, 250 ms, mA to give 100 - 500 μR (1 - 5 μGy) dose. 2 point = 50% of maximum kV, mAs to give 100 - 500 μR (1 - 5 μGy) dose. mAs = ________			
EXP No.	**DOSE (mR)**	**DIFFERENCE**	**DIFFERENCE^2**
1			
2			
3			
4			
5			
	$\overline{mR}$ = ________	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = ________
Calculate standard deviation (S) using formula at beginning of this section: S = ________ Calculate reproducibility = $\frac{S}{\overline{mR}}$ = ________ (not to exceed 0.045)			

Table 3: Reproducibility

3.0 REPRODUCIBILITY (Cont)

3 point = 80% of maximum kV, 250 ms, mA to give 100 - 500 μR (1 - 5 μGy) dose.

2 point = 80% of maximum kV, mAs to give 100 - 500 μR (1 - 5 μGy) dose. MAS = ________

EXP No.	DOSE (mR)	DIFFERENCE	DIFFERENCE^2
1			
2			
3			
4			
5			
	$\overline{mR}$ = ______	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = ________

Calculate standard deviation (S) using formula at beginning of this section: S = ________

Calculate reproducibility = $\frac{S}{\overline{mR}}$ = ________ (not to exceed 0.045)

Table 4: Reproducibility

EXAMPLE mAs = 20

EXP No.	DOSE (mR)	DIFFERENCE	DIFFERENCE^2
1	249.0	4.4	19.36
2	245.0	0.4	0.16
3	244.0	0.6	0.36
4	242.0	2.6	6.76
5	243.0	1.6	2.56
	$\overline{mR}$ = 244.6	Calculate each of the differences ie: $DIFF_1 = mR_1 - \overline{mR}$. Repeat for each remaining mR value.	Square each difference. Then calculate the sum of the difference^2. Sum of difference^2 = 29.2

Calculate standard deviation (s) using formula at beginning of this section: S = 2.70

Calculate reproducibility = $\frac{S}{\overline{mR}}$ = 0.011 (not to exceed 0.045)

Table 5: Reproducibility

4.0 LINEARITY

1. Record two additional series of dose measurements for entry into tables 6 and 7:
   - For table 6, use settings per table 3 ***EXCEPT*** use an mA (or mAs) value adjacent to the mA (or mAs) setting used in table 3.
   - For table 7, use settings per table 4 ***EXCEPT*** use an mA (or mAs) value adjacent to the mA (or mAs) setting used in table 4.
   - Record the mAs in the header of tables 6 and 7 as per 3.0 step 3.

1. Calculate and record the average dose $\overline{mR}$ for table 6 and 7.

2. Record the preselected mAs and the average dose values taken from tables 3 and 4, and from tables 6 and 7, at the top of the next page.

3. Using the appropriate mAs and $\overline{mR}$ values, calculate X_3, X_4, X_6, and X_7 in tables 8 and 9.

4. Calculate the coefficient of linearity, L, as per tables 8 and 9.

mAs = ________	
EXP No.	**DOSE (mR)**
1	
2	
3	
4	
5	
	$\overline{mR}$ = ________

Table 6: Linearity

mAs = ________	
EXP No.	**DOSE (mR)**
1	
2	
3	
4	
5	
	$\overline{mR}$ = ________

Table 7: Linearity

4.0 LINEARITY (Cont)

Record the mAs and $\overline{mR}$ values taken from tables 3, 4, 6, and 7 below.

Table 3	mAs_3 = _____	$\overline{mR}_3$ = _____
Table 4	mAs_4 = _____	$\overline{mR}_4$ = _____
Table 6	mAs_6 = _____	$\overline{mR}_6$ = _____
Table 7	mAs_7 = _____	$\overline{mR}_7$ = _____

$$X_3 = \frac{\overline{mR}_3}{mAs_3} = \_\_\_\_\_\_\_\_$$

$$X_6 = \frac{\overline{mR}_6}{mAs_6} = \_\_\_\_\_\_\_\_$$

$$L = \frac{X_3 - X_6}{X_3 + X_6} = \_\_\_\_\_\_\_\_ \quad \text{(not to exceed 0.095)}$$

In the numerator of the above equation, use the absolute value of $X_3 - X_6$ (disregard the minus sign).

Table 8: Linearity

$$X_4 = \frac{\overline{mR}_4}{mAs_4} = \_\_\_\_\_\_\_\_$$

$$X_7 = \frac{\overline{mR}_7}{mAs_7} = \_\_\_\_\_\_\_\_$$

$$L = \frac{X_4 - X_7}{X_4 + X_7} = \_\_\_\_\_\_\_\_ \quad \text{(not to exceed 0.095)}$$

In the numerator of the above equation, use the absolute value of $X_4 - X_7$ (disregard the minus sign).

Table 9: Linearity

5.0 H.V.L. EVALUATION

1. Be sure the X-ray source assembly (X-ray tube and beam limiting device) is fully assembled and functional.

2. Use the test setup as per figure 1.

3. Set the generator as follows: 3 point generators, 80 kV, 200 mA, 50 ms, large focus. For 2 point generators use 80 kV, 200 mA if this can be set, and 10 mAs.

4. Take a series of three exposures and record the mR values in table 10. Calculate and record the average of the three exposures.

5. Place 2 mm of Al on top of the lead diaphragm (total of 2 mm added), repeat the exposure and record the mR value in table 10.

6. Place an additional 1 mm of Al on top of the lead diaphragm (total of 3 mm added), repeat the exposure; and record the mR value in table 10.

7. Place an additional 3 mm of Al on top of the lead diaphragm (total of 6 mm added), repeat the exposure; and record the mR value in table 10.

8. The relative transmission for the average of the three mR values where no Al was added is assigned a value of 1.00. Using that base, assign relative transmission values to the remaining mR values. For example, if the average mR value was 247 and has a relative transmission factor of 1.00, then 162 mR will have a relative transmission of 162 / 247 = 0.66.

9. Plot the relative transmission values in figure 1. This should produce a straight line on the graph since the X-axis is logarithmic.

10. Interpolate to determine the HVL. The Al thickness at a relative transmission of 0.5 will be the required HVL value.

11. Repeat steps 4 to 10: 3 point generators, 100 kV, 200 mA, 50 ms, large focus. For 2 point generators use 100 kV, 200 mA if this can be set, and 10 mAs. Use table 11 to record the values and figure 2 to plot the results

12. Table 12 and figure 3 show example HVL determination.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0		
0		
0		
0 (Average of three readings)		1.00
2		
1		
3		

Table 10: HVL dose values 80 kVp

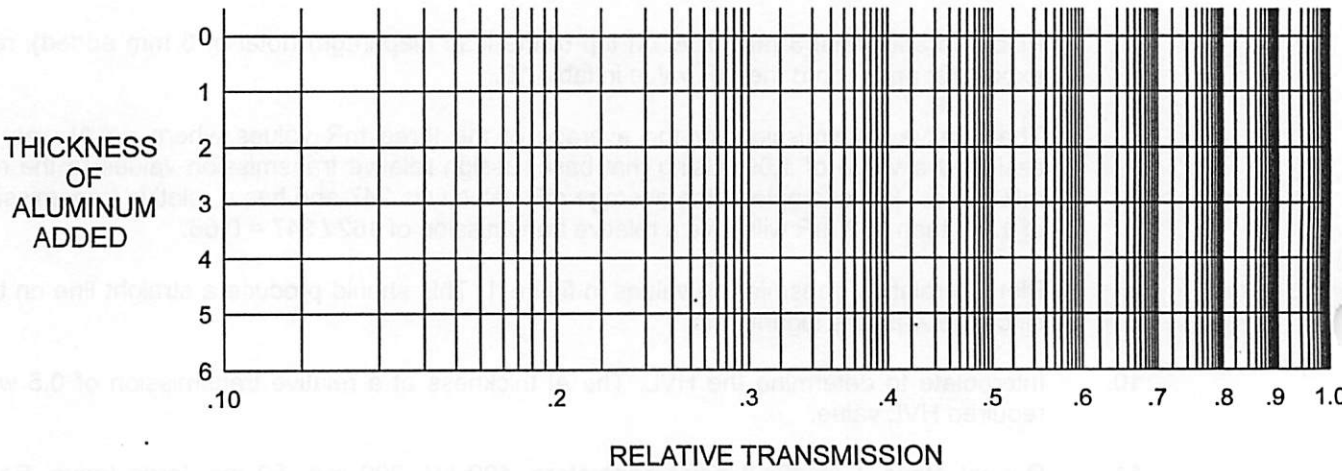


Figure 1: HVL plot 80 kVp

For 80 kVp, the HVL must be ≥ 2.3 mm Al.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0		
0		
0		
0 (Average of three readings)		1.00
2		
1		
3		

Table 11: HVL dose values 100 kVp

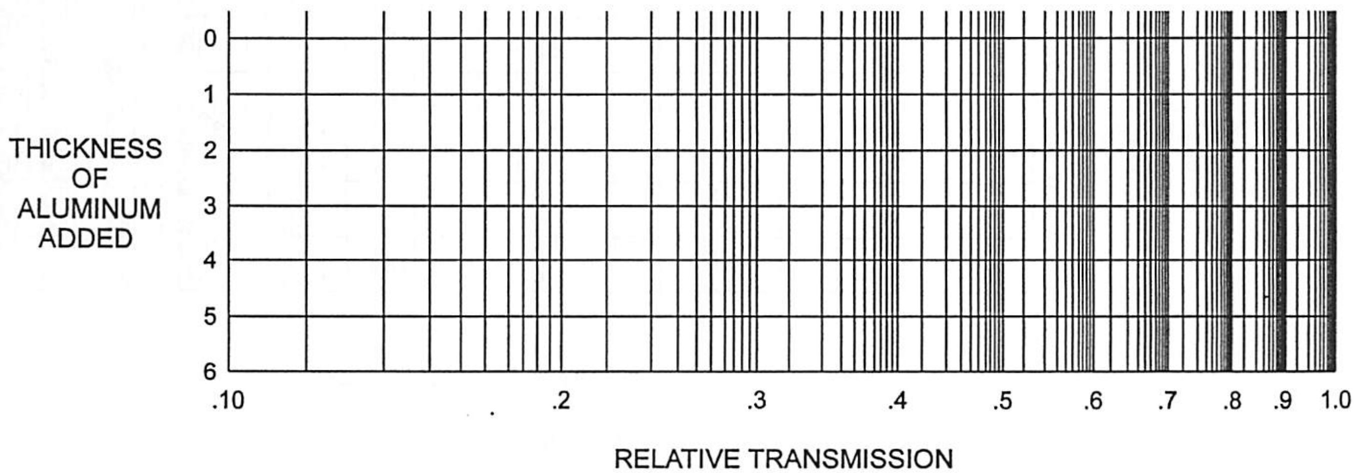


Figure 2: HVL plot 100 kVp

For 100 kVp, the HVL must be ≥ 2.7 mm Al.

5.0 H.V.L. EVALUATION (Cont)

ADDED ALUMINUM FILTER	DOSE (mR)	RELATIVE TRANSMISSION
0	249	
0	244	
0	247	
0 (Average of above three readings)	247	1.00
2	162	.66
1	131	.53
3	70	.28

Table 12: HVL dose values (example)

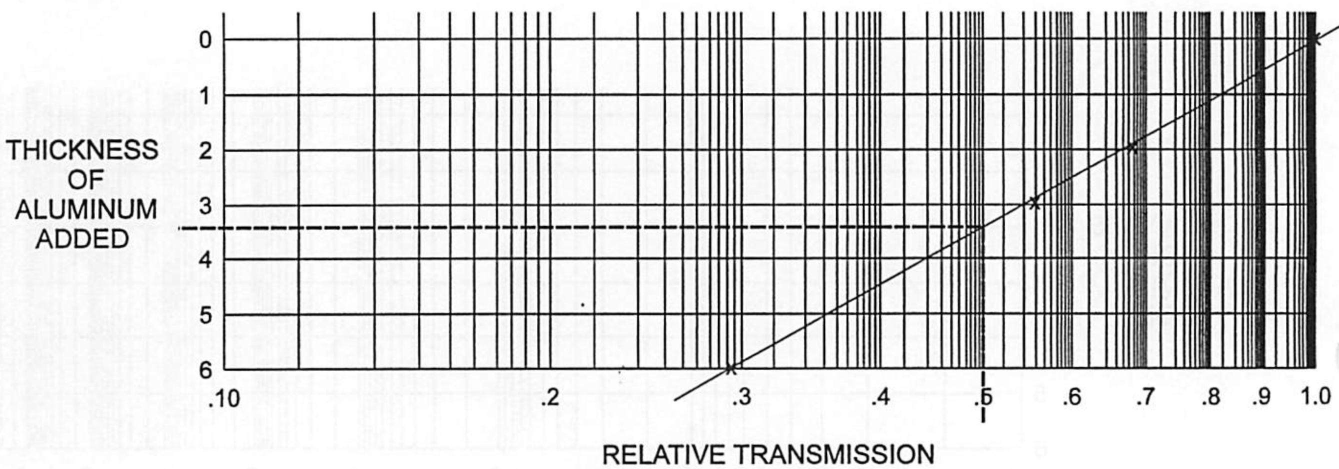


Figure 3: HVL plot (example)

By interpolating the thickness of Al at a relative transmission value of 0.5, it can be seen that the HVL is approximately 3.3.

CHAPTER 5

TROUBLESHOOTING

CONTENTS:

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5.2.0 STATUS AND ERROR CODES 5-2
5.2.1 Operator Messages..5-2
5.2.2 Limit Messages 5-2
5.2.3 Error Messages..5-3

5.1.0 INTRODUCTION

The Millenia and Indico 100 console will display status messages on the LCD display during normal and abnormal operation of the generator. This chapter contains tables of those messages and suggests actions to be taken by service personnel to correct any malfunctions that may occur.

5.2.0 STATUS AND ERROR CODES

5.2.1 Operator Messages

These messages indicate the status of the generator. No action is required.

MESSAGE	DESCRIPTION
INITIALIZATION	Displayed during power up sequence.
SPINNING ROTOR	Displayed when prep state is active.
X-RAY READY	Displayed when generator is ready to expose
X-RAY ON	Displayed during both a rad and fluoro exposure.
DAP NOT READY	The optional DAP (Indico 100 only) is in its "warm up" state, and not ready to make DAP measurements.

5.2.2 Limit Messages

These messages indicate that an exposure has been requested that exceeds one or more limits.

MESSAGE	PROBLEM	ACTION
TUBE KV LIMIT	Requested kV not allowed as tube kV limit has been reached.	None.
GEN KV LIMIT	Requested kV not allowed as generator kV limit has been reached.	None.
TUBE MA LIMIT	Requested mA not allowed as tube mA limit has been reached.	None.
GEN MA LIMIT	Requested mA not allowed as generator mA limit has been reached.	None.
TUBE KW LIMIT	Requested parameter not allowed as tube kW limit has been reached.	None.
GEN KW LIMIT	Requested parameter not allowed as generator kW limit has been reached.	None.
TUBE MAS LIMIT	Requested mAs not allowed as tube mAs limit has been reached.	None.
GEN MAS LIMIT	Requested mAs not allowed as generator mAs limit has been reached.	None.
GEN MS LIMIT	Requested ms not allowed as generator ms limit has been reached.	None.
CAL LIMIT	Requested parameter not calibrated.	Recalibrate X-ray tube or select a calibrated parameter.
AEC DENSITY LIM	Requested density not programmed.	Select another density or program requested density step.
ANODE HEAT WARN	Anode has exceeded programmed warning level.	Wait for anode to cool.
FL TIMER WARN	Fluoro interval timer ≥ 5.0 mins.	Reset fluoro timer.
INVALID PARAM	Generator detected invalid parameter within received message, message ignored.	Select valid parameter.

5.2.2 Limit Messages (Cont)

HOUSE HEAT WARN	X-ray tube housing heat has exceeded housing warning limit.	Wait for housing to cool.
GEN DUTY WARNING	The generator has reached its duty cycle warning limit.	Re-evaluate technique factors. Allow generator to cool if possible. If exposures are continued, serious generator damage may result due to overheating.
DAP ACCUM WARN	The accumulated DAP value has reached the programmed DAP limit.	Reset the DAP.
DAP RATE WARN	The current DAP rate exceeds the programmed DAP rate limit.	Reduce the dose.

5.2.3 Error Messages

These messages indicate that an error has occurred. The errors are logged in the error log, previous errors should be reviewed by service personnel before taking further action.

ERROR CODE	MESSAGE	PROBLEM	ACTION
E001	GEN EPROM ERR	Generator CPU EPROM has been corrupted.	Call product support for new generator CPU EPROM.
E003	GEN NVRAM ERR	Generator CPU NVRAM data has been corrupted.	Re-initialize generator CPU NVRAM using generator factory defaults.
E004	GEN RTC ERROR	Generator CPU real time clock is not functioning.	Reset time and date.
E005	PS CONTACT ERR	Main contactor in HF power supply did not energize.	Call product support.
E006	ROTOR FAULT	1. Rotor starter may have detected a current fault in the stator. 2. Power supply was not ready to start rotor.	Power unit off and retry rotor start.
E007	FILAMENT FAULT	Power supply has detected filament current <2 amps.	1. Check for open filament in X-ray tube. 2. Check for poor connections in the cathode cable. 3. Check fuses on filament board(s).

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E008	KV/MA FAULT	Power supply has detected a fault in the kV or mA output during an exposure and immediately terminated the exposure. This may be caused by arcing in the X-ray tube, arcing of the HV cables, or HT tank.	1. If arcing of the X-ray tube is suspected, check condition of tube. The X-ray tube may be damaged or simply require "seasoning". Refer to chapter 6 for tube seasoning procedure. 2. If failure of HT tank is suspected, contact product support.
E009	PS NOT READY	Power supply is not ready to make an exposure.	Retry exposure.
E011	HIGH MA FAULT	Generator CPU detected mA greater than allowed tolerance.	Recalibrate X-ray tube.
E012	LOW MA FAULT	Generator CPU detected mA less than allowed tolerance.	Recalibrate X-ray tube.
E013	MANUAL TERMIN	Operator released exposure switch during exposure.	1. Re-take exposure if necessary. 2. Check for faulty switch contacts or wiring.
E014	AEC BUT ERROR	AEC exposure exceeded allowed back up time.	1. Check exposure technique settings. 2. Check that correct AEC chamber is energized.
E015	AEC BU MAS ERR	AEC exposure exceeded allowed back up mAs.	1. Check exposure technique settings. 2. Check that correct AEC chamber is energized.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E016	TOMO BUT ERROR	Tomo exposure exceeded back up time.	1. Check exposure technique settings. 2. Increase tomo back up time if necessary.
E017	NOT CALIBRATED	Selected mA not calibrated for selected kV.	Recalibrate X-ray tube.
E018	PREP TIMEOUT	Generator has been in prep state too long.	Reduce length of time in prep state.
E019	ANODE HEAT LIMIT	Selected parameters will cause X-ray tube to exceed its programmed anode heat limit.	Reduce parameters or wait for tube to cool.
E020	THERMAL INT #1	X-ray tube # 1 too hot and its thermal switch has opened.	Wait for X-ray tube # 1 to cool.
E021	THERMAL INT #2	X-ray tube # 2 too hot and its thermal switch has opened.	Wait for X-ray tube # 2 to cool.
E022	DOOR INTERLOCK	Door is open.	Close door.
E023	COLLIMATOR ERR	Collimator is not ready.	Check collimator.
E024	CASSETTE ERROR	Cassette is not ready.	Check cassette.
E025	II SAFETY INT	II safety is not ready.	Check II safety.
E026	SPARE INT	Spare input is not ready.	Check spare input.
E028	PREP SW CLOSED	Prep input active during power on initialization phase.	Check prep switch and input for short circuit.
E029	X-RAY SW CLOSED	X-ray input active during power on initialization phase.	Check X-ray switch and input for short circuit.
E030	FLUORO SW CLOSED	Fluoro input active during power on initialization phase.	Check fluoro switch and input for short circuit.
E031	REMOTE COMM ERR	Communication error detected with remote fluoro control unit.	1. Check remote fluoro control cable for damage and proper connection. 2. Turn power off and then on to Reset Generator.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E032	CONSOLE COMM ERR	Generator has detected error in communication to console.	1. Check console cable for damage and proper connection. 2. Turn power off and then on to reset generator.
E033	GEN BATTERY LOW	Generator detects lithium battery voltage is low.	Replace lithium battery.
E034	+12VDC ERROR	+12VDC rail is out of tolerance.	Check +12VDC rail.
E035	-12VDC ERROR	-12VDC rail is out of tolerance.	Check -12VDC rail.
E036	+15VDC ERROR	+15VDC rail is out of tolerance.	Check +15VDC rail.
E037	-15VDC ERROR	-15VDC rail is out of tolerance.	Check -15VDC rail.
E038	CAL DATA ERROR	Generator detects corrupt calibration data.	Re-calibrate X-ray tube(s).
E039	AEC DATA ERROR	Generator detects corrupt AEC data.	Reprogram AEC data or set factory defaults.
E040	FLUORO DATA ERROR	Generator detects corrupt Fluoro data.	Reprogram fluoro data or set factory defaults.
E041	REC DATA ERROR	Generator detects corrupt receptor data.	Reprogram receptor data or set factory defaults.
E042	TUBE DATA ERR	Generator detects corrupt tube data.	Reprogram tube data or set factory defaults.
E043	KV ERROR	KV detected in non x-ray state.	Switch OFF generator. Prevent further use of generator. Call product support.
E044	COMM ERROR	Received communication message not valid and ignored.	Reset error.
E045	NOT SUPPORTED	Received message valid, but not supported by this system.	Reset error.
E046	MODE INHIBITED	Received message valid, but not allowed during present state.	Reset error.
E047	FL TIMER LIMIT	Fluoro Timer has exceeded time limit.	Reset Fluoro timer.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E048	FOCUS MISMATCH	Focus selected does not match current focus enabled by power supply.	Check power supply interface cables between power supply and generator CPU board.
E049	NOT ENABLED	Requested function not programmed to be enabled.	Reprogram to enable function.
E050	GEN DATA ERROR	Generator detects corrupt generator limit data.	Reprogram generator limit data or set factory defaults.
E051	AEC DEVICE ERR	Generator has detected no feedback signal from AEC device.	1. Check that X-ray tube is pointing at correct AEC device. 2. Check AEC cable for damage and proper connection.
E052	HIGH SF CURRENT	Generator detects small focus filament current greater than limits in standby mode.	Check small focus filament board.
E053	HIGH LF CURRENT	Generator detects large focus filament current greater than limits in standby mode.	Check large focus filament board.
E054	AEC OUT OF RANGE	AEC reference has reached a maximum or minimum limit.	Re-adjust AEC calibration including density to operate within AEC range (O to 1OVDC).
E055	NO FIELDS ACTIVE	AEC enabled but no fields are selected.	Select AEC field(s).
E056	NO TUBE SELECTED	All Receptors have no X-ray tube programmed.	Program receptor(s) with tube number.
E057	AEC STOP ERROR	AEC stop signal (P.T. stop signal) is active low indicating exposure is finished during prep state.	1. Check that P.T. ramp does not exceed P.T. reference during prep state. 2. Check AEC device for proper operation.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E058	CONSOLE BUT ERR	Console has detected exposure exceeded backup time and terminated exposure.	Call product support.
E059	HOUSE HEAT LIMIT	X-ray tube housing has exceeded limit.	Wait for tube to cool.
E060	EXP KV HIGH	KV exceeds high KV tolerance level.	1. Check the output of the kV reference DAC on the generator CPU board. 2. Measure the output of the generator with a dynalyzer or a non-invasive kVp meter.
E061	EXP KV LOW	KV exceeds low KV tolerance level.	1. Check the output of the kV reference DAC on the generator CPU board. 2. Measure the output of the generator with a dynalyzer or a non-invasive kVp meter.
E062	EXP_ SW ERROR	The EXP_SW signal on the generator Interface and generator CPU board is enabled when it should be disabled.	Call product support.
E063	FACTORY DEFAULTS	SW1 switch 8 on the generator CPU board is set to default the generator CPU NVRAM with factory defaults.	Set SW1 switch 8 to its non default position. The generator will not exit the initialization phase until this switch is set.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E066	NO SYNC PULSE	Pulsed fluoro has been requested, but no sync pulse is present.	1. Check that the imaging system is active, and cables are connected properly. 2. Check JW22 on the generator interface board.
E070	SOFTWARE KEY ERR	Defective or missing GAL U29 on generator CPU board 734573.	Call product support for new GAL U29.
E071	DAP OVERFLOW	The accumulated DAP value exceeds the display limit.	Reset the DAP.
E072	DAP DEVICE ERROR	The DAP device is not functional.	1. Check the DAP wiring. 2. Check the DAP interface board.
E073	DAP DATA ERROR	The DAP configuration data is corrupted.	Reset factory defaults.
E100	CAL_MAX MA ERR	Maximum mA has been exceed during auto calibration.	Repeat auto calibration and/or decrease standby current.
E101	CAL_DATA LIMIT	Auto calibration has exceeded data table length due to an excessive number of exposures.	1. Check to see if the filament standby current is too low. 2. Retry auto calibration.
E102	CAL_MAX FIL ERR	Maximum filament current for the selected focus has been exceeded.	1. Check to see if the maximum filament current limit can be increased. 2. Retry auto calibration.
E103	CAL_MAN TERM	Operator released exposure button during auto calibration.	Retry auto Calibration.
E104	CAL_NO MA	No mA feedback detected during auto calibration.	Check power supply Interface cables between HF power supply and generator CPU board.

5.2.3 Error Messages (Cont)

ERROR CODE	MESSAGE	PROBLEM	ACTION
E105	CAL_MIN MA ERR	Minimum generator mA was exceeded at start of calibration. This is usually caused by too high a filament standby current on the primary and or secondary filament. (Primary is the current filament being calibrated, secondary is the other filament and applies only to generators with two independent filament supplies).	Reduce filament standby current on primary and/or secondary filament.

CHAPTER 6

REGULAR MAINTENANCE

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6.1.0 INTRODUCTION

This chapter of the manual provides a recommended schedule for periodic maintenance of the Millenia and Indico 100 family of generators.

6.2.0 X-RAY GENERATOR UPDATE/SERVICE RECORD

The X-ray generator update / service record is stored in the upper cabinet of the generator (Millenia) or on the back of the panel which accesses the control boards in the lower cabinet (Indico 100). The installation date and location should be recorded on this form at the time of the original site installation.

Service and repairs must be recorded in the update / service record. The record should be as thorough as possible, detailing the scope and type of work that was performed (all service and a record of all replacement parts that were installed). Additionally, the person performing the work should date and sign the record.

This information will be invaluable in the future for traceability and to ensure continued compatibility of the generator.

6.3.0 MAINTENANCE SCHEDULE

WARNING: ***MAINTENANCE IS TO BE PERFORMED ONLY BY COMPETENT, TRAINED PERSONNEL WHO ARE FAMILIAR WITH THE POTENTIAL HAZARDS ASSOCIATED WITH THIS EQUIPMENT.***

NOTE: ***MAINTENANCE SCHEDULE FREQUENCY MAY BE DETERMINED BY CERTAIN REGULATORY REQUIREMENTS OF THE COUNTRY OR STATE IN WHICH THE INSTALLATION IS LOCATED. ALWAYS CHECK THE LOCAL CODES AND REGULATIONS WHEN DETERMINING A MAINTENANCE SCHEDULE.***

WARNING: ***ALWAYS SWITCH OFF MAINS POWER TO THE GENERATOR AND WAIT A MINIMUM OF 5 MINUTES FOR CAPACITORS TO DISCHARGE BEFORE BEGINNING ANY PREVENTATIVE MAINTENANCE, INCLUDING CLEANING.***

WARNING: ***OBSERVE ESD PRECAUTIONS. KEEP ALL STATIC - SENSITIVE COMPONENTS AND CIRCUIT BOARDS IN THEIR STATIC - SHIELDING PACKAGING UNTIL READY TO INSTALL. ENSURE THAT YOU ARE GROUNDED AT ALL TIMES WHEN HANDLING STATIC - SENSITIVE COMPONENTS AND CIRCUIT BOARDS.***

6.3.0 MAINTENANCE SCHEDULE (Cont)

Maintenance Frequency	Description of Preventative Maintenance
As governed by local regulations.	Check and recalibrate the DAP meter in the generator.
Every 6 Months AND whenever a related certifiable X-ray component is replaced:	1. Clean and re-grease all HV connections using vapour proof compound. 2. Clean the control console, remote fluoro control (if used) and main cabinet as needed. **REFER TO 6.5.0 CLEANING BEFORE PROCEEDING** 3. Perform the X-ray tube auto calibration routine, refer to chapter 2. 4. Verify the calibration of the generator; refer to chapter 4 of this manual. 5. Test the X-ray tube thermal switch circuits in the generator. Disconnect the tube thermal switch(s) and verify the correct error message, and that X-ray exposures are inhibited. 6. For fan cooled Indico 100 generators in particular, remove accumulated dust from the cooling vents. Vacuuming is recommended. 7. Perform any additional tests required by laws governing this installation.
Every 12 months:	1. Examine the following for any visible damage and replace any damaged components: • The exterior of the control console and remote fluoro control if used, including the membrane switch assembly. • The cable between the control console and the generator main cabinet and between the remote fluoro control (if used) and generator main cabinet. • The hand switch and fluoro footswitch (if used) and the cables connecting these to the console. 2. Open the generator cabinet and examine the unit for any visible damage: missing or loose ground connections, oil leaks, damaged cables etc. 3. Ensure that there are no obstructions blocking any of the ventilation holes or louvers on the generator cabinet.
Every 5 years:	Replace the lithium battery on the CPU board in the control console and on the generator CPU board in the main cabinet. Refer to the spares list in chapter 8 for the required part number. Refer to subsection 6.7.0 for battery replacement procedure.

6.4.0 OIL FILL/LEVEL CHECK (HT TANK)

The insulating oil level in the HT transformer does NOT require periodic checking under normal conditions. However, if there is evidence of possible oil loss, the procedure for checking the correct oil level follows. Refer to 6.4.1 for Millenia generators, and to 6.4.2 for Indico 100 generators.

6.4.1 Millenia Oil Fill/Level Check

1. Using a suitable wrench, remove the oil fill cap on top of the HT transformer.

2. Measure the oil level from the TOP surface of the oil fill flange using a **clean** ruler. The oil level should be in the range of 7/8" (22 mm) to 1 3/8" (35 mm) from the top of the flange. Add oil if the oil level is low, that is greater than 1 3/8" (35 mm) from the top.

3. Use only fresh oil, type Shell DIALA AX or equivalent. Take care not to damage delicate components inside the tank if using a funnel for oil fill.

4. Replace the oil filler cap and tighten when finished. Wipe up any oil spills. Dispose of soiled absorber in compliance with government requirements and ensure conformity to local disposal regulations.

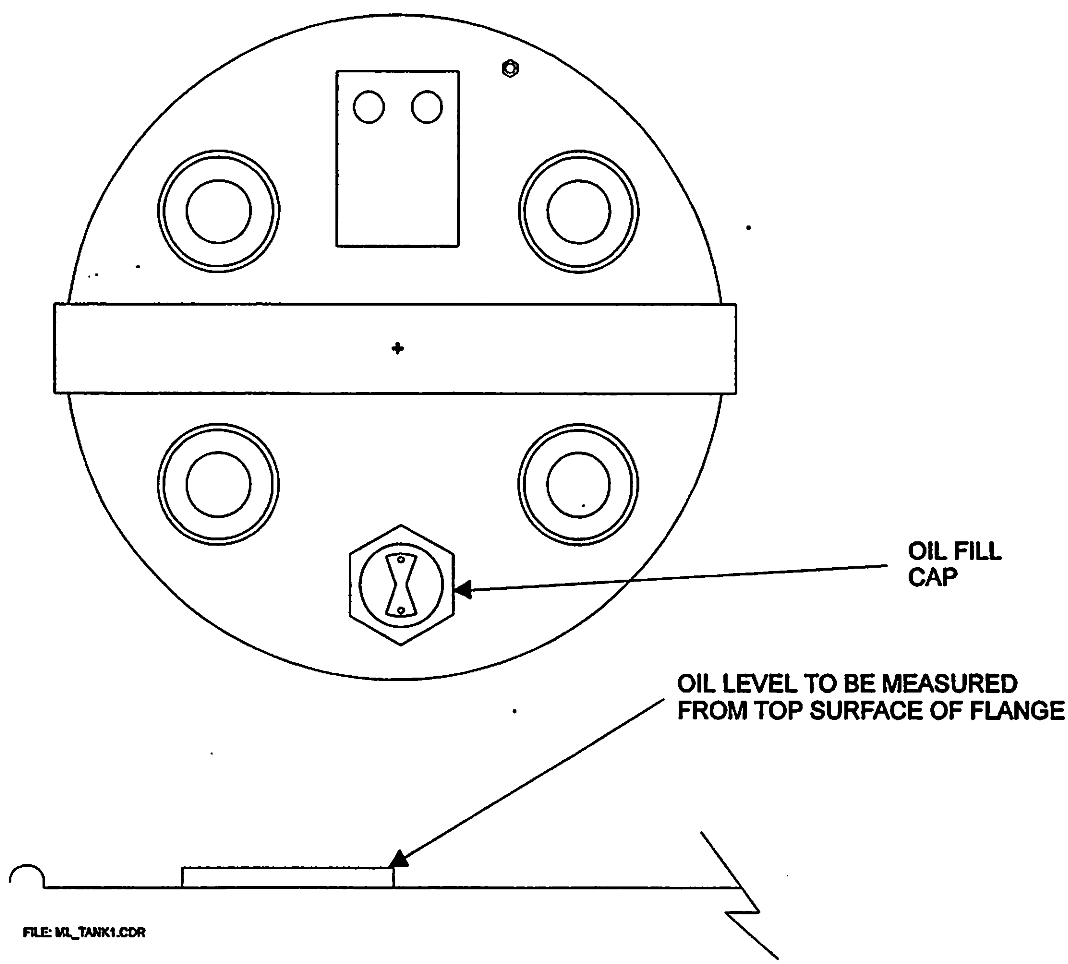

Figure 6-1: Millenia HT tank oil fill

6.4.2 Indico 100 Oil Fill/Level Check

1. Loosen the oil fill plug screw on the Indico 100 tank lid.

2. With the screw sufficiently loosened, remove the rubber (neoprene) plug.

3. Use a **clean** ruler, strip of cardboard, or other equivalent material to determine the oil level -- **measured always from the TOP surface of the HT tank's lid.**
   - Normally the oil level should be between 1.0 - 1.25 inches (25 - 32 mm) from the top of the tank lid.
   - If the oil level is between 1.25 - 1.6 inches (32 - 41 mm) from the top of the tank lid, then clean oil should be added as needed.
   - If the oil level is greater than 1.6 inches (41 mm) below the top of the tank lid, please consult the factory.

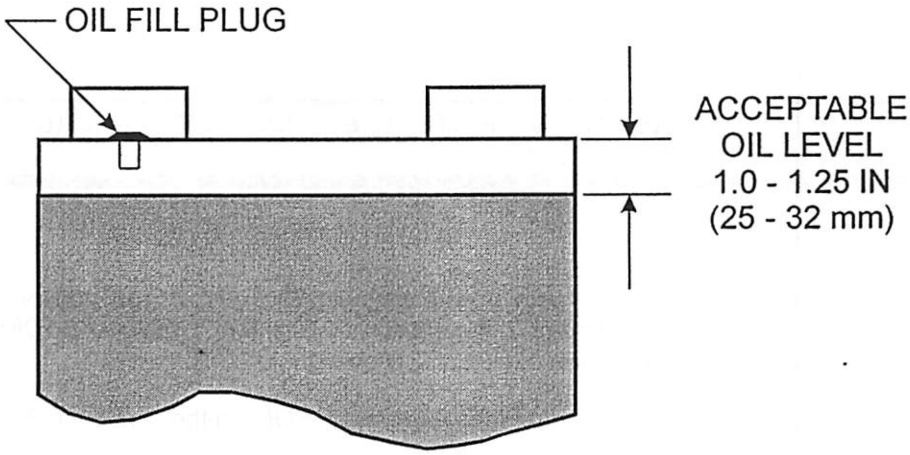

Figure 6-2: HT tank oil level

4. Use only fresh oil, type Shell DIALA AX or equivalent. If a funnel is used to add the oil, take care not to damage any of the delicate components inside the tank.

5. Replace the oil fill plug. Once the plug is installed and the screw properly seated, tighten the screw 4 turns. This will secure the oil fill plug. Wipe up any oil spills. Dispose of soiled absorber in compliance with government requirements and ensure conformity to local disposal regulations. THE OIL DOES NOT CONTAIN PCBs.

6.5.0 CLEANING

- Never use anything other than soap and water to clean plastic surfaces. Other cleaners may damage the plastic.
- **Never use any corrosive, solvent or abrasive detergents or polishes.**
- Ensure that no water or other liquid can enter any equipment. This precaution prevents short circuits and corrosion forming on components.
- Methods of disinfection used must conform to legal regulations and guidelines regarding disinfection and explosion protection.
- If disinfectants are used which form explosive mixtures of gases, these gases must have dissipated before switching on the equipment again.
- Disinfection by spraying is not recommended because the disinfectant may enter the X-ray equipment.
- If room disinfection is done with an atomizer, it is recommended that the equipment be switched OFF, allowed to cool down and covered with a plastic sheet. When the disinfectant mist has subsided, the plastic sheet may be removed and the equipment be disinfected by wiping.

6.6.0 EPROM REPLACEMENT

WARNING: ***PLEASE TAKE APPROPRIATE ELECTROSTATIC PRECAUTIONS AT ALL TIMES WHEN HANDLING THE EPROM's.***

6.6.1 Console EPROM

1. With the generator mains power switched OFF, open the console to gain access to the console EPROM. Refer to chapter 2, the section *CHECKING THE RAM BACKUP BATTERY VOLTAGE*, for the procedure to access the console CPU board.
2. Locate and carefully remove the existing EPROM on the console CPU board (refer to figure 1E-4).
3. Carefully insert the replacement EPROM into the socket *observing the orientation per figure 1E-4.*
4. Re-assemble the console as per the procedure in chapter 2.
5. Refer to 6.6.4 before re-energizing the generator.

6.6.2 Power EPROM

1. With the generator mains power switched OFF, locate and carefully remove the existing power EPROM on the generator CPU board (U38 or U41, refer to figure 1E-1).
2. Carefully insert the replacement EPROM into the socket *observing the orientation per figure 1E-1.* **NOTE THAT THE REPLACEMENT EPROM MAY HAVE FOUR LESS PINS THAN THE SOCKET IT IS TO BE INSERTED INTO. IF THIS IS SO, THE EMPTY PINS MUST BE ON THE PIN 1 SIDE OF THE EPROM AS SHOWN IN FIGURE 1E-1.**
3. Refer to 6.6.4 before re-energizing the generator.

6.6.3 Dual Speed Starter EPROM (If fitted)

1. Switch the generator mains power OFF, **AND WAIT 5 MINUTES FOR THE DC BUS CAPACITORS TO FULLY DISCHARGE.**

   STEPS 2 AND 3 APPLY TO MILLENIA GENERATORS ONLY. IN INDICO 100 GENERATORS, THE DUAL SPEED STARTER BOARD IS FULLY ACCESSIBLE WITH THE APPROPRIATE GENERATOR SIDE PANEL(S) REMOVED.

2. Loosen the two nuts securing the clamping bracket at the top of the dual speed starter. Slide the bracket up and gently remove the dual speed starter assembly. The cables connected to the dual speed starter do not need to be removed in order to change the EPROM.

3. Carefully rotate the dual speed starter chassis to fully expose the dual speed starter board inside the unit.

4. Locate and carefully remove the existing EPROM on the dual speed starter board (U26, refer to figure 1E-6).

5. Carefully insert the replacement EPROM into the socket *observing the orientation per figure 1E-6.*

6. Reinstall the dual speed starter assembly by reversing steps 2 and 3 (Millenia).

6.6.4 Resetting Factory Defaults

Should the ***part number*** *(not revision)* of the replacement EPROM be different from the EPROM being replaced, then the FACTORY DEFAULT procedure(s) must be performed as detailed below. This will initialize the CPU's NVRAM as required by the new software and sets the data to its factory-configured state. Note that there are separate procedures for the console CPU board and for the generator CPU board.

CONSOLE CPU FACTORY DEFAULTS:

23 X 56 CM AND 31 X 42 CM CONSOLES:

1. With the power OFF, set switch 8 of SW1 on the console CPU board to its **ON** position.

2. Power ON the generator. The console will prompt for a **YES** or **NO** to loading defaults for two conditions (console settings and APR memory). Select **YES** to both.

3. Power OFF the console. Reset switch 8 of SW1 on the console CPU board to its **OFF** position.

This will initialize both the CONSOLE settings (refer to CONSOLE settings in chapter 3C) and the APR to the factory default settings.

6.6.4 Resetting Factory Defaults (Cont)

RAD-ONLY CONSOLE:

1. In chapter 3C, refer to **LOAD CONSOLE DEFAULTS.** This is in the **UTILITY** menu, under the **CONSOLE** submenu. Set **LOAD CONSOLE DEFAULTS** to **YES.**
2. Select **<<** and **EXIT** to return to the **UTILITY** menu.
3. Select **EXIT** again to return to the **GENERATOR SETUP** menu.
4. Briefly switch the generator OFF, and then ON again. The console will prompt for a **YES** or **NO** to loading defaults when it is powered on again. Select **YES** to both prompts to reset the console and APR defaults.
5. This will initialize both the CONSOLE settings (refer to CONSOLE settings in chapter 3C) and the APR to the factory default settings.

The **LOAD CONSOLE DEFAULTS** setting automatically resets to **NO** the next time the generator is switched on.

GENERATOR CPU FACTORY DEFAULTS:

1. With the power OFF, set switch 8 of SW1 on the generator CPU board to its **OFF** position.
2. Power ON the generator. After the initialization is complete, the console will display the message **FACTORY DEFAULTS.**
3. Power OFF the generator. Reset switch 8 of SW1 on the generator CPU board to its **ON** position.

This will initialize all generator data to the factory defaults (tube selection, generator limits, receptor setup, I/O configuration, AEC setup, AEC calibration, fluoro setup, tube calibration, time & date, error log and statistics).

6.7.0 SOFTWARE KEY INSTALLATION / REPLACEMENT

WARNING: ***PLEASE TAKE APPROPRIATE ELECTROSTATIC PRECAUTIONS AT ALL TIMES WHEN HANDLING THE "SOFTWARE KEY" I.C.***

This feature is available on Indico 100 generators only. The "software key" activates specific options in the Indico 100 X-ray generator, and may need to be installed to add certain options, or may need to be replaced if it is desired to alter the current configuration of the generator. To install or replace the software key follow the procedure below.

1. With the generator mains power switched OFF, locate the socket for the "software key", U29, on the generator CPU board. Refer to figure 6-3.
2. Remove the existing I.C. U29, if fitted. The original I.C. should be placed in anti-static packaging, and may be set aside for future use in a generator that requires the options that are activated by that I.C.
3. Carefully insert the replacement "software key" into the U29 socket *observing the orientation per figure 6-3.*
4. Perform setup and calibration, if required, of the new features that have been activated by the new software key. Refer to the applicable sections of the service manual.

6.7.0 SOFTWARE KEY INSTALLATION / REPLACEMENT (Cont)

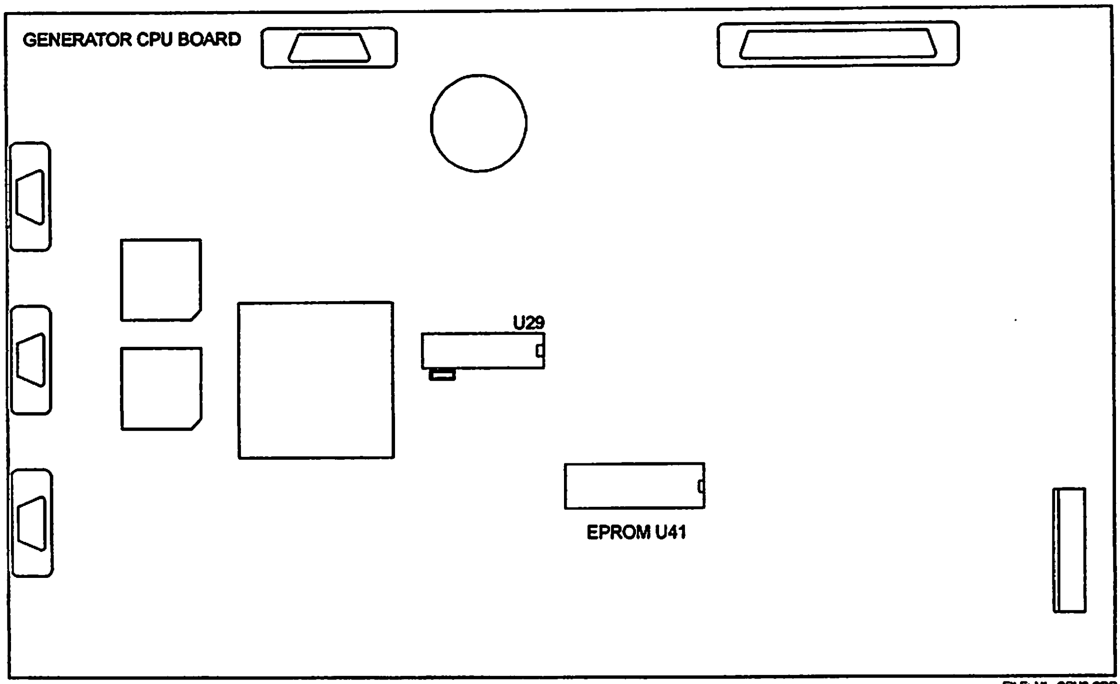

Figure 6-3: Software key location and orientation

6.8.0 BATTERY REPLACEMENT

To replace the battery on the console CPU board or on the generator CPU board, follow the procedure below. Refer to the figure showing the location of these batteries in chapter 2, in the section "CHECKING THE RAM BACKUP BATTERY VOLTAGE". Refer to that section in chapter 2 for console disassembly instructions to gain access to the console CPU board if required.

NOTE:	***THE CONSOLE BATTERY SHOULD BE REPLACED WITH THE GENERATOR POWERED UP. THIS WILL PREVENT THE CONSOLE DATA FROM BEING LOST WHEN THE BATTERIES ARE REMOVED.*** ***THIS IS THE ONLY EXCEPTION TO THE RULE OF NOT SERVICING THE GENERATOR WHILE THE POWER IS ON. FAMILIARIZE YOURSELF WITH THE HIGH VOLTAGE LOCATIONS AND HAZARDS BEFORE REPLACING THIS BATTERY.***

1. Remove the battery from the holder by gently prying under the battery at the access slot in the battery holder using a small screwdriver. Slide the battery over the edge of the holder and remove it when it is free.
2. Check the voltage of the new battery prior to inserting it. This should be nominally 3.0V, do not use if it is under 2.80 V.
3. Wipe the replacement battery with a clean cloth, and ensure that the holder is clean and free of debris before inserting the battery.
4. Gently lift the spring contact on the holder and insert the replacement battery positive (+) side up

6.9.0 TUBE CONDITIONING / SEASONING

Tube conditioning or "seasoning" is particularly important for new tubes or tubes that have not been used for several days. This should be performed on each X-ray tube before attempting auto calibration, as an unseasoned tube may not operate properly at higher kV values without arcing. Refer to the X-ray tube manufacturer's instructions, if available, for the tube conditioning or "seasoning" procedure. If the X-ray tube manufacturers instructions are not available, the following procedure may be used:

6.9.1 Tube Conditioning (Overview)

The generator does X-ray tube auto calibration at 50 kV, 60 kV, 70 kV, 80 kV, 100 kV and 120 kV. The tube normally needs to be seasoned before it can be operated at the higher voltages encountered during auto calibration.

Tube seasoning is started by auto calibrating the kV stations up to and including part of the 70 kV station. The tube is then seasoned at 70 kV. Progressively higher kV stations are then auto calibrated and seasoned. Finally the entire kV and mA range is auto calibrated, then the tube is seasoned at the remaining high kV values.

Manually releasing the exposure button during auto calibration of a particular kV station in the following procedure prevents the generator from attempting operation beyond that kV/mA value.

<u>NOTE:</u>	***THE TUBE MANUFACTURER'S RECOMMENDED SEASONING PROCEDURE, IF AVAILABLE, MUST ALWAYS BE USED IN PLACE OF THE FOLLOWING PROCEDURE.***

<u>NOTE:</u>	***LOW SPEED ONLY EXPOSURES ARE RECOMMENDED FOR THE SEASONING EXPOSURES, TO PREVENT EXCESSIVE HEAT BUILD-UP IN THE HOUSING FROM THE STATOR WINDINGS OR THE ROTOR BEARINGS.***

X-ray tubes that have not been used for more than 8 hours may suffer thermal shock if operated at high mA and kV without a warm-up procedure. A cold anode (Molybdenum) is very brittle and when suddenly heated over a small area may experience thermal cracking of the anode surface, eventually leading to permanent tube damage.

6.9.2 Tube Conditioning (Procedure)

The procedure below is intended for seasoning an X-ray tube prior to attempting tube auto calibration. To season a tube that does not need to be calibrated, simply follow steps 2, 4, 6, 8, and 9.

1. Start the tube auto calibration sequence, and manually terminate the exposure at 70 kV and 250 mA.

2. Season the tube at 70 kV by taking approximately 10 exposures of 200 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.

3. Restart the auto calibration sequence and manually terminate the exposure at 100 kV and 250 mA.

4. Season the tube at 100 kV by taking approximately 5 exposures of 200 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.

5. Restart the auto calibration sequence and manually terminate the exposure at 120 kV and 160 mA.

6. Season the tube at 120 kV by taking approximately 5 exposures of 160 mA and 100 ms. These exposures should be taken at the rate of approximately one every 15 seconds.

6.9.2 Tube Conditioning (Procedure) Cont

7. Restart the auto calibration sequence and allow the auto calibration sequence to complete.

8. Season the tube at 130 kV by taking approximately 5 exposures of 100 mA and 50 ms. These exposures should be taken at the rate of approximately one every 15 seconds.

9. Repeat step 8 at 140 kV, and then at 145 kV.

6.10.0 END OF PRODUCT LIFE

If the generator has completed its useful service life, local environmental regulations must be complied with in regard to disposal of possible hazardous materials used in the construction of the generator.

In order to assist with this determination, the noteworthy materials used in the construction of this generator are itemized below:

ITEM

- Electrical insulating oil in HT tank. This is a mineral oil with trace additives (60 Litre (17 U.S. gal) for Millenia, 25 Litre (6.5 U.S. gal) for Indico 100).
- Solder (lead/tin).
- Epoxy fiberglass circuit board materials, tracks are solder on copper.
- Wire, tinned copper. Insulated with PVC, tefzel, or silicone.
- Steel and / or aluminum (generator cabinet and console chassis).
- Plastic (console enclosure and console membrane).
- Electrical and electronic components: IC's, transistors, diodes, resistors, capacitors, etc.

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CHAPTER 7

THEORY OF OPERATION

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7.1.0 INTRODUCTION

This chapter covers the theory of operation of the Millenia family of X-ray generators.

7.2.0 HF POWER SUPPLY

7.2.1 Functional Outputs (HF Power Supply)

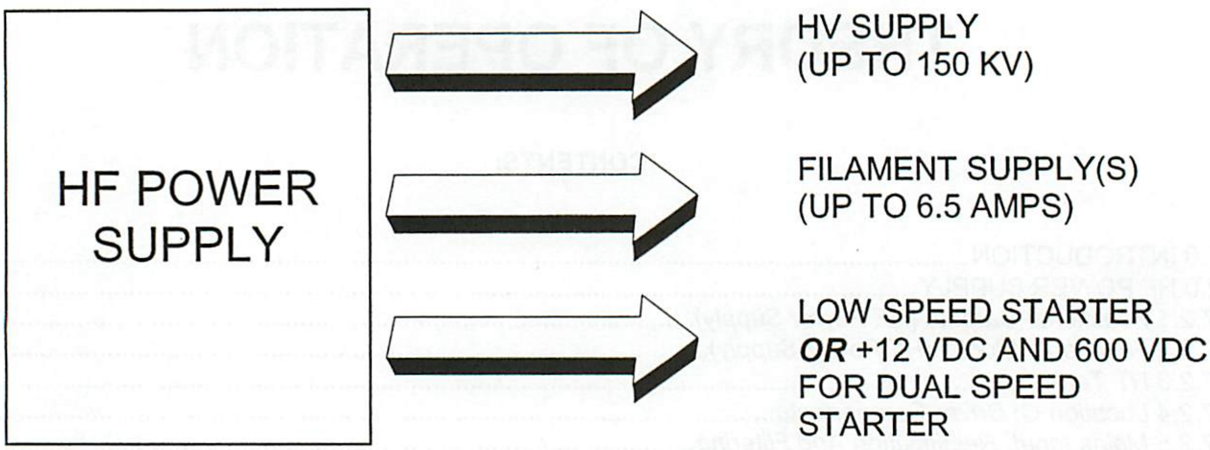


Figure 7-1: HF power supply outputs

As shown in Figure 7-1, the HF power supply provides 3 outputs:

HV SUPPLY	Up to 150 kV. This consists of the cathode supply (up to -75 kV) and the anode supply (up to +75 kV).
FILAMENT SUPPLY	Depending on configuration 1 or 2 filament supplies are used. Each filament supply can source up to 6.5 amps.
LOW SPEED OR DUAL SPEED STARTER	The low speed starter board and associated circuits are part of the HF power supply. If the optional dual speed starter is used, the HF power supply provides +12 VDC and 600 VDC to operate the dual speed starter.

7.2.2 Functional Blocks (HF Power Supply)

Figure 7-2 shows the main functional blocks of the HF power supply.

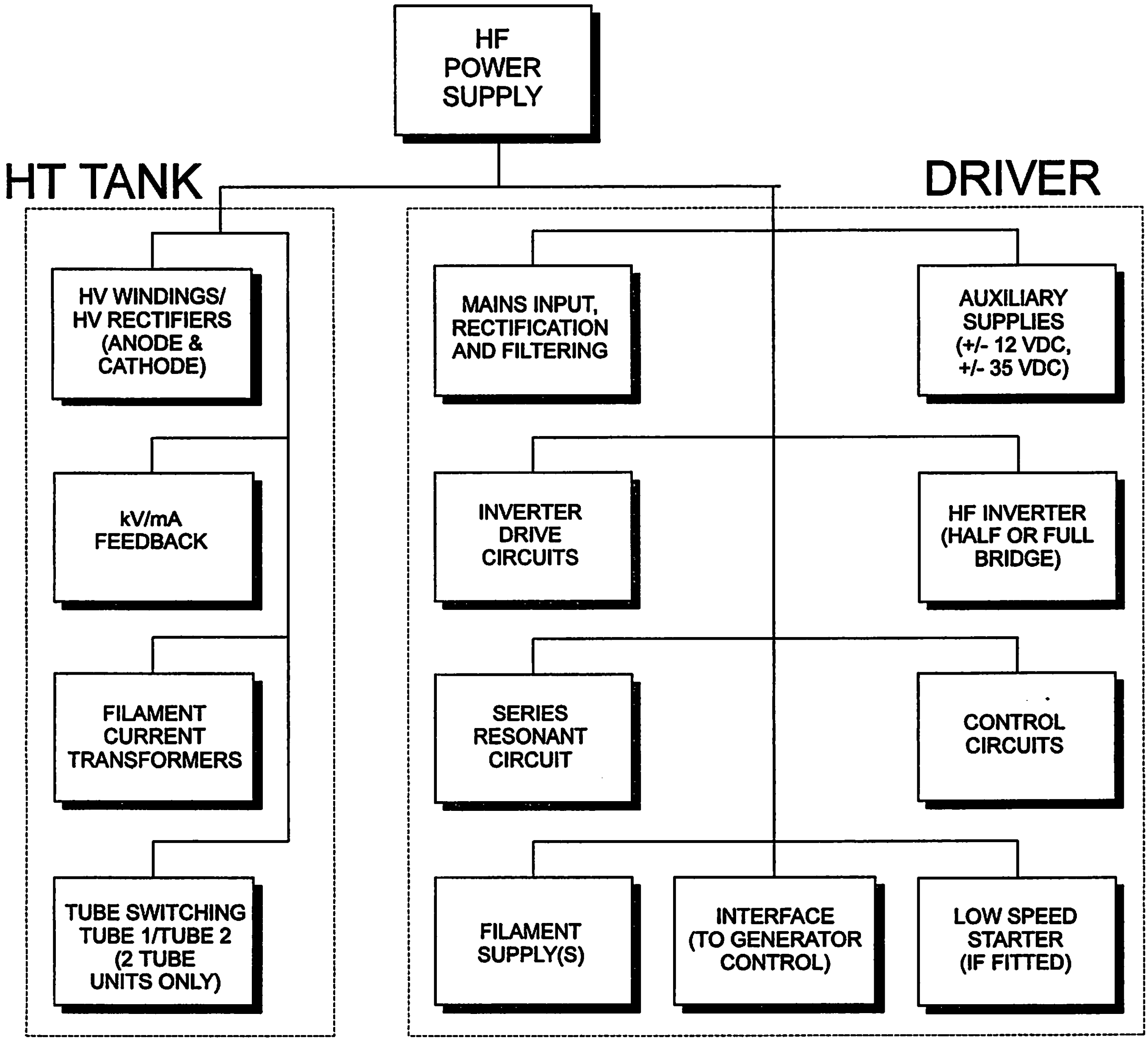


Figure 7-2: HF power supply functional blocks

7.2.3 HT Tank

Figure 7-3 is a schematic overview of a typical HT tank. The theory of operation of the HT tank follows:

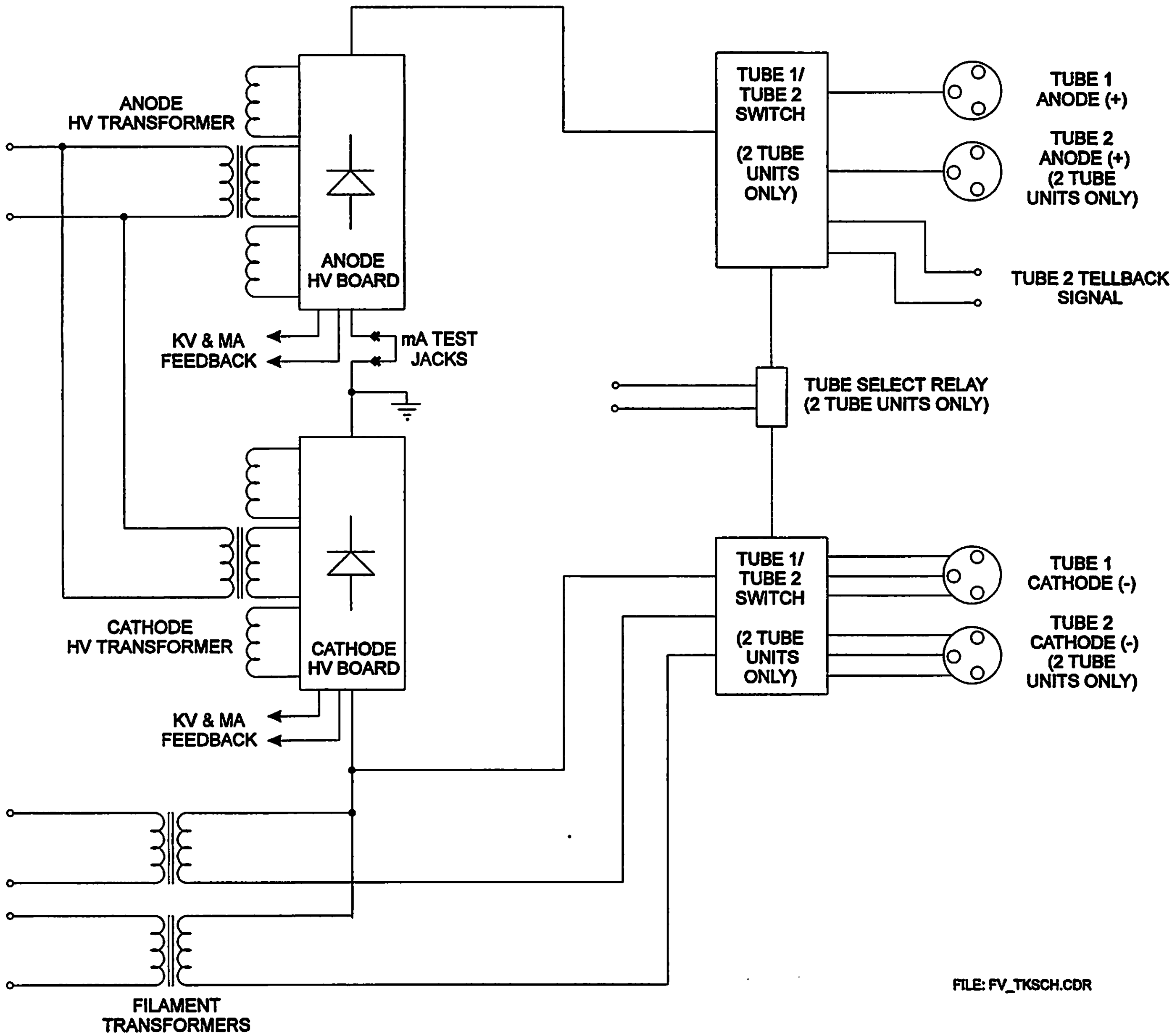


Figure 7-3: Schematic overview of HT tank

7.2.3 HT Tank (cont)

The HT tank contains all of the components and assemblies shown in figure 7-3 (filament transformers, HV transformers, anode and cathode HV boards, HV output connectors, and optional relay and switches for tube 2 selection).

The output of the HF inverter and series resonant circuit in the driver is fed to the primary of the anode and cathode HV transformers. These transformers step up the primary voltage, the high voltage from the secondaries is then taken to the anode and cathode HV boards to be rectified to produce up to +75 kV and -75 kV respectively. The high voltage output from the two HV boards is connected directly to the HV output connectors on one tube tanks, or connected to a high voltage switch that allows selection of tube 1 or tube 2 on two tube tanks.

Each of the HV boards has a precision high voltage divider to provide a sample of the kV signal for feedback to the driver, and series resistors to sample the tube current which is also fed back to the driver (kV and mA feedback).

The output of the filament supply(s) in the driver are fed to the primary of the two filament transformers in the HT tank. The main function of the filament transformers is to couple this filament current to the X-ray tube filaments while providing isolation between the low voltage on the filament supply board(s) and the secondary voltage (up to 75 kV). One filament transformer supplies current to the small filament in the X-ray tube, the second transformer supplies current to the large filament.

Selection of tube 2 (two tube units only) is achieved by 115 VAC being applied via the driver to the tube select relay. The tube select relay in turn activates the tube 1 / tube 2 switch in the HT tank. An extra set of contacts on the tube 1 / tube 2 switch in the HT tank supplies a tellback signal to the HF power supply interface board in the driver to indicate that tube 2 has been selected.

Most models of HT tank have mA monitor jacks fitted, which allow measurement of the X-ray tube current.

7.2.4 Location Of Driver Components

Figure 7-4 shows the general layout and major components of the driver for a typical HF power supply.

Due to the diversity of generator models, some of the driver details may not be exactly as shown.

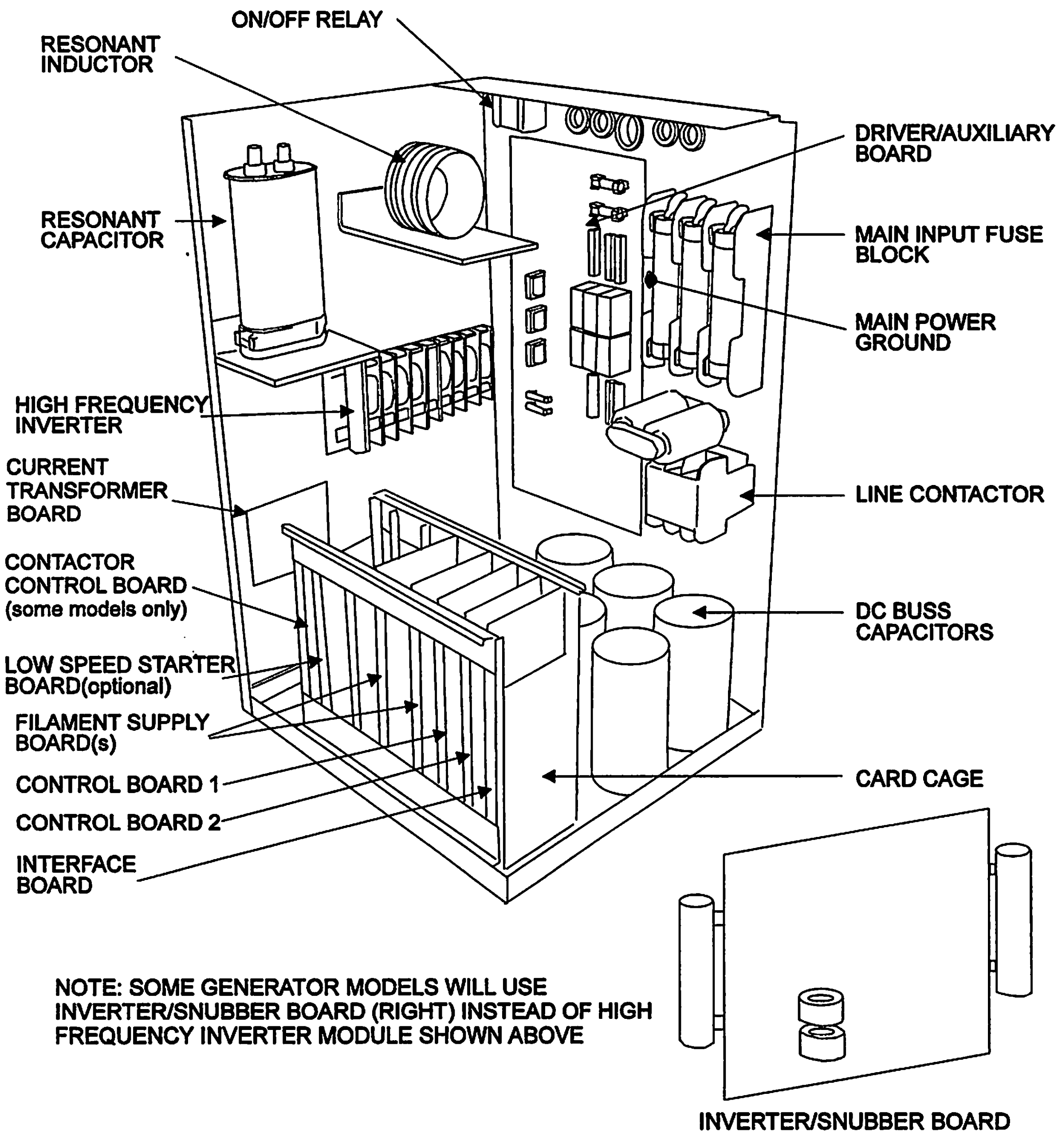


Figure 7-4: Major components - HF power supply driver

7.2.5 Mains Input, Rectification And Filtering

Refer to the HF power supply system schematic, drawing number per the schematic index in chapter 9 of this manual (listed in the index as *Schematic, HF P/S overview).*

The mains input (1ϕ or 3ϕ) is connected to the main input fuse block located at the top right of the driver. The output of the fuses is connected to the main contactor via the EMI filter, and 1 phase of the mains is also taken to the driver/auxiliary board. See the section *driver/auxiliary board* for further details regarding that board.

When the generator is switched on (via the console or the **ON** switch on the generator interface board) the line contactor under the main input fuse block closes after a brief delay. This applies the mains voltage to the main rectifier diodes to be converted to DC, it is then filtered by the DC bus capacitors to produce smooth DC.

240 VAC 1ϕ power supplies have the mains voltage doubled to produce a bus voltage of approximately 660 VDC, 400 and 480 VAC 3ϕ units have a bus voltage of approximately 560 VDC (the optional line adjusting transformer steps the 480 VAC mains down to approximately 400 VAC for input to the power supply).

7.2.6 Driver/Auxiliary Board

The driver/auxiliary board contains drive and timing circuits for the line contactor, drive circuits for the high frequency SCR inverter, auxiliary supplies, under voltage detection, DC bus capacitor pre-charging circuits, the tube 1/tube 2 select relay and other circuits as described below.

The mains input voltage that is brought to the driver/auxiliary board is connected to the on/off relay contacts. This relay is energized by the generator ON command. When this relay is energized, several events occur:

- Mains voltage is connected to the primary of the auxiliary transformer in the driver. This transformer has a tap at 115 VAC to drive the tube select relay in the HT tank on two tube tanks, a tap at 240 VAC to supply the low speed starter if fitted, and line adjusting taps to match the mains voltage. The secondary of the transformer supplies the low voltage which is rectified to produce ± 35 VDC unregulated for the filament supplies and SCR drivers and ± 12 VDC regulated for the logic circuits. Smoothing capacitors for these DC supplies are located on the chassis bottom assembly.
- The DC bus capacitors begin charging via a soft start circuit on the driver/auxiliary board. Pre-charging these capacitors prior to closing the line contactor prevents large inrush currents when the line contactor closes (on the 30 kW 240 VAC 1ϕ power supply the soft start circuit is located on the inverter/snubber board).
- The timer for the line contactor driver starts timing. After approximately 8 seconds delay (to allow DC bus capacitor pre-charge) the line contactor is energized. A logic signal generated by the contactor driver inhibits exposures during the contactor delay time.

The driver circuits for the SCR's in the HF inverter are also located on the driver/auxiliary board. There are two drivers for half bridge inverters, and four drivers for full bridge inverters. The inverter drivers take the relatively low level gate pulses from control board 2, boost them sufficiently to drive the SCR's and also isolate the control logic from the SCR gates which are at high voltage potential.

The +12 VDC and -12 VDC supplies have an under-voltage monitoring circuit that inhibits exposures if either of these two supplies drop below acceptable limits.

The relay for tube 1/tube 2 selection (two tube generators only) applies 115 VAC to the tube select relay in the HT tank when commanded by the generator control circuits.

Lastly, protection is provided on this board against shorts on the DC bus capacitors. A circuit is provided that is enabled only if the bus voltage exceeds nominally 120 VDC at pre-charge. If a short circuit is present on the DC bus, causing the bus voltage to remain under 120 VDC, this circuit will prevent the line contactor driver from beginning it's timing cycle and closing the line contactor.

7.2.7 High Frequency Inverter/Series Resonant Circuit

The high frequency inverter is configured as a half bridge inverter in 30 and 50 kW power supplies, and full bridge configuration in 65 and 80 kW units. There are two types of half bridge inverters used in HF power supplies: capsule or "hockey puck" style SCR's with separate parallel diodes used in most models of power supplies, and combined SCR/diode modules used in several other models of power supplies.

Functionally there is no difference between the two styles of half bridge inverters, and for the purpose of this discussion no significant difference between half bridge and full bridge inverter configurations.

The SCR's can be considered as switches that are switched on when pulsed by the inverter drive circuits and switched off when the resonant current crosses through zero at the end of one half-cycle of the series resonant circuit. When the SCR's are switched on, current begins to flow from the DC bus capacitors through the SCR's, through the resonant circuit consisting of the resonant capacitor(s) and resonant inductor, and through the primary of the HV transformers in the HT tank. High voltage is then produced at the output of the HT tank, the actual value of the voltage depending on the rate at which the SCR's are pulsed. The SCR pulse rate is controlled by control board 1 and control board 2.

7.2.8 Inverter/Snubber Board (If Fitted)

The inverter/snubber board is used on power supplies using a half bridge inverter with the SCR/diode modules described above.

The SCR/diode modules in this case are mounted to the driver chassis panel directly underneath the inverter/snubber board. This board contains electrical connections to the SCR/diode modules, snubbers for the modules, two current transformers which sample the resonant current, and the soft start circuit on the 30 kW 240 VAC 1ϕ power supply.

The sampled resonant current output from one of these transformers is used to detect resonant over current, the second transformer is used to sense the zero crossing of the resonant current. More details are in the sections *control board 1* and *control board 2.*

Power supplies that use the inverter/snubber board DO NOT use the current transformer board (figure 7-4).

7.2.9 Current Transformer Board (If Fitted)

The current transformer board is used on all power supplies which use the capsule style SCR's. This board contains two current transformers that sample the resonant current. As described above, the sampled resonant current output from one of these transformers is used to detect resonant over current, the second transformer is used to sense the zero crossing of the resonant current. More details are in the sections *control board 1* and *control board 2.*

7.2.10 Backplane Board

The primary function of the backplane board is to serve as a motherboard to interconnect the circuit boards in the power supply card cage.

The backplane board contains seven connectors for the card cage boards. These connectors along with interconnections on the backplane board connect all of the plug in boards in the card cage in parallel. The backplane board also contains the connector which drives the coil of the ON/OFF relay in the power supply, and a connector for the optional dual speed starter logic cable along with level translation circuits to properly drive the opto couplers on the dual speed starter.

7.2.11 Control Loop (Pictorial)

Figure 7-5 is a pictorial representation of the HF power supply showing the main functional blocks associated with producing and regulating the kV output.

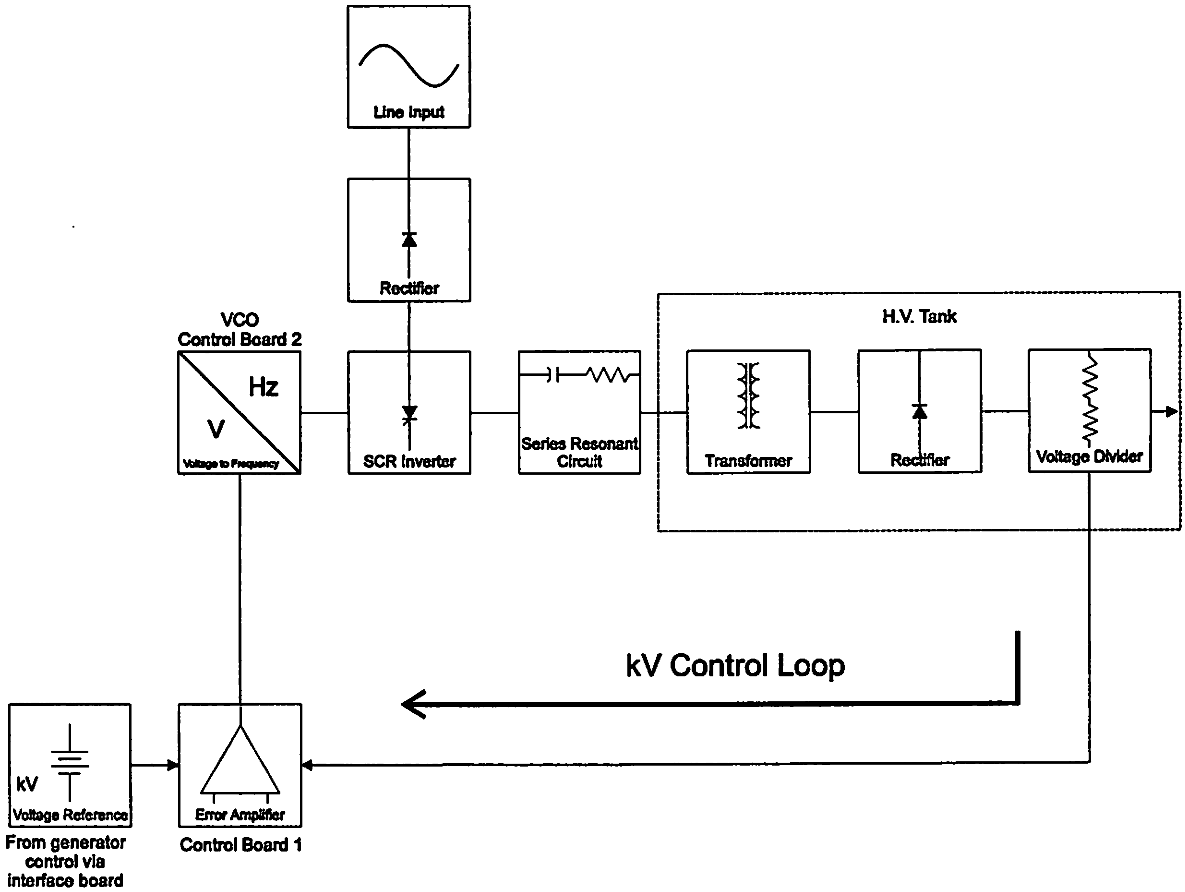


Figure 7-5: Control loop - HF power supply

7.2.12 Control Board 1

Refer to figure 7-6 for control board 1 operation. This is a block diagram of a typical control board 1, this may be used in conjunction with the detailed control board 1 schematic for your generator in chapter 9 if desired. Please note that the reference designations used in this section apply to figure 7-6 only.

The differential kV feedback voltage from the HT tank is brought to control board 1 to be processed. This feedback voltage is first brought to a compensation network consisting of compensation capacitors and switches which are factory adjusted to match control board 1 to the HT tank. The compensation network may need re-adjusting if either the HT tank is replaced, or if control board 1 is replaced. The compensation network is depicted by the two capacitors in front of IC's 1 and 2 in figure 7-6.

The compensated kV feedback voltage is then buffered and amplified by IC's 1, 2 and combined by differential amplifier IC 3. The processed kV feedback signal at the output of IC 3 is used internally on control board 1 and also routed to the generator control circuits.

IC 4 is a differential amplifier which buffers the kV demand voltage from the generator control circuits. The kV feedback voltage and kV demand voltages (outputs of IC 3 and IC 4 respectively) are summed together and fed into the error amplifier IC 5. The two summed voltages are opposite in polarity and will sum to zero if they are equal in magnitude, that is if the kV output from the power supply is equal to the kV demanded.

The output voltage range of the error amplifier ranges from approximately +11 VDC for full demand to approximately -4 VDC for zero kV demand (this range is an approximate guide only and will vary from model to model) The error amplifier output is buffered by IC 6, thus inverting and reducing the magnitude of the error amplifier output. The output of IC 6 is diode OR'ed together with a signal from IC 10 discussed later in this section. The OR'ed voltage output of IC 6 (and IC 10) is termed the VCO (voltage controlled oscillator) signal and is fed to control board 2 for further processing.

In addition to the kV feedback voltage, the HT tank supplies mA feedback voltage. The mA feedback voltage is brought to the input of differential amplifier IC 7. The output of IC 7 feeds two independent paths. The first path consists of IC 8 and IC 9 which have gain such as to supply a mA feedback signal scaled 1V = 100 mA. This is the Rad mA feedback signal, and is fed to the generator control circuits. The second path is used on R & F generators, and consists of IC 11 and associated circuits. This IC has higher gain and extra noise filtering circuits to supply a mA feedback signal scaled 1V = 2.5 mA. and is also fed to the generator control circuits The output of this IC is not useable above approximately 25 mA of tube current as the amplifier output saturates at that point.

The output of IC 8 also drives IC 10. This IC is configured as a summing amplifier, with the negative output of IC 8 as one of the inputs and a positive current set by fixed value resistors as the other input. The value of the positive summing current is set such that IC 9 becomes active at approximately 5-10 % above the maximum rated output current for that power supply. The output of IC 10 will swing high (positive) in case of an over current, clamping the VCO and therefore the power supply output current.

Control board 1 also has protection circuits against excess kV, against excess resonant current and against excess output current/arcing. A sample of the kV feedback voltage is fed to IC 15, which is a voltage comparator. This comparator is set up to detect output voltage greater than approximately 155 kV. High kV causes the output of IC 15 to go low, this takes the beam fault line low inhibiting control board 2 and lighting fault indicator LED 17.

Protection against resonant over current is provided by diode bridge 14 and IC 16. A sample of resonant current from the inverter/snubber board or from the current transformer board is rectified by diode bridge 14, then compared to a fixed reference voltage by IC 16. In case of resonant over current, operation of IC 16 is similar to that of IC 15 during an over voltage condition.

Protection against output voltage arcing is provided by a sensing circuit which monitors the mA feedback current. This circuit is represented by item 12 in figure 7-6 and consists of very fast transistor switches that trigger comparator IC 16 in case of output arcs. The output of IC 15 or IC 16 is driven low by the occurrence of a fault, and latched low by latch circuit 13. This prevents the output of the two fault detector IC's from spontaneously returning to a normal state.

As stated above, the power supply latches the beam fault line. However the generator control will immediately reset the fault latch. The beam fault LED, 17, will therefore be seen to flash as the fault occurs and is cleared. However the generator control will display an error message and will inhibit further exposures until it is reset.

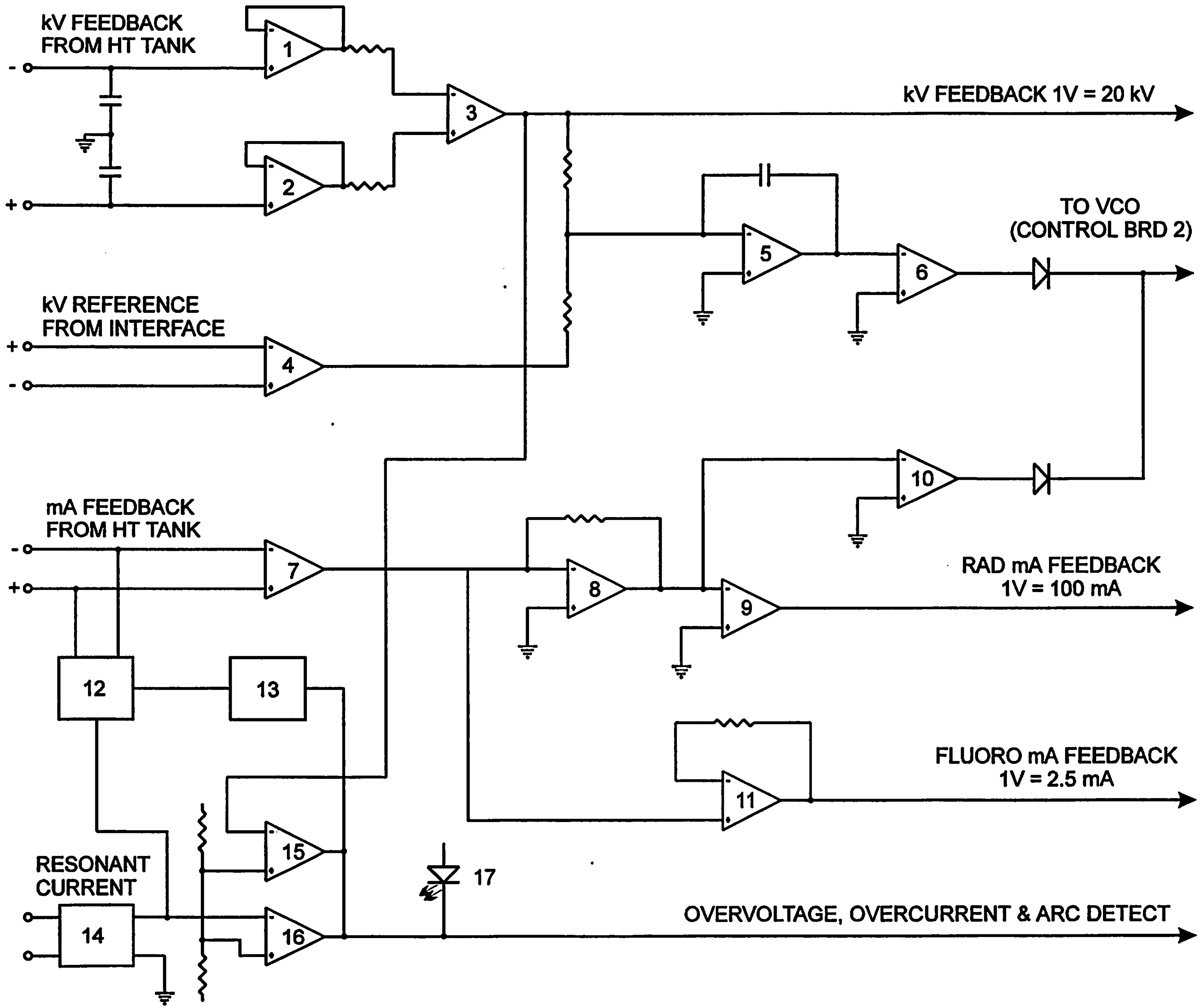


Figure 7-6: Control board 1 block diagram

7.2.13 Control Board 2

Refer to figure 7-7 for control board 2 operation. This diagram is an overview of a typical control board 2 and may be used in conjunction with the detailed control board 2 schematic for your generator in chapter 9 if desired. The reference designations used in this section apply to figure 7-7 only.

The VCO voltage from control board 1 is connected to IC 3 on control board 2. This IC with its associated components is a voltage controlled oscillator. The frequency of oscillation is proportional to the applied VCO voltage. This voltage ranges from approximately +1 VDC at which point the VCO is inhibited to approximately -4 VDC when the VCO runs at maximum frequency (this range is an approximate guide only and will vary from model to model).

When the VCO is enabled the capacitor across IC 3 charges causing a ramp voltage to be generated at the output of IC 3. This ramp voltage is compared with a fixed reference voltage by IC 4. Once the ramp voltage exceeds the reference voltage the output of IC 4 switches high. The output of IC 4 is AND'ed with an inhibit signal by IC 5. The positive output of IC 5, when IC 5 is enabled, resets the VCO by shorting the capacitor across IC 3. The output of IC 5 also triggers monostable multivibrator IC 6 which generates 4 us wide pulses. The inverted (Q/) output of IC 6 drives the clock input of IC 7, generating alternate pulses at its outputs which are then fed to one of the inputs of AND gates IC 8 and IC 9. These pulses are only generated while the VCO is running, the pulse rate being proportional to the VCO frequency.

The second inputs of IC 8 and IC 9 are driven by the Q output of IC 6. These pulses when AND'ed with the outputs of IC 7 produce alternate 4 us wide gate pulses at the output of IC 8 and IC 9. The outputs of IC 8 and IC 9 are then fed to a pair of drivers circuits 10 and 11 which provide the required current gain to be able to drive the SCR drivers on the driver/auxiliary board.

The portion of control board 2 described so far is capable of generating alternating gate pulses that are proportional in frequency to the VCO voltage. In order for these pulses to be able to properly drive the SCR's, they must be synchronized to the resonant current. The portion of control board 2 that controls this timing is covered next. The description so far, which discusses IC 3 through IC 9, refers to the generation of alternate gate pulses. In actual operation the second and following gate pulses only occur if enabled by additional circuits on this board.

The pulse generated at the Q output of IC 6 resets IC 12, setting the output of IC 12 low. This takes the inhibit pin of AND gate IC 5 low, inhibiting further pulses and also resetting the VCO in preparation for the next pulse. The Q output of IC 6 also triggers IC 21 which is a 150 us monostable vibrator. The output of IC 21 triggers IC 22 after the 150 us period. IC 22 is a 10 us* monostable multivibrator which clocks the output of IC 12 high after the 10 us* period. This enables IC 5, allowing gate pulses to be generated again. The next gate pulse will again inhibit the VCO until it is enabled again for the next gate pulse in an orderly fashion.

A sample of resonant current from the inverter/snubber board or from the current transformer board is routed to control board 2 to be compared to reference voltages slightly above and below zero by IC 13 and IC 14. The slight offset of the references from zero ensures that IC 13 and IC 14 detect the current after it has gone through zero. The output of IC 13 and IC 14 is then inverted by IC 15 and IC 16 respectively. The positive going edges of the output of IC 15, IC 16 occur just after the zero cross of the resonant current, these edges clock the outputs of IC 17, IC 18 high. The outputs of IC 17 and IC 18 are AND'ed by IC 19 to produce a high at the output of IC 19, triggering monostable multivibrator IC 20 to produce a 3 us wide negative going pulse at it's output. This 3 us wide pulse immediately resets IC 21 low, normally before the 150 us timer is finished timing. As before, the 10 us* timer IC 22 sets the output of IC 12 high, again enabling the VCO.

The 10 us* timer ensures that the next SCR cannot fire until at least 10 us* after a zero cross of the resonant current.

Gate pulses will continue to be generated as long as the VCO control voltage demands gate pulses, and as long as the inhibit input of IC 5 is enabled.

* Some models use 8.5 us instead of 10 us.

....Continued on page 7-14

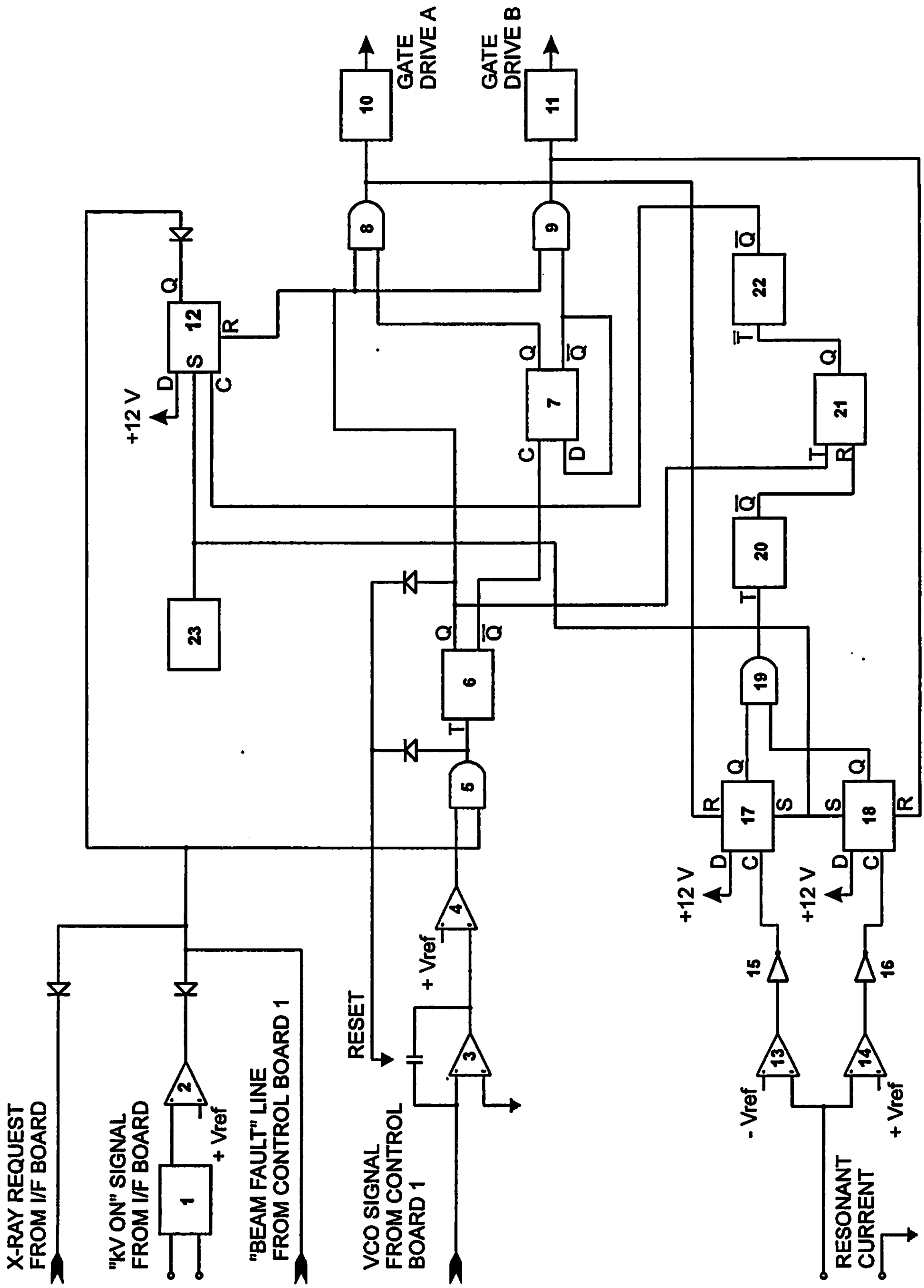


Figure 7-7: Control board 2 block diagram

7.2.13 Control Board 2 (cont)

There are three control inputs OR'ed together to inhibit IC 5. Any of the inputs listed below can inhibit the VCO by taking the inhibit of IC 5 low:

- A "kV ON" signal from the interface board energizes opto coupler 1; the opto coupler output then is inverted by IC 2 causing the output of IC 2 to go high. This line is low if "kV ON" is not requested.
- An X-ray request signal from the interface board which is low if x-rays are not requested is the second input. This signal must be high to request X-rays.
- The beam fault line from control board 1 is the third input. This line is low if a beam fault has been detected, and high for normal operation.

Lastly, the power-on reset circuit 23 presets the Q output of IC 12, IC 17 and IC 18 high when the power supply is switched on. This is necessary to ensure correct start up of the logic circuits.

7.2.14 Filament Supply Board(s)

Refer to figure 7-8 for filament supply board operation. The filament supply schematic in chapter 9 may be used in conjunction with this figure. The reference designations used in this section apply to figure 7-8 only.

Millenia power supplies use either one or two filament supplies. The operation is similar on both filament supplies, differences are noted below where applicable.

The filament reference voltage that is produced by the generator control circuits is buffered and inverted by differential amplifier IC 1. The output of IC 1 is summed with a current limit signal from IC 2. The maximum filament current limit of 5.5 or 6.5 amps is determined by the setting of JW1 on the filament supply board. The combined filament reference voltage from IC 1 and IC2 is then summed with a positive feedback signal at the input of IC 3. These signals sum to zero when the filament demand and feedback are equal, and produce an error voltage at the output of IC3 when they are not equal. If the filament demand is greater than the actual filament current the output of IC 3 rises, in turn causing the pulse width of pulse-width modulator IC 4 to increase. The output pulses from IC 4 drive current amplifiers 5 and 6; the current amplifiers in turn drive the power amplifier 7 on this board. The power amplifier is configured as a half bridge (two power transistors) on low power filament supplies, and as a full bridge (four power transistors) on high power filament supplies. The operational differences are not significant for this discussion. The filament drive current available from the power amplifier is dependent on the pulse width of the drive, which is proportional to the error signal seen by IC 3.

The output of the power amplifier is sampled by current transformer 9, and fed to relay 8 where it is switched to drive either the small or the large filament transformer. The common line for both of the filament transformers returns to the other side of the power amplifier. The large/small drive signal for relay 8 is generated by the generator control circuits.

Relay 8 is ONLY used on single filament power supplies where one filament supply drives both small and large filaments. Units with separate large and small filament supplies have the power amplifier connected directly to the appropriate filament transformer output on the filament supply boards after passing through current sense transformer 9.

The filament current sample from current transformer 9 is fed into RMS converter circuit 10, and then buffered by IC 11. The output of IC 11 is a voltage that is proportional to the RMS value of the actual filament current. This output voltage is summed with the reference voltage at IC 3 as mentioned earlier, and also amplified by IC 12. The output of IC 12 is split, with one path supplying a filament feedback voltage proportional to filament current, and with the second path feeding comparator IC 13. This comparator, in conjunction with transistor 13, supplies a filament fault signal (logic "low" for normal filament current ≥ 1.8 amps, "high" for a filament fault condition.

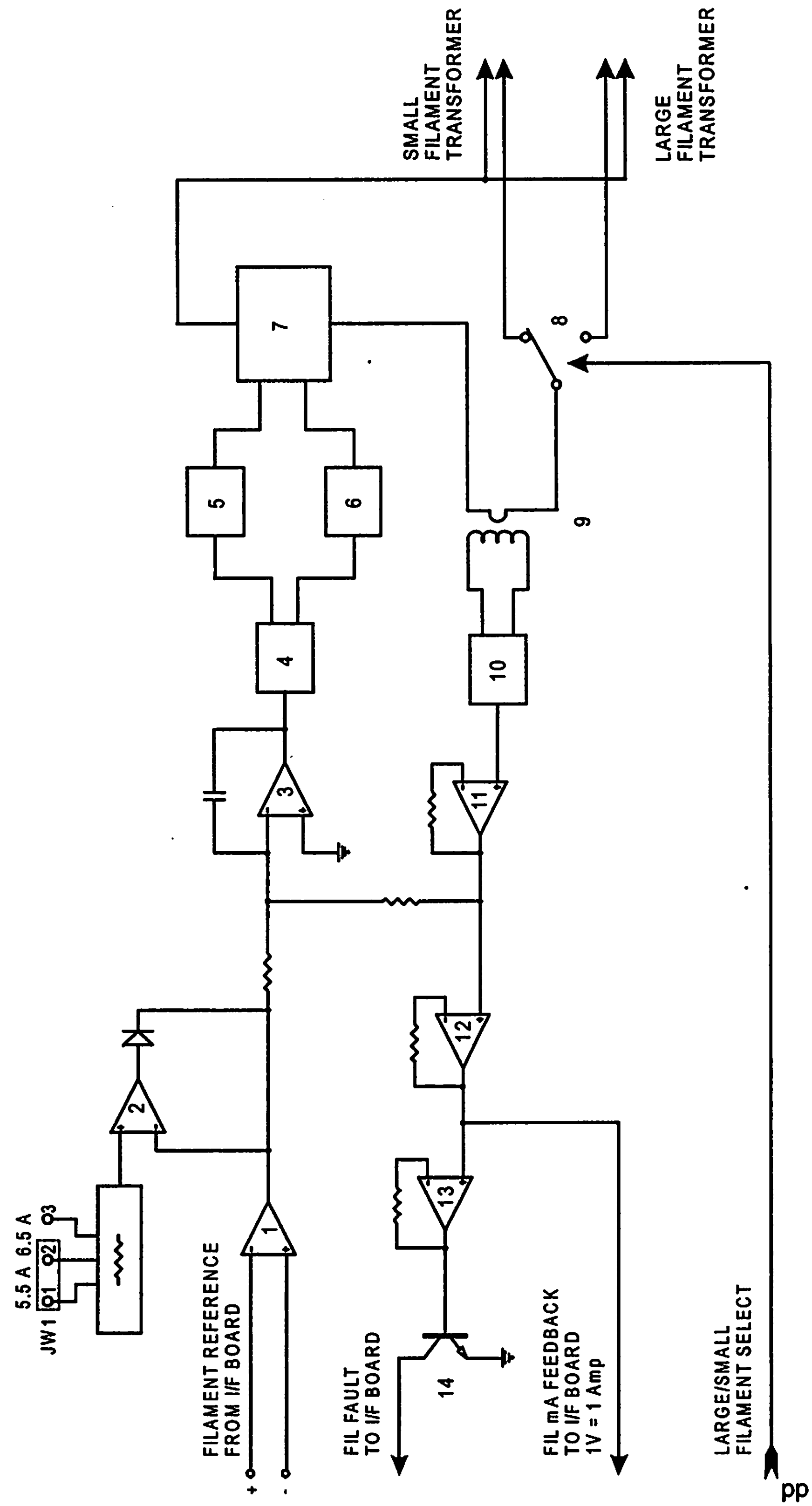


Figure 7-8: Filament supply block diagram

7.2.15 Interface Board

Refer to the interface board schematic in chapter 9 of this manual. The interface board connects to the generator control circuits via J1 and J2 on the interface board. J1 is used on all generators, J2 is only used if that generator model requires functions accessed through J2.

The interface board routes the reference voltages from J1 and J2 for kV demand and filament current demand via the backplane board to control board 1 and the filament supply board(s) respectively. Feedback signals to monitor actual kV, actual X-ray tube current, and actual filament current generated by control board 1 and the filament supply board(s) respectively are routed via the backplane board to J1 and J2 on the interface board

Additional control signals routed through J1 and J2 on the interface board are:

- The ON command (24 VDC) from the generator control to energize the on/off relay in the power supply.
- A large/small filament command to toggle the large/small filament select relay on single filament supply units. This command is used by the contactor control board if fitted. See the section *contactor control board.*
- A kV enable command that must be present before the prep and X-ray functions are enabled. This signal is toggled by the generator control circuits to reset the beam fault error on control board 1.
- A prep command that starts the boost cycle on the low speed or dual speed starter. The prep signal must also be present to enable the X-ray function.
- An X-ray command that enables X-rays to be taken if all other required commands are present and no errors are present.
- A tube 1/tube 2 select command that is used to drive the tube select relay on the driver/auxiliary board, and a relay on the low speed starter board or dual speed starter board used to route the stator voltages to the correct X-ray tube. This is available on two tube units only.
- A rotor boost time command. This allows for extension of boost time on generators equipped with low speed starters under software control, and is used to select low speed/high speed modes on dual speed starter equipped generators.
- A large/small filament feedback signal that indicates whether large or small filament has been selected.
- A filament fault feedback signal originating at the filament supply board(s).
- A rotor fault feedback signal originating at the low speed starter or dual speed starter board.
- A contactor closed feedback signal to indicate that the line contactor is energized. This signal originates at the driver/auxiliary board.
- A beam fault feedback signal. This beam fault signal originates at control board 1, and represents faults as described in that section.
- A ready feedback signal to indicate that no faults are present and that all required logic commands are present. The kV enable signal and prep signal must be present and filament fault, beam fault, rotor fault, and under voltage/contactor closed conditions must all be normal i.e. no fault before a ready signal is available.

The tube 2 tellback signal from the HT tank is brought to J4 on the interface board. Logic circuits on this board compare the tube selection signal to the tube 2 tellback signal, and inhibit power supply operation if a mismatch is detected between the tube actually selected and the tube that has been requested.

7.2.16 Contactor Control Board (If Fitted)

The contactor control board is only used on some models of generators. Refer to the schematic of the contactor control board in chapter 9 if applicable.

The contactor control board uses the large/small filament select signal to switch transistors Q1 and Q2 on this board. The output of Q2 energizes an extra contactor in the HF power supply. This extra contactor switches the resonant capacitors when needed to allow operation of the required load map (kV/mA stations).

7.2.17 Low Speed Starter Board (If Fitted)

The low speed starter is standard on Millenia generators, the dual speed starter being optional. Refer to the low speed starter schematic in chapter 9 if applicable.

The low speed starter drives the stator at 50 Hz or 60 Hz depending on line frequency. The tube power curves are derated automatically in software for 50 Hz operation if required.

The low speed starter board consists of the major functional blocks:

- A 1.5 sec timer circuit to time the rotor boost.
- An oscillator synchronized to the AC mains.
- A triac driver to switch the output current.
- A low rotor current sensing circuit.
- A relay to switch the output current to the tube 2 stator (two tube units only).

The oscillator operation will be discussed first. This begins by assuming that opto coupler U1 is energized, turning Q1 off and allowing the oscillator to operate.

The line voltage is rectified but not filtered, and applied across R5 and D5. This unfiltered and pulsed DC voltage synchronizes the oscillator to the line frequency. C2 (and C1 for 50 Hz operation) charge through R4 and R8, the charge time being determined by the RC time constant. When C2 and/or C1 charges to the trigger voltage of Q2, Q2 fires causing Q3 to fire. This essentially short circuits the bridge rectifier through current limit resistor R1, thus firing triac Q4 for the duration of that half cycle.

The short circuited bridge resets the oscillator in preparation for the next half cycle. The stator voltage is determined by the triac on time, which is determined by the charge time of C2 and/or C1. The charge time is in turn set by the value of R4 and R8 for the stator run voltage. For rotor boost, full voltage is required i.e. maximum duty cycle of the oscillator. To achieve this maximum duty cycle during rotor boost time, opto coupler U2 is energized placing R3 in parallel with R4 and R8. This charges the capacitor(s) very quickly after the start of a half cycle allowing essentially full voltage 240 VAC boosts.

The prep line (J3 pin 15A and 15C) on the low speed starter board is at logic low in the idle state i.e. no prep. This turns on Q5 and Q6 which de-energizes opto coupler U1, inhibiting the oscillator. Meanwhile, Q6 keeps the input of U3 low which holds the output of U3 low, generating a rotor fault signal.

When a prep command is received to start rotor operation, the prep line goes high. This turns off Q5, enabling U1 and thus the oscillator. At the same time Q6 turns off, allowing the 1.5 sec timer U3 output to switch high after the 1.5 sec boost time. During the boost time while the output of U3 remains low, U2 is enabled forcing maximum oscillator duty cycle . Also while the output of U3 is low during boost, a rotor fault signal is generated to inhibit exposures.

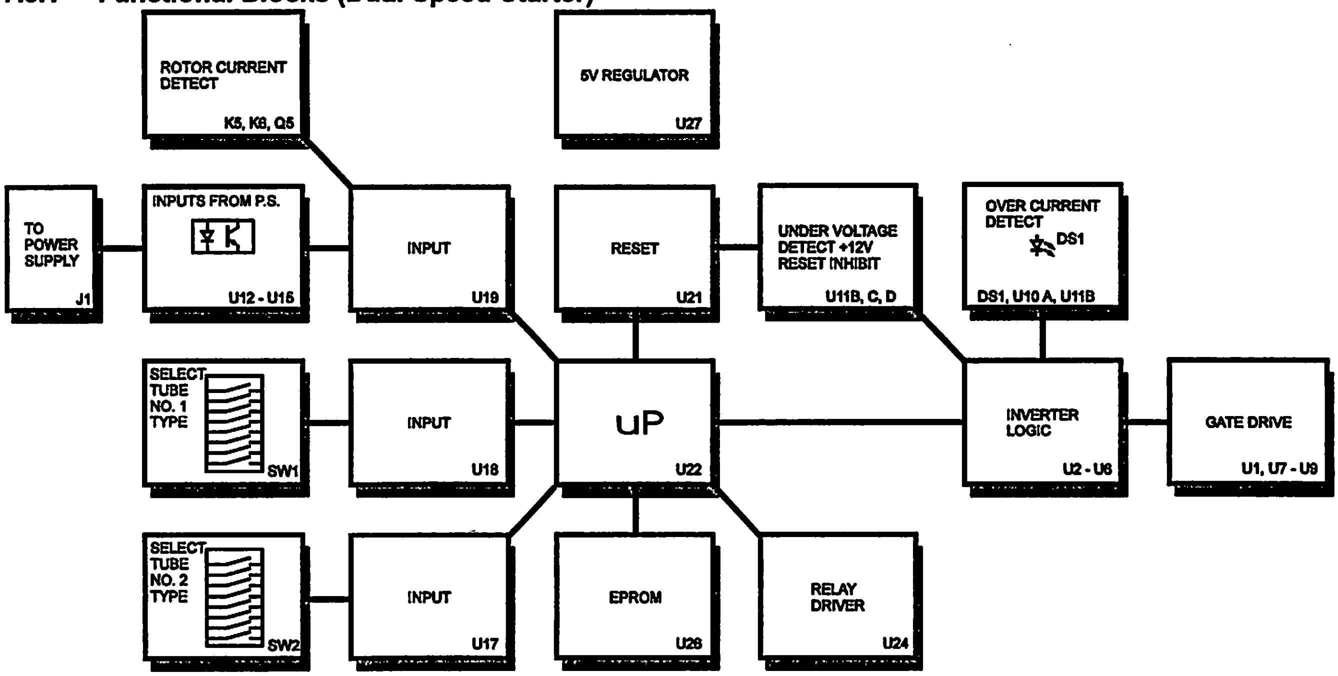
At the end of the boost time the output of U3 goes high, turning off opto coupler U2. This also allows Q7 to turn on, assuming that low rotor current is not detected, indicating normal rotor operation .

The coils for K1 and K2 are in series with the two stator windings. With normal stator currents the contacts of K1 and K2 close. This keeps C5 charged, holding Q7 on. Little or no rotor current causes K1 and/or K2 to open, causing C5 to discharge thus turning off Q5 and indicating a rotor fault.

K3 switches the stator current to tube 2 when requested by the generator control circuits on two tube units.

7.3.0 DUAL SPEED STARTER (IF FITTED)

7.3.1 Functional Blocks (Dual Speed Starter)



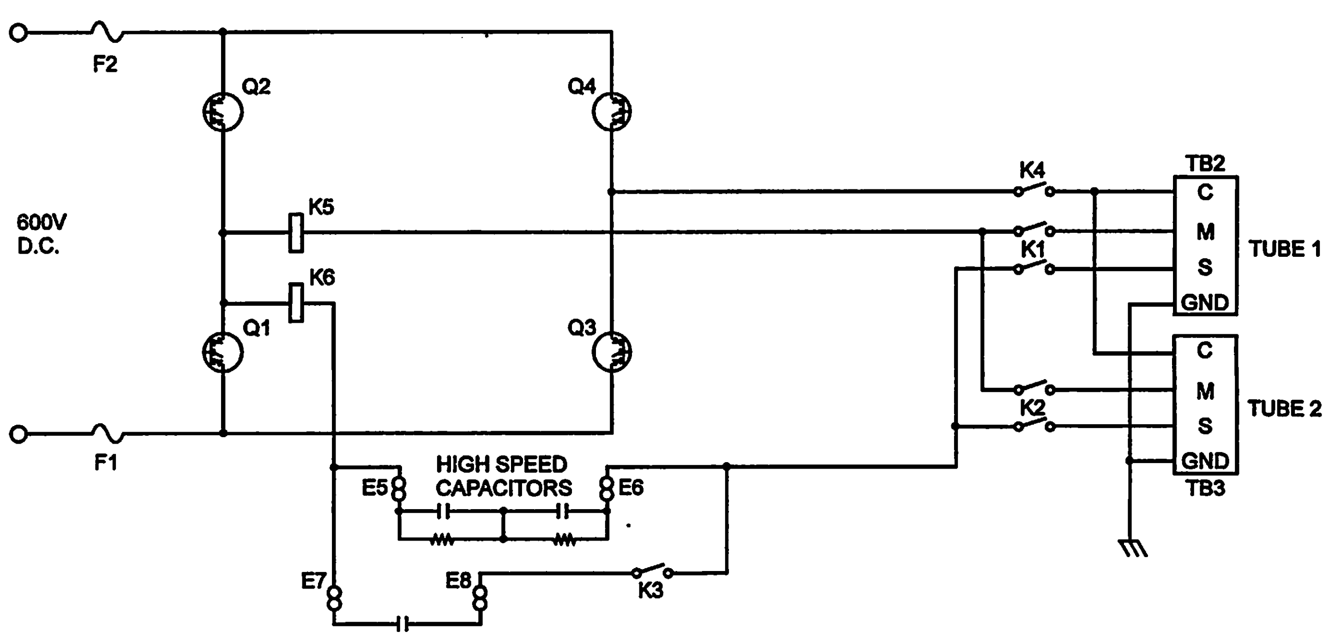


Figure 7-9: Dual speed starter functional and schematic block diagram

7.3.2 Dual Speed Starter Circuit Description

Refer to figure 7-9 and the dual speed starter board schematic in chapter 9.

Sheet 1 of the schematic shows the interconnects between the circuits on sheets 2, 3 and 4. Sheet 2 shows the microprocessor and logic portions, sheet 3 shows the gate drive and over current detector circuits and sheet 4 shows the power output stage of the dual speed starter.

The dual speed starter board is capable of driving the stator at 60 Hz (low speed) or 180 Hz (high speed). This frequency is independent of line frequency. A DC brake is provided for high speed operation.

U22 is the microprocessor and U26 is the EPROM containing the firmware. U19 is used as an input port from the power supply. Inputs from the power supply are isolated via U12 to U15. These opto couplers are energized to obtain the desired response.

Relay contacts K5-A and K6-A are part of the current sense relays and are used to detect the presence of stator current.

U18 is used to read dip switch SW1 where SW1 selects tube type 1. Similarly, U17 reads dip switch SW2, where SW2 is used to select tube type 2.

U11-B inhibits operation of the inverter if the microprocessor is in the reset state. U11-C is an under voltage detector for the +12 VDC supply, inhibiting the inverter if the supply drops below its acceptable limit. U11-D processes the enable signal from the microprocessor.

U24 and relays K1, K2 and K4 are used to select the tube 1 or tube 2 outputs. Relay K3 is energized for low speed operation, selecting the low speed phase shift capacitor.

The inverter drive signals, drive 1 and drive 2, are generated by port 1 of the microprocessor. These two drive signals are split into the four drive signals required by the inverter.

Oscillator U6-A and U6-B modulates the gate drive signal at approximately 250 kHz for transmission across the isolation barrier presented by gate drive transformers T1 to T4.

U1, U7, U8 and U9 buffer and amplify the gate drive signals. U11 is a comparator which senses the output of hall effect sensor CS1. If the sensor output exceeds the comparator threshold, the output of U10-B is set low which disables the gate drive signals. U6-C and U6-D ensure that U10-B is set to the correct logic state at power up of the generator.

The inverter output stage consists of Q1 to Q4. These transistors supply current to the stator of tube 1 or tube 2 via L2, L3 and the associated switching relays and phase shift capacitors.

7.4.0 GENERATOR CIRCUITS

7.4.1 Generator Interface Board

Refer to the generator interface board schematic in chapter 9 of this manual.

Features are described in this section which are not available on all models of generator i.e. ABS circuitry which is only available on R&F generators.

The primary purpose of the generator interface board is to provide buffering for input and output signals interfaced to this board, and to connect these signals to the microprocessor on the generator CPU board. Auxiliary logic supplies and the generator on/off circuits are also on this board.

The generator interface board has an input for the standard CPI console via J4. The ABS feedback signal is fed in through J7 or J8, or expansion connector J13 on some digital configurations. The tube thermal switch connections are directly or indirectly brought to J5 depending on generator configuration.

Connections to the microprocessor on the generator CPU board are via J12. J13 is used for digital image system control. Connections to other boards are as shown on the schematic.

The relays on the room interface board are driven by U6 and U7. Relay drivers U6 and U7 obtain their drive signals from octal latches U11 and U12.

Flip flops U45-A and U45-B hold the relays in the off state from the time that the microprocessor is reset until the octal latches are written to by the microprocessor. This prevents spurious outputs during system initialization.

U26 provides address decoding for the input and output devices. U18 and U19 are octal bus transceivers, used as 8 bit inputs to the microprocessor.

The input signals from the room interface board are buffered by a series of opto couplers. Jumpers allow each input to be configured to accept 24 VDC input or to accept a dry contact closure.

Critical signals, for example X-ray request, are enabled by two opto couplers U37 and U38. U37 generates the signal CONCOM which can be read by the microprocessor via U18. The output of U38 is taken via U22 directly to the HF power supply. This allows exposures to be interrupted, manually terminated exposures, independently of the microprocessor on the generator CPU board. The emitter of U38 is pulled low by U7 only when an exposure request from the console is anticipated i.e. when the console is in the radiographic mode.

A similar circuit is implemented using U30 and U42 to control fluorographic exposures on R & F units. U39 is part of the last image hold circuitry. This allows fluoroscopic exposures to continue for a maximum of 100 ms after the footswitch has been released. The actual time is determined by the generator software.

J5 is connected to the normally closed thermostat in the X-ray tube housing. The thermal switch inputs are isolated by opto couplers U13 and U16 and read by the microprocessor via U19.

U35 demultiplexes the address lines from the data/address bus. U25 buffers the data bus. U36-A, U36-B and U36-C control the enabling and direction of the data bus buffer.

J10 connects the AEC drive signals to the AEC board via the AEC transition board. The output signals for the AEC board are generated by octal latch U23 and buffered by U33.

U40 provides a square wave to the microprocessor at the line frequency. This is used by the microprocessor to adjust line frequency dependent parameters as needed.

The amplifiers for the ABS feedback signal, U17-A to U17-D, are also on this board. Jumpers are provided to allow selection of ABS feedback sources, to allow input signal polarity inversion if required, and to allow other parameters to be matched to the ABS signal source as described later in this section.

U17-D is used for composite video only, the output of this IC is rectified to produce a positive going DC signal for further processing. U17-A is configurable to be an inverting or non-inverting amplifier to allow input of either positive or negative going DC signals. U17-B is an inverting buffer, and U17-C a variable gain inverting amplifier that allows use of different magnitudes of ABS signals by adjusting R48. The processed ABS signal output is sent to the generator CPU board via J11.

Table 7-1 defines the jumper positions for various ABS configurations.

7.4.1 Generator Interface Board (cont)

JUMPER POSITION	FUNCTION
JW5	In for 75 Ω video termination of J8. Only functional when JW19 is jumpered pins 2-3 to route video signal to U17-D.
JW20	Isolates shell of J8 and therefore external video ground from chassis ground if JW20 is open. Normal position is closed i.e. JW20 in.
JW19: pins 2-3	Connects the ABS signal from J8 to U17-D. This is normally used for composite video.
JW19: pins 1-2	Connects the ABS signal from J8 to JW11, the polarity selection connector. This is normally used for proportional DC
JW11: pins 1-2 JW11: pins 2-3 JW11: pins 3-4	Connects the DC proportional signal from J7 or J8 to the inverting input of U17-A. This position is used for negative going DC signal. Connects the DC proportional signal from J7 or J8 to the non inverting input of U17-A. This position is used for positive going DC signal. Connects the rectified positive going composite video signal from U17-D to the non inverting input of U17-A.
JW12 JW13	Select the gain of U17-A in the non-inverting configuration. Both jumpers out gain = 0.5, JW12 in gain = 1, JW13 in gain = 16.5. Normal position is JW12 in for non-inverting configurations of U17-A (JW11 pins 2-3 and JW11 pins 3-4). Omit both jumpers for inverting configuration, JW11 pins 1-2.
JW21: pins 1-2 JW21: pins 2-3	Selects external ABS signal i.e. from expansion connector J13. Selects ABS signal from U17-A and therefore from J7 or J8.
JW4	Connects low pass filter capacitor C19 into circuit.

Table 7-1: ABS jumper configurations

NOTE: TABLE 7-1 IS TO BE USED FOR TRAINING PURPOSES ONLY. REFER TO CHAPTER 3 SECTION E FOR INFORMATION REGARDING ABS CONFIGURATION AND SETUP.

Sheet 3 of the generator interface board schematic shows the power supplies which are used for the generator interface board, generator CPU board, AEC board and room interface board.

Logic supplies +15 VDC, +12 VDC, +5 VDC, -12 VDC and -15 VDC regulated and ± 24 VDC unregulated for use by the other generator boards are on the generator interface board. Also, the 110 and 220 VAC supplies for the room interface board originate on this board.

The ON/OFF circuitry for the generator is on this board. When the ON switch is pressed, Q2 is turned on providing base current for Q3. Q3 turning on latches Q2 on, and also energizes relays K2 and K3 which power the logic supplies.

Depending on the jumper positions on JW1, K1, which switches the 110 and 220 VAC supplies for the room interface board, is energized only when the generator is actually switched on or is energized whenever the AC mains is applied to the generator.

The Q2-Q3 latch is switched off by pressing the OFF switch, turning on Q1. When Q1 is turned on, base drive is removed from Q2. This turns Q2 off, turning off Q3 and de-energizing relays K2, K3 and possibly K1 depending on configuration of the jumpers on JW1.

7.4.2 Generator CPU Board

Refer to the generator CPU board schematic in chapter 9 of this manual.

The generator CPU board contains a microprocessor, ROM, an EPROM, and interface circuits to translate the serial data from the console into the analog and digital control signals required by the HF power supply and the room interface circuits. This board also processes the feedback signals from the HF power supply and from the generator interface board. Firmware on the board provides closed loop control of mA.

Sheet 1 shows the microprocessor section of this board. U27 is the microprocessor. The firmware resides in EPROM U38, and U25 provides 32K bytes of battery backed up RAM. Battery B1 and U3 preserve the memory when the generator is switched off.

The data/address bus is demultiplexed by U32. Address decoding is provided by U19, U20 and U31. U30 is the real time clock. U40, if fitted, is a serial link to the dual speed starter.

DIP switch SW1 programs the generator type and options. This switch is read via U37. The settings for this switch are given in table 7-2.

SW1 must be configured to match the hardware. Reconfiguring SW1 from 50 kW to 65 kW for example will not give more power, the maximum power available being determined by the HF power supply. Incorrect SW1 configuration in this example would not properly software limit the HF power supply output. The likely result would be nuisance trips (beam fault) if the generator microprocessor attempted to drive the power supply beyond its rated output.

The information in table 7-2 is to allow you, the service engineer, to verify correct settings of SW1 and to allow proper setup of this switch after replacing the generator CPU board should this be required. Refer to the product description in chapter 1D for compatibility of the generator if required.

GENERATOR SERIES	MAXIMUM mA	SW1 -3	SW1-2	SW1-1
350 (30 kW)	320 mA	ON	ON	OFF
650 (50 kW)	630 mA	OFF	ON	ON
850 (65 kW)	800 mA	OFF	ON	OFF
1050 (80 kW)	1000 mA	OFF	OFF	ON

SW1-4	OFF > 2 FILAMENT SUPPLY BOARDS USED IN HF POWER SUPPLY	ON > 1 FILAMENT SUPPLY BOARD USED IN HF POWER SUPPLY
SW1-5	OFF > 150 kV MAXIMUM	ON > 125 kV MAXIMUM
SW1-6	OFF > DUAL SPEED STARTER	ON > LOW SPEED STARTER
SW1-7	OFF > 2 TUBE GENERATOR	ON > 1 TUBE GENERATOR
SW1-8	OFF > SET FACTORY DEFAULTS	ON > DEFAULTS DISABLED

Table 7-2: Programming of SW1 on generator CPU board

SW1-8 should normally be left ON. Setting this switch to OFF at power up resets the factory defaults for receptor programming, AEC setup and calibration, fluoro setup, tube selection, generator limits, I/O configuration, and clears the error log and statistics.

Sheet 2 shows the serial communication portion of the generator CPU board. There are two DUART (dual universal asynchronous receiver/transmitters) U24 and U29 on this board.

Crystal Y1 provides the timebase for the DUARTs. Q10 and diodes D1 to D4 combine, OR, the interrupt request signals from the DUARTs and invert the signal.

LEDs DS1, DS2, DS14, DS16 DS31, DS35, DS47 and DS48 provide visual indication that communication is taking place. U11, U12, U39 and U43 provide level translation from TTL level signals to RS232 level signals.

COM 3 and COM 4 (the serial ports accessed through J1 and J2) are options, therefore the associated components are not fitted on all generators. Additionally, J11 is used for the optional remote fluoro control on R & F generators, therefore the associated circuit is not fitted on all models.

7.4.2 Generator CPU Board (cont)

Sheet 3 shows the analog inputs, and the analog to digital converter (ADC). The ADC, U35, has four input channels with a range of ± 10 VDC. The third channel is muliplexed by U45, increasing the number of ADC inputs to 11. The octal latch, U46, is used to control U45.

The ADC is a 12 bit ADC connected to a 8 bit data bus. When the least significant 8 bits of the ADC are read, the most significant 4 bits are transferred to data latch U41. The microprocessor can then read the most significant 4 bits in the latch. U42 and U47 provide ± 5 VDC to the ADC.

The differential feedback signals from the power supply are buffered and ground referenced by differential amplifiers U16-A, U16-C, U22-A, U22-C, U34-A and U34-B. R16 is used to calibrate RAD mA, and R58 calibrates the fluoro mA. Test points are provided at the differential amplifier outputs to allow the signals to be monitored with an oscilloscope or DVM.

A set of voltage dividers RN16-A to RN16-H scale the ± 12 VDC and ± 15 VDC supplies to suitable voltage levels for input to the ADC.

Sheet 4 shows the analog outputs, and the digital to analog converters (DAC). U14 and U21 are dual 12 bit DACs. The outputs of the DACs is buffered by U15.

U13-A and Q3, Q4 hold the filament references at 0 volts from the time the microprocessor is reset until the DACs are written to by the microprocessor. This prevents damage to the filaments during the time the microprocessor is in the reset state. Test points are provided to allow the outputs of the DACs to be monitored.

Sheet 5 shows the connections to the generator interface board. J6 contains the microprocessor signals, the line frequency input, and the exposure switch input.

J7 contains the communication signals to the console, the AEC signals, an interlock signal (currently unused), and a sync input (currently unused). J13 is used to connect to the logic supplies on the generator interface board. LEDs D38, D41, D43, D45 and D46 indicate the presence of the ± 15, ± 12 and + 5 VDC supplies.

Sheet 6 shows the digital inputs and outputs used to control the HF power supply and the dual speed starter if fitted. U28 is an octal latch used to provide digital outputs. Level translation is provided by U17. The output signals from the power supply are coupled through opto couplers U4 to U9 and U18. LEDs provide a visual indication of the status of these digital signals.

7.4.3 Console CPU Board

Refer to the console CPU board schematic in chapter 9 of this manual.

The console CPU board includes hardware features intended for future use i.e. PC style keyboard support and parallel printer support. The related circuits are discussed in this section, although those features are not available at this time.

The console CPU board, located in the control console, provides input/output circuits to interface with the keypad and console displays, and to communicate with the microprocessor on the generator CPU board.

U23 is the microprocessor. The firmware resides in EPROM U26, and U22 provides 32 K bytes of battery backed up RAM. Battery B1 and U1 preserve the memory when the generator is switched off.

The data/address bus is demuliplexed by U27. Address decoding is provided by U24 and U28. The audio tones are generated by speakers X1 and X2 in conjunction with transistor array U7 and octal latch U8. U2, U15-C and U15-D are used to drive an optional parallel printer through connector J1.

DIP switch SW1-8 resets the factory defaults for APR and console settings. This switch should normally be set OFF. Setting SW1-8 ON at power up restores factory defaults. SW1-1 to SW1-7 should not be field adjusted.

The console LCD display connects to J9 on the console CPU board, and R2 is the contrast adjustment for the LCD display.

7.4.3 Console CPU Board (cont)

U25 is a DUART (dual universal asynchronous receiver/transmitter). Crystal Y2 provides the timebase for the DUART. LEDs D1 to D4 provide visual indication that communication is taking place.

The serial link to the generator interface board is configured for RS232 if U6 is installed, or RS422 if U5 and U9 are installed. U20 provides level translation from TTL level signals to RS232 level signals for the serial port connector J2.

U4, U17, U18 and U19 convert serial data from an optional PC style keyboard connected to J4 to parallel data which can be read by the microprocessor.

U30 and Q5 are part of a switching power supply. This converts the unregulated 24 VDC supply from the generator interface board to a +5 VDC and -12 VDC supply. The +5 VDC supply is generated across the capacitors at the output of D7. A sample of this voltage is fed back to U30 via the voltage divider consisting of R22 and R21 to regulate the voltage output. The -12 VDC supply is regulated by U31.

U32 is an inverter module which converts 12 VDC input to the high voltage needed to operate the CCFL (cold cathode fluorescent) tube used for backlighting the LCD display.

Opto couplers U10 to U14 and U21 couple the X-ray, prep and fluoro commands from the console and optional footswitch and handswitch to the microprocessor via U3.

7.4.4 Console Display Board

Refer to the console display board schematic in chapter 9 of this manual.

The console display board contains the 7 segment readout displays i.e. kV, mA etc and the status LEDs i.e. receptor indicators etc. This board also contains the logic circuits to drive the on board displays and to decode the front panel switch matrix (receptor select buttons, kV up/down, etc).

Octal latches U1, U3, U5, U7 decode and latch the data for the 7 segment LEDs. These decoders drive transistor arrays U2, U4, U6, U8 which in turn drive the LEDs via current limiting resistor networks. Each of the decoders supplies data to as many as 6 LED displays in parallel. Those groups of displays are then multiplexed in order to display the correct data when required. This is achieved by use of octal latch U11 in conjunction with mosfets Q1 to Q6. U11 strobes Q1 to Q6 on sequentially, the outputs of Q1 to Q6 then enable in sequence each of the LED displays in each group defined above. That sequence is repeated continuously, allowing the LED displays to be updated when needed. Octal latch U9 and transistor array U10 drive the status LEDs which are also multiplexed in a similar fashion.

U12 and U13 decode the front panel switch matrix. U12 sends data out to the switch matrix, a switch closure is then detected by U13. The button that was pressed is identified by the location of the switch closure in the matrix.

U14 is an address decoder for the latches on this board.

7.4.5 Room Interface Board

Refer to the room interface board schematic and to the system interface schematic in chapter 9 of this manual.

The room interface board provides for the room interface connections via terminal blocks TB-1 to TB-6. The room interface connections include room inputs such as interlocks, thermal switches etc, and room outputs such as bucky select commands etc.

The inputs signals to the generator are routed from the terminal blocks on the room interface board to opto couplers on the generator interface board. Of the thirteen inputs, nine can be configured such that the input is activated by a switch or relay closure across the inputs, or they can be configured such that 24 VDC input is needed to energize the opto couplers. The two thermal switch inputs, the remote fluoro input, and the room door interlock are hardware configured to require external contact closures to energize their opto couplers.

Refer to sheet 2 of the system interface schematic. The inputs with the 4 pin jumpers shown adjacent to the opto couplers (i.e. JW 7, JW 9 etc) are programmed to accept an external contact closure if pins 1-2 and 3-4 on these connectors are jumpered. If these connectors are jumpered from pins 2-3 only, an external 24 VDC source is needed to energize the opto couplers (observe polarity if the latter option is chosen, negative must go to the cathodes of the opto couplers, positive to the anodes). The jumpers on the system interface schematic are shown configured to accept dry contact closures as inputs.

Refer to sheet 1 of the system interface schematic for the outputs. Outputs are in the form of dry relay contacts in some cases i.e. room light and magnification select functions. Several of the outputs are programmable to select dry relay contacts or to output 24 VDC i.e. ALE output and the tube indicator outputs. Selection of dry relay contacts for these outputs is achieved by jumpering pins 2-3 on JW6, JW7 or JW8. To output 24 VDC, the appropriate connector(s) must be jumpered 1-2 and 3-4. The system interface schematic shows these jumpers configured to output 24 VDC on relay closure.

The remaining outputs are programmable to select dry relay contacts, or to output 24 VDC or 110 or 220 VAC. These are the bucky select outputs, and programming is achieved by selecting the jumper positions on JW1 to JW5. If pins 4-6 are jumpered on these connectors, the output is a dry relay closure. To select one of the voltage outputs, JW1 to JW5 as appropriate must be jumpered pins 6-8. Additionally, to select a voltage output a jumper must be connected from the appropriate relay voltage input on TB11 to the desired voltage source i.e. 24 VDC from TB8, 110 VAC from TB9 or 220 VAC from TB10.

If the intent is to program the bucky outputs for dry contacts, there should NOT be a jumper from the relay voltage input on TB11 to any of the voltage sources. The system interface schematic shows these outputs programmed for dry relay closure.

7.4.6 Remote Fluoro Control Board (If Fitted)

Refer to the remote fluoro control board schematic in chapter 9 of this manual if applicable.

The optional remote fluoro control is connected to J11 of the generator CPU board. This connector is an RS232 port, allowing the remote fluoro control unit to communicate with the generator via a serial link.

U1 on the remote fluoro control board is the microprocessor and U3 is the EPROM which contains the firmware for the remote fluoro control. U2 is a demultiplexer to separate data/address lines, and U4 an address decoder for the displays and the keypad.

U7 is an RS232 transceiver that converts TTL data from the microprocessor to RS232 data for the serial link. U5 provides under voltage/watchdog protection, resetting the microprocessor in case of a low +5 VDC supply. This IC will also reset the microprocessor if the software fails to execute normally. Either of these faults will inhibit the displays via U6-A.

An on-board regulator, U8, regulates the +12 VDC input to a +5 VDC supply for use by the logic circuits.

7.4.7 Remote Fluoro Display Board (If Fitted)

Refer to the remote fluoro display board schematic in chapter 9 of this manual if applicable.

The remote fluoro display board is driven via J1 of the remote fluoro control board. Octal latches U7, U8, and U9 decode and latch the data for the displays. These decoders drive transistor arrays U4, U3, and U2 which in turn drive the LEDs via current limiting resistor networks. Each of these decoders supply data to as many as 6 LED displays in parallel. These groups of LEDs are then multiplexed in order to display the correct data when required. This is achieved by use of octal latch U6 and transistor arrays U1 and U10, where U1 and U10 enable in sequence each LED in each of the above groups.

Two outputs of U1 send data to the rows of the switch matrix on the front of the remote fluoro control. U5 reads back the data from the columns, identifying which switch has been pressed by the location of the switch closure in the matrix.

7.5.0 AEC (AUTOMATIC EXPOSURE CONTROL) IF FITTED

The Millenia family of generators may be configured to be compatible with solid state chambers (i.e. Ziehm/Comet), or various ionization chambers, or PMT(photomultiplier tube) output.

In order to support this variety of AEC chambers/pickup devices, your generator may be fitted with a dedicated AEC board which is designed to be compatible with one specific type of AEC device only, or a universal AEC board assembly which is factory configured to support the AEC device listed in the product description.

The distinction is subtle. The universal AEC board assembly, after it has been factory configured to support a specific AEC device, is only compatible with that device type. However, circuits are provided on the universal AEC board to interface with most AEC devices on the market. The appropriate circuits are activated at the time that the board is factory configured for interface to a specific AEC device.

NOTE:	ALWAYS REFER TO THE PRODUCT DESCRIPTION, SECTION 1D OF THE MANUAL, FOR AEC COMPATIBILITY OF THIS GENERATOR.

The universal AEC board assembly consists of two stacked boards. The lower of the two boards (the AEC board) contains the amplifiers, logic and switching circuits, and the card edge connector to interface to the generator control circuits while the upper board (the AEC interface board) contains a high voltage power supply that provides +300 or +500 VDC for biasing ionization type chambers and -1000 VDC, adjustable, used to bias a PMT device. The input connectors to connect to the AEC device(s) are also on this board, as well as the connector for the -1000 VDC PMT supply.

Ionization type chambers either generate a DC voltage proportional to the radiation dose, or generate a ramp voltage where the slope of the ramp is proportional to the radiation dose. The polarity of the chamber output may be positive going or negative going. The AEC board will be configured to integrate the output of the chamber if a DC signal is produced, or will be configured as a non integrating amplifier if the output of the ionization chamber is a ramp voltage. Depending on the polarity of the chamber output signal, the output is either fed into an inverting or non-inverting input on the AEC board.

Field select signals select left, middle, or right fields on the chamber. These signals may be active low or active high. A start signal is needed to initiate the chamber output at the start of exposure, this signal also may be active low or active high. Ionization chambers also require a high voltage bias supply, nominally +300 or +500 VDC.

PMT devices require approximately -1000 VDC bias. The output of a PMT is a very low level current, which is then converted to a voltage by a preamplifier on the AEC board.

Solid state chambers require no bias supply or field select signals. Field selection is accomplished by selecting the desired cathode via one of the analog switches. The signal from either one, two, or three of the diodes in the chamber will be connected to one AEC input via the analog switches, depending on how many fields are selected at one time. The common anodes are connected to the other input of that channel.

7.5.0 AEC (CONT)

Refer to figure 7-10 and the AEC schematic(s) from chapter 9 of this manual. Figure 7-10 depicts the universal AEC board with its extra circuits to support a variety of AEC devices.

The output of each AEC device will be connected to one of the input channels. Up to four inputs are available, meaning up to four AEC chambers may be supported, or three AEC chambers and one PMT.

- IONIZATION CHAMBERS: The +300 or +500 VDC bias supply for ionization chambers is generated on the AEC interface board, refer to the schematic for that board. The logic circuits for the field select signals and start signal are on the AEC board. Transistor switches invert the field select commands to produce active high signals if required.
- PMT: The -1000 VDC adjustable supply is also generated on the AEC interface board. The PMT output is connected to one of the input channels, normally channel 4.
- SOLID STATE CHAMBERS: The AEC board contains all the interface circuits for solid state chambers. There is one set of analog switches for each channel. These analog switches are enabled by the active high signal generated by the transistor switches connected to the field select inputs.

When a start command is received from the generator, the AEC amplifier circuits are enabled. This removes the short from the integrating capacitor if used for that AEC device. The signal from the AEC device will be processed by the amplifier circuits (amplified or amplified and integrated), the resulting ramp voltage at the amplifier outputs will be proportional to radiation dose. Separate gain adjustments for each channel allow precise setting of the ramp magnitute as required for proper AEC density.

The ramp from each of the amplifier circuits is connected to an analog switch at the output of each amplifier section. Channel selection is accomplished by enabling the analog switch at the output of the desired channel. This connects the ramp voltage to a comparator circuit where it is compared with a predetermined reference voltage. This comparator will generate a logic low signal when the magnitute of the ramp is equal to the reference voltage. This causes the generator to terminate the exposure.

The reference voltage calculated by the software varies depending on kVp technique, base density, film/screen, field selection if a solid state chamber is used, and density selection. Proper AEC calibration is essential to generation of the correct reference voltage.

For solid state chambers, correction is done in software to compensate for extra fields, i.e. for the effect of the signal from the extra diodes that are switched in. For one field (1 diode), the reference is the nominal value, for two fields (2 diodes) the reference is 2/3 of the nominal value, and for all three fields (3 diodes) the reference is 1/3 of the nominal value.

The operation of the dedicated AEC boards is similar to that of the universal AEC board. However, circuits not required for that configuration are not included, and all of the circuits are on one board including the high voltage bias supplies if required for that configuration..

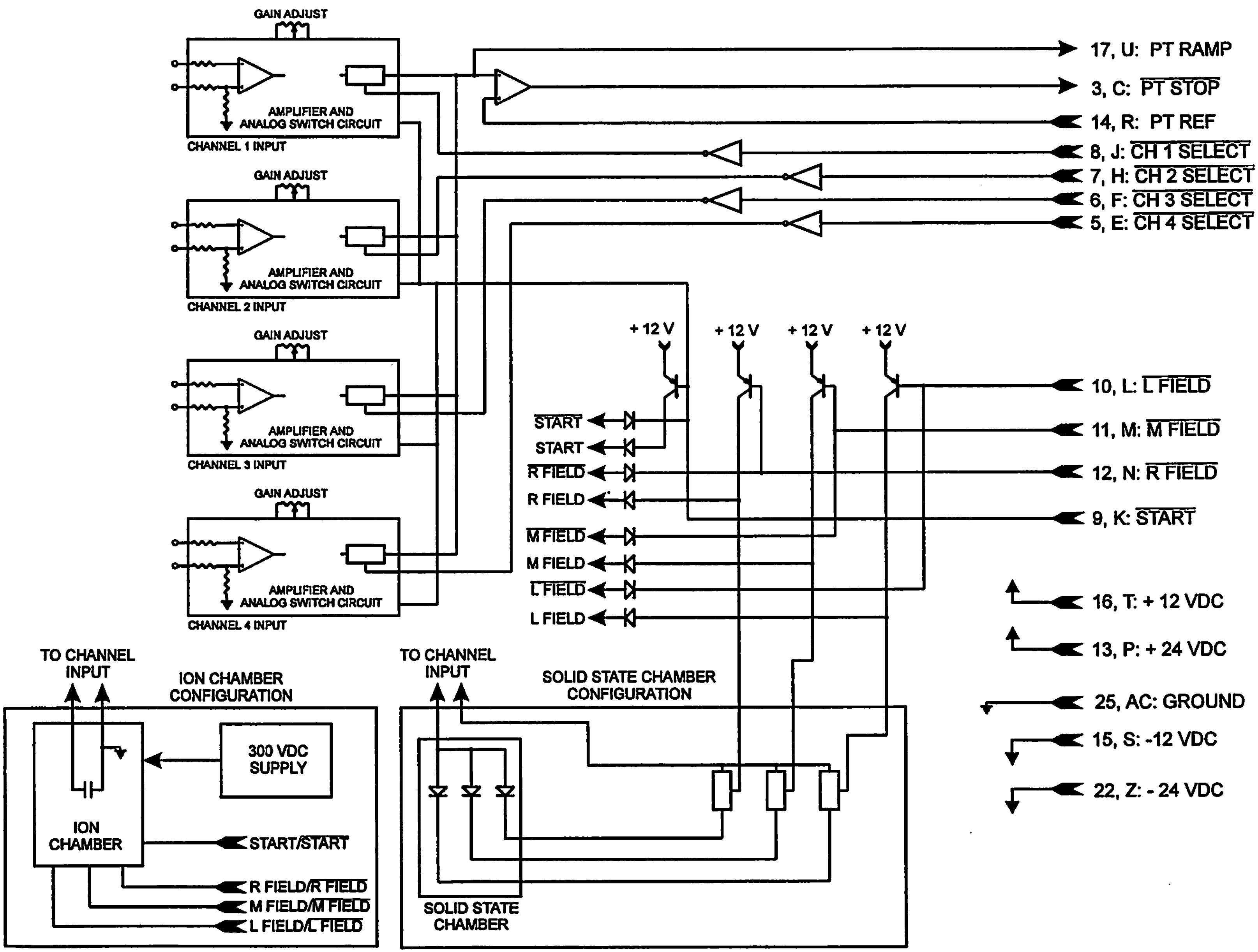


Figure 7-10: AEC board block diagram

7.6.0 ABS (AUTOMATIC BRIGHTNESS STABILIZATION) R& F UNITS ONLY

Refer to chapter 3E.

CHAPTER 8

SPARES

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8.3.0 SPARE PARTS LIST GENERATOR 8-19

8.1.0 INTRODUCTION

This chapter contains the list of recommended spare parts for the various models of generators. The spares list is organized with HF power supply spares (HF driver and HT tank) in section 8.2.0, and generator spares in section 8.3.0.

8.2.0 SPARE PARTS LIST HF POWER SUPPLY

Due to the variety of HF power supplies used in the various CPI generators, the spares list for HF power supplies is sorted by power supply part number.

To find the applicable HF power supply part number for your generator, refer to the product description at the end of section 1D in this manual. The required part number will be in the section ***PRODUCT DEFINITION***, to the right of **H.V GENERATOR P/N:** (example 733512-01).

8.2.1 Spares For HF Power Supply 728152-03

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590805	1
Control board 1	72638302	1
Control board 2	72592605	1
Filament supply board (large)	72818104	N/A
Filament supply board (small)	72818105	N/A
Filament supply board (large/small)	N/A	1
Driver/auxiliary board	72591903	1
Inverter/snubber board	72640200	1
Extender card	72714100	1
Auxiliary transformer assy	72648901	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 3300 uF 400 VDC	SC3593	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91	6623507000	3
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, MDA-5	6713000100	10
Fuse, NLN-100	6711906500	5
SCR/diode module (inverter)	SC3616	2
HT tank assy (complete)	72947301	1

8.2.2 Spares For HF Power Supply 729155-03

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72906808	1
Control board 2	72592606	1
Filament supply board (large)	72818104	1
Filament supply board (small)	72818105	1
Filament supply board (large/small)	N/A	N/A
Driver/auxiliary board	72591980	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 2.5 uF 3000 VDC	4149999800	2
Capacitor, DC buss 2000 uF 450 VDC	4154999700	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91	6623507000	3
Inverter assy, HF full bridge	72637100	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	73269900	1

8.2.3 Spares For HF Power Supply 729155-04

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72906808	1
Control board 2	72592606	1
Filament supply board (large)	N/A	1
Filament supply board (small)	N/A	1
Filament supply board (large/small)	72818103	N/A
Driver/auxiliary board	72591980	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 2.5 uF 3000 VDC	4149999800	2
Capacitor, DC buss 2000 uF 450 VDC	4154999700	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91	6623507000	3
Inverter assy, HF full bridge	72637100	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	73269900	1

8.2.4 Spares For HF Power Supply 729162-01

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72638323	1
Control board 2	72592606	1
Filament supply board (large)	N/A	N/A
Filament supply board (small)	N/A	N/A
Filament supply board (large/small)	72818103	1
Driver/auxiliary board	72591980	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 2000 uF 450 VDC	4154999700	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91	6623507000	3
Inverter assy, HF full bridge	72637100	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	73269900	1

8.2.5 Spares For HF Power Supply 729504-01

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590805	1
Control board 1	72906807	1
Control board 2	72592609	1
Filament supply board (large)	N/A	N/A
Filament supply board (small)	N/A	N/A
Filament supply board (large/small)	72818103	1
Driver/auxiliary board	72591901	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 2000 uF 400 VDC	SC3818	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91 *	6623507000	3
Inverter assy, HF half bridge	72593800	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	72949802	1

* SEE NOTE AT END OF SUBSECTION 8.2.17

8.2.6 Spares For HF Power Supply 729504-03

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72906807	1
Control board 2	72592609	1
Filament supply board (large)	72818104	1
Filament supply board (small)	72818105	1
Filament supply board (large/small)	N/A	N/A
Driver/auxiliary board	72591901	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 2000 uF 400 VDC	SC3818	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91 *	6623507000	3
Inverter assy, HF half bridge	72593800	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	72951600	1

*** SEE NOTE AT END OF SUBSECTION 8.2.17**

8.2.7 Spares For HF Power Supply 729504-04

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590805	1
Control board 1	72906807	1
Control board 2	72592609	1
Filament supply board (large)	72818104	1
Filament supply board (small)	72818105	1
Filament supply board (large/small)	N/A	N/A
Driver/auxiliary board	72591901	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 2000 uF 400 VDC	SC3818	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91 *	6623507000	3
Inverter assy, HF half bridge	72593800	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	725522-00	1
Resistor assy, bleeder (resonant caps)	725947-00	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	72949802	1

*** SEE NOTE AT END OF SUBSECTION 8.2.17**

8.2.8 Spares For HF Power Supply 732914-02

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590805	1
Control board 1	72638323	1
Control board 2	72592606	1
Filament supply board (large)	N/A	N/A
Filament supply board (small)	N/A	N/A
Filament supply board (large/small)	72818103	1
Driver/auxiliary board	72591980	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 2000 uF 450 VDC	4154999700	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91	6623507000	3
Inverter assy, HF full bridge	72637100	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	723293002	1

8.2.9 Spares For HF Power Supply 732920-01

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590805	1
Control board 1	72906808	1
Control board 2	72592606	1
Filament supply board (large)	N/A	N/A
Filament supply board (small)	N/A	N/A
Filament supply board (large/small)	72818103	1
Driver/auxiliary board	72591980	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 2.5 uF 3000 VDC	4149999800	2
Capacitor, DC buss 2000 uF 450 VDC	4154999700	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91	6623507000	3
Inverter assy, HF full bridge	72637100	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	723293002	1

8.2.10 Spares For HF Power Supply 732926-00

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590805	1
Control board 1	72906808	1
Control board 2	72592607	1
Filament supply board (large)	72818104	1
Filament supply board (small)	72818105	1
Filament supply board (large/small)	N/A	N/A
Contactor control board	72635500	1
Driver/auxiliary board	72591980	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 2.5 uF 3000 VDC	4149999800	2
Capacitor, DC buss 2000 uF 450 VDC	4154999700	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Contactor, mode select	SC3448	1
Diode, mains rectifier IRKD91	6623507000	3
Inverter assy, HF full bridge	72637100	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	73293002	1

8.2.11 Spares For HF Power Supply 732932-00

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72638331	1
Control board 2	72592606	1
Filament supply board (large)	N/A	N/A
Filament supply board (small)	N/A	N/A
Filament supply board (large/small)	72818103	1
Driver/auxiliary board	72591906	1
Inverter/snubber board	72640202	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 3300 uF 400 VDC	SC3593	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91 *	6623507000	3
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
FUSE, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	5
SCR/diode module (inverter)	SC3616	2
HT tank assy (complete)	73293600	1

*** SEE NOTE AT END OF SUBSECTION 8.2.17**

8.2.12 Spares For HF Power Supply 732949-00

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590805	1
Control board 1	72638331	1
Control board 2	72592606	1
Filament supply board (large)	N/A	N/A
Filament supply board (small)	N/A	N/A
Filament supply board (large/small)	72818103	1
Driver/auxiliary board	72591901	1
Inverter/snubber board	72640202	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 3300 uF 400 VDC	SC3593	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91 *	6623507000	3
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
FUSE, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	5
SCR/diode module (inverter)	SC3616	2
HT tank assy (complete)	73295100	1

*** SEE NOTE AT END OF SUBSECTION 8.2.17**

8.2.13 Spares For HF Power Supply 733209-01

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72906808	1
Control board 2	72592607	1
Filament supply board (large)	72818104	1
Filament supply board (small)	72818105	1
Filament supply board (large/small)	N/A	N/A
Contactor control board	72635500	1
Driver/auxiliary board	72591980	1
Current transformer board	72593000	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 2.5 uF 3000 VDC	4149999800	2
Capacitor, DC buss 2000 uF 450 VDC	4154999700	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Contactor, mode select	SC3448	1
Diode, mains rectifier IRKD91	6623507000	3
Inverter assy, HF full bridge	72637100	1
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
HT tank assy (complete)	73269900	1

8.2.14 Spares For HF Power Supply 733495-01

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72638302	1
Control board 2	72592605	1
Filament supply board (large)	N/A	N/A
Filament supply board (small)	N/A	N/A
Filament supply board (large/small)	72818103	1
Driver/auxiliary board	72591901	1
Inverter/snubber board	72640202	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 1100 uF 450 VDC	SC1484	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91 *	6623507000	3
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
SCR/diode module (inverter)	SC3616	2
HT tank assy (complete)	73285401	1

*** SEE NOTE AT END OF SUBSECTION 8.2.17**

8.2.15 Spares For HF Power Supply 733495-02

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72638302	1
Control board 2	72592605	1
Filament supply board (large)	72818104	1
Filament supply board (small)	72818105	1
Filament supply board (large/small)	N/A	N/A
Driver/auxiliary board	72591901	1
Inverter/snubber board	72640202	1
Extender card	72714100	1
Auxiliary transformer assy	72648900	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 1100 uF 450 VDC	SC1484	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91 *	6623507000	3
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, ADTR-3	6716960100	10
Fuse, MDA-5	6713000100	10
Fuse, OTS-60	SC3434	10
SCR/diode module (inverter)	SC3616	2
HT tank assy (complete)	73285401	1

*** SEE NOTE AT END OF SUBSECTION 8.2.17**

8.2.16 Spares For HF Power Supply 733512-01

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72638302	1
Control board 2	72592605	1
Filament supply board (large)	N/A	N/A
Filament supply board (small)	N/A	N/A
Filament supply board (large/small)	72818103	1
Driver/auxiliary board	72591903	1
Inverter/snubber board	72640200	1
Extender card	72714100	1
Auxiliary transformer assy	72648901	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 3300 uF 400 VDC	SC3593	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91	6623507000	3
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, MDA-5	6713000100	10
Fuse, NLN-100	6711906500	5
SCR/diode module (inverter)	SC3616	2
HT tank assy (complete)	73285401	1

8.2.17 Spares For HF Power Supply 733512-02

DESCRIPTION	PART NUMBER	SUGGESTED QTY
Interface board	72590804	1
Control board 1	72638302	1
Control board 2	72592605	1
Filament supply board (large)	72818104	1
Filament supply board (small)	72818105	1
Filament supply board (large/small)	N/A	N/A
Driver/auxiliary board	72591903	1
Inverter/snubber board	72640200	1
Extender card	72714100	1
Auxiliary transformer assy	72648901	1
Capacitor, resonant, 5.0 uF 2000 VDC	SC1964	2
Capacitor, DC buss 3300 uF 400 VDC	SC3593	2
Capacitor, auxiliary supply 12000 uF 40 VDC	SC1487	1
Contactor, line	SC2715	1
Diode, mains rectifier IRKD91	6623507000	3
Relay, on/off	SC3436	1
Resistor assy, bleeder (DC buss)	72552200	1
Resistor assy, bleeder (resonant caps)	72594700	1
Fuse, AGC-4	SC2672	10
Fuse, MDA-5	6713000100	10
Fuse, NLN-100	6711906500	5
SCR/diode module (inverter)	SC3616	2
HT tank assy (complete)	73285401	1

NOTE: ***IRKD91 MAINS RECTIFIER DIODE REPLACES IRKD56 MAINS RECTIFIER DIODE. IF YOUR 30 OR 50 KW HF POWER SUPPLY IS FITTED WITH IRKD56 RECTIFIERS AND REPLACEMENT IS NECESSARY, ALL THREE MAINS RECTIFIERS MUST BE REPLACED WITH TYPE IRKD91.***

8.3.0 SPARE PARTS LIST GENERATOR

This section contains the spares list for the generator. This includes all items not in the HF power supply.

DESCRIPTION	PART NUMBER	SUGGESTED QTY	NOTE
Generator CPU board	See note ⇒	1	1
Generator interface board	73217706	1	2
Room interface board	73196900	1	3
AEC board	See note ⇒	1	4
Console CPU board	See note ⇒	1	1
Console display board	See note ⇒	1	5
Remote fluoro display board	72905300	1	6
Remote fluoro control board	72903800	1	6
Display assy, LCD	73339600	1	3
Dual speed starter subassembly	See note ⇒	1	7
Low speed starter board	See note ⇒	1	8
Fuse, A70QS10-14F	6739951800	5	7
Fuse, FNQ-2	5550005300	5	3
Fuse, FNQ-3	6711906100	5	9
Fuse, GDC-1.6	5550033300	5	3
Fuse, GDC-2	5550032600	5	3
Fuse, GDC-2.5	5550034400	5	3
Fuse, GDC-5	5550035600	5	3
Battery, lithium 3.0V	7412290100	2	3
Transformer assy, room I/F	See note ⇒	1	10

<u>**NOTE:**</u>

1. Two versions of generator CPU boards and console CPU boards are used in Millenia generators. Please confirm the original part number(s) of these boards in your generator before ordering spares. If your original generator CPU board is part number 732174-XX (where XX is a number from 00 to 08), order part number 732174-12. *In this case, upgraded firmware will be required along with the new CPU board. Please consult the factory for details.*

   If the original generator CPU board is part number 732174-12, it will be replaced with the same part number. In this case, a firmware upgrade is not required.

   If your original generator CPU board is part number 734573-00, order part number 734573-02. *In this case, upgraded firmware will be required along with the new CPU board. Please consult the factory for details.*

   If the original generator CPU board is part number 734573-02, it will be replaced with the same part number. In this case, a firmware upgrade is not required.

   The generator CPU board and the console CPU board must be matched per the table below:

GENERATOR CPU BOARD		CONSOLE CPU BOARD
If the original board is 732174-XX, order part number 732174-12 for spares usage. See note 1 above.	<MUST USE WITH>	732218-00
If the original board is 734573-XX, order part number 734573-02 for spares usage. See note 1 above.	<MUST USE WITH>	733903-00

8.3.0 SPARE PARTS LIST GENERATOR (Cont)

2. The part number shown is the suggested replacement for the original generator interface board. The spares board is "full featured" and will replace the original generator interface board regardless of configuration. This is intended to eliminate the need to stock multiple configurations of this board.

3. This part is common to all models of Millenia generators.

4. The AEC board for your generator was selected to be compatible with specific AEC device(s). To maintain full compatibility, the original part number must be ordered as a replacement. Refer to chapter 9, section 9.2.0 for the part number of the original AEC board shipped in the generator for which this manual was prepared.

5. The console display board is supplied pre-mounted to the console front panel switch assembly. To determine the required spares part number for this assembly, refer to the table below.

DESCRIPTION	SWITCH/DISPLAY ASSY PART NO
SWITCH/DISPLAY ASSY, R&F, ENGLISH	73442900
SWITCH/DISPLAY ASSY, R&F, GERMAN	73442901
SWITCH/DISPLAY ASSY, RAD, ENGLISH	73443000
SWITCH/DISPLAY ASSY, RAD, GERMAN	73443001

6. Remote fluoro control is an option, spares should be stocked accordingly.

7. These parts used only on dual speed starter option, spares should be stocked accordingly. Five part numbers of dual speed starter (which are tube stator dependent) are used in Millenia generators. To determine which dual speed starter assembly is in your generator, note the DUAL SPEED STARTER ASSY part number. This will be on a label near the top of the dual speed starter chassis. Select the corresponding part number of the dual speed starter subassembly from the table below. This will be the part number that must be ordered for spares usage.

The dual speed starter fuses listed on the previous page are used on all four versions of dual speed starter.

DUAL SPEED STARTER ASSY	DUAL SPEED STARTER SUBASSEMBLY
732685-00	73316000
732685-04	73316003
732685-05	73316002
732685-06	73316004
732685-07	73316005
732685-08	73316007
732685-09	73316008

8.3.0 SPARE PARTS LIST GENERATOR (Cont)

8. This item used only on generators fitted with low speed starter, spares should be stocked accordingly. Three part numbers of low speed starter board (also known as rotor board), which are tube stator dependent, are used in Millenia generators. To determine which board is in your generator, note the LOW SPEED STARTER KIT part number. This will be on a label near the low speed starter terminal block on the lower door of the generator (refer to figure 2-13). Select the corresponding low speed starter board from the table below.
The low speed starter board uses quantity 2 type MDA-5 fuses (or equivalent), part number 6713000100. These fuses also have useage in the HF power supply (refer to HF power supply spares in 8.2.0).

LOW SPEED STARTER KIT PART NO	LOW SPEED STARTER (ROTOR) BOARD
733522-00	725911-01
733522-01	725911-01
733522-02	725911-02
733955-00	725911-01
733955-01	725911-01
733955-02	725911-02
733955-03	725911-00
733955-04	725911-02

9. This fuse only used on generators fitted with neutral block option (F3, to the right of the HF power supply).

10. Two different room I/F transformers are used in Millenia generators. For 230 VAC 1 phase units use part number 733685-00, for 380/400/480 VAC three phase units use transformer part number 732179-00.

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CHAPTER 9

SCHEMATICS

CONTENTS:

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9.1.0 INTRODUCTION

This chapter contains the schematics for your X-ray generator, placed in order per the schematic index (section 9.2.0). The schematics are customized for each generator, that is only the applicable schematics with the appropriate revision for your generator are included.

Also included in this section are the available functional drawings.

RESTRICTION ON USE, DUPLICATION OR DISCLOSURE OF PROPRIETARY INFORMATION

This chapter (the schematics) contains information proprietary to the manufacturer, to its affiliates or to a third party to which the manufacturer may have a legal obligation to protect such information from unauthorized disclosure, use or duplication. Any disclosure, use or duplication of this document or of any of the information contained herein for other than the specific purpose for which it was disclosed by the manufacturer is expressly prohibited, except as the manufacturer may otherwise agree in writing.

9.2.0 SCHEMATIC INDEX

The schematic index customized for your generator follows this page.

9.3.0 FUNCTIONAL DRAWING INDEX

The functional drawing index immediately follows the schematic index page.

This page is customized specifically for the generator for which this manual was prepared

HF POWER SUPPLY SCHEMATICS (INCLUDING HT TANK)		
SCHEMATIC DESCRIPTION	**SCHEMATIC NUMBER**	**REVISION**
Schematic, HF P/S (System)	732865	B
Interface Board	725906	P
Control Board 1	729069	P
Control Board 2	727850	F
Filament Supply Board	728179	H
Contactor Control Board	N/A	N/A
Driver/Auxiliary Board	725918	T
Inverter/Snubber Board	N/A	N/A
Current Transformer Board	725928	A
Backplane Board	728878	C

GENERATOR SCHEMATICS (INCLUDING CONSOLE AND OPTIONS)		
SCHEMATIC DESCRIPTION	**SCHEMATIC NUMBER**	**REVISION**
Schematic, System I/F	732612	D
Generator CPU Board	734571	F
Generator I/F Board	732175	J
Room Interface Board	731967	B
Console CPU Board	N/A	N/A
Console Display Board	N/A	N/A
AEC Board	734612	D
AEC Interface Board	N/A	N/A
AEC Transition Board	N/A	N/A
Dual Speed Starter Board	728875	J
Low Speed Starter Board	N/A	N/A
Remote Fluoro Control Board	N/A	N/A
Remote Fluoro Display Board	N/A	N/A
Digital Interface Board	735404	A
Power Distribution Board	735518	A

THE PART NUMBER OF THE ORIGINAL AEC BOARD IN THE GENERATOR FOR WHICH THIS MANUAL WAS PREPARED IS LISTED BELOW:

AEC BOARD PART NUMBER (AS ORIGINALLY SHIPPED)
0073461401

THIS PAGE REPLACES PAGE 9-3

MILLENIA FUNCTIONAL DRAWINGS	
DESCRIPTION	DRAWING NUMBER
DC Bus Circuits	MD-0718

THIS PAGE REPLACES PAGE 9-4

9.4.0 SCHEMATICS

The schematics selected specifically for your generator follow this page.

9.5.0 FUNCTIONAL DRAWINGS

The functional drawings immediately follow the schematics.

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